RESOLUTION NO. <u>2023-48</u>

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF TOMBALL, TEXAS APPROVING THE WATER AND WASTEWATER MASTER PLAN; AND PROVIDING AN EFFECTIVE DATE.

* * * * * * * * *

WHEREAS, the City Council of the City of Tomball, Texas (the "City"), approved prior funding for the update of the Water Master Plan and Wastewater Master Plan;

WHEREAS, the City of Tomball completed the Water Master Plan in 2018 and the Wastewater Master Plan in 2019 and

WHEREAS, funding was allocated in the Fiscal Year 2022-2023 budget to complete required updates to the Water and Wastewater Master Plan, and a contract was executed with Freese & Nichols, Inc. on October 6, 2022 to prepare the study and report; and

WHEREAS, a Capital Improvement Plan was presented to City Council and adopted by Resolution Number 2023-43 on September 18, 2023; and

WHEREAS, The City Council desires to authorize the latest update to the City of Tomball Water and Wastewater Master Plan, attached as Exhibit A, to address the City's growth rate and need to adequately plan, prepare, and provide for the health, safety, and well-being of the City's citizens; and

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF TOMBALL, TEXAS

<u>Section 1.</u> The findings set forth in the recitals of this Resolution are hereby found to be true and correct and are hereby adopted as findings of the City Council and are incorporated into the body of this Resolution as if fully set forth herein.

<u>Section 2.</u> That the City Council of the City of Tomball hereby approves the Water and Wastewater Master Plan, attached as Exhibit A, a copy of same being attached hereto and incorporated herein for all purposes.

<u>Section 3.</u> The City Council hereby finds and declares that written notice of the date, hour, place and subject of the meeting at which this Resolution was adopted was posted and that such meeting was open to the public as required by law at all times during which this Resolution and the subject matter hereof were discussed, considered, and formally acted upon, all as required by the Open Meetings Act, Chapter 551, Texas Government Code, as amended.

<u>Section 4.</u> This Resolution shall take effect immediately upon its passage.

PASSED, APPROVED, AND RESOLVED this 6th day of November 2023.

____
Lori Klein Quinn
Mayor

ATTEST:

____
Tracylynn Garcia
City Secretary

CITY OF TOMBALL

2023 WATER AND WASTEWATER MASTER PLAN UPDATE

PREPARED FOR:

City of Tomball

PREPARED BY:

Freese and Nichols, Inc.
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Pearland, Texas 77584
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2023 WATER AND WASTEWATER MASTER PLAN UPDATE

Prepared for:

City of Tomball

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The City of Tomball retained Freese and Nichols, Inc. (FNI) to update their Water and Wastewater Master Plans (project). The City's previous Water Master Plan and Wastewater Master Plan were developed in 2018 and 2017, respectively. FNI also performed a study to update and calibrate the City's water distribution system model in 2022. The goals of this master plan update project included update and calibration of the wastewater collection system model, evaluation of the existing water and wastewater system, and development of capacity and renewal recommendations for 5-year, 10-year, and 25-year water and wastewater capital improvement plans (CIPs). These recommended improvements will serve as a basis for the financing, design, and construction of projects required to meet Tomball's existing and anticipated wastewater capacity and system renewal needs.

As part of this study, FNI conducted the following major tasks:

- City-wide flow monitoring and inflow/infiltration analysis
- Land use assumptions for the City's water and wastewater service areas
- Water demand and wastewater flow projections
- Wastewater model update and calibration
- Existing and future water and wastewater system analyses
- Water and wastewater system capital improvements plan and report

2.0 LAND USE ASSUMPTIONS AND POPULATION PROJECTIONS

Population and land use are important elements in the analysis of water distribution and wastewater collection systems. Water demands and wastewater flows are dependent on the residential population and commercial development served by the system and affect the sizing and location of system infrastructure. FNI worked with City staff to develop water and wastewater service areas and corresponding water and wastewater projections for the **5-year**, **10-year**, and **25-year** planning periods for the City of Tomball. These assumptions were utilized throughout this project. The water service area population projections are graphed on **Figure ES-1** and the wastewater service area population projections are graphed on **Figure ES-2**.

Figure ES-1: Water Service Area Population Projections

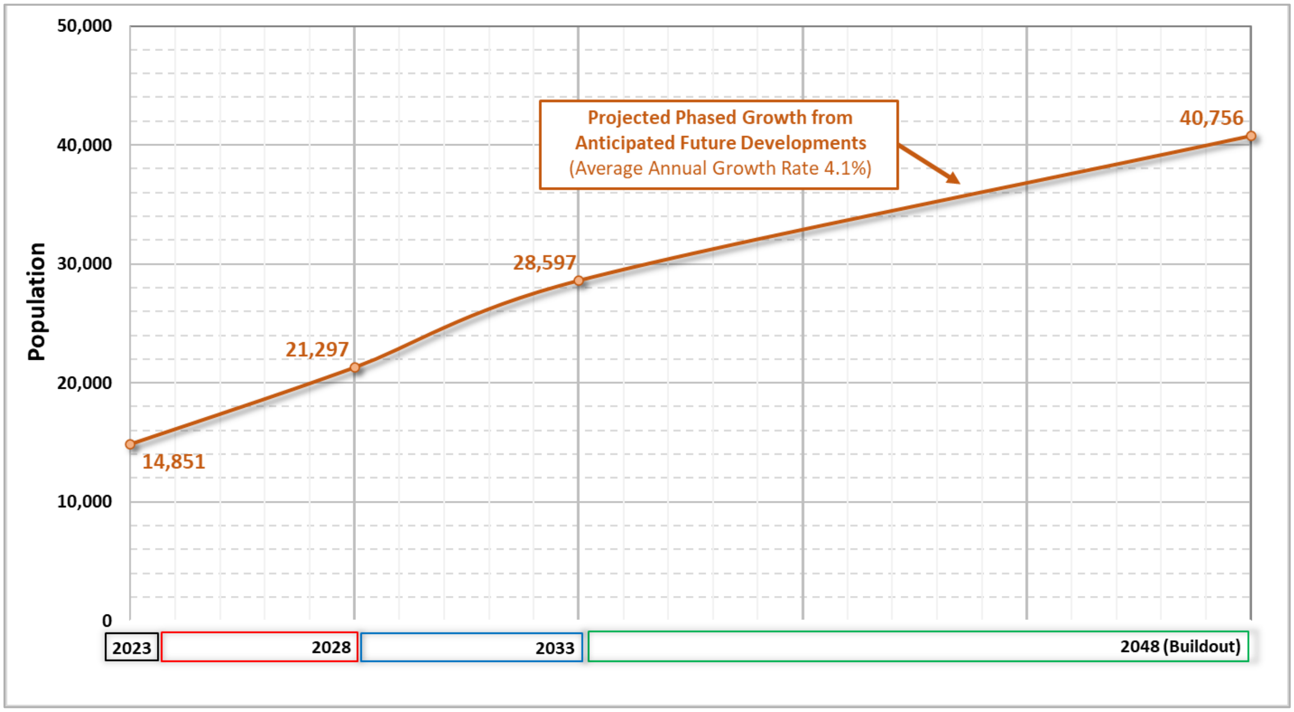
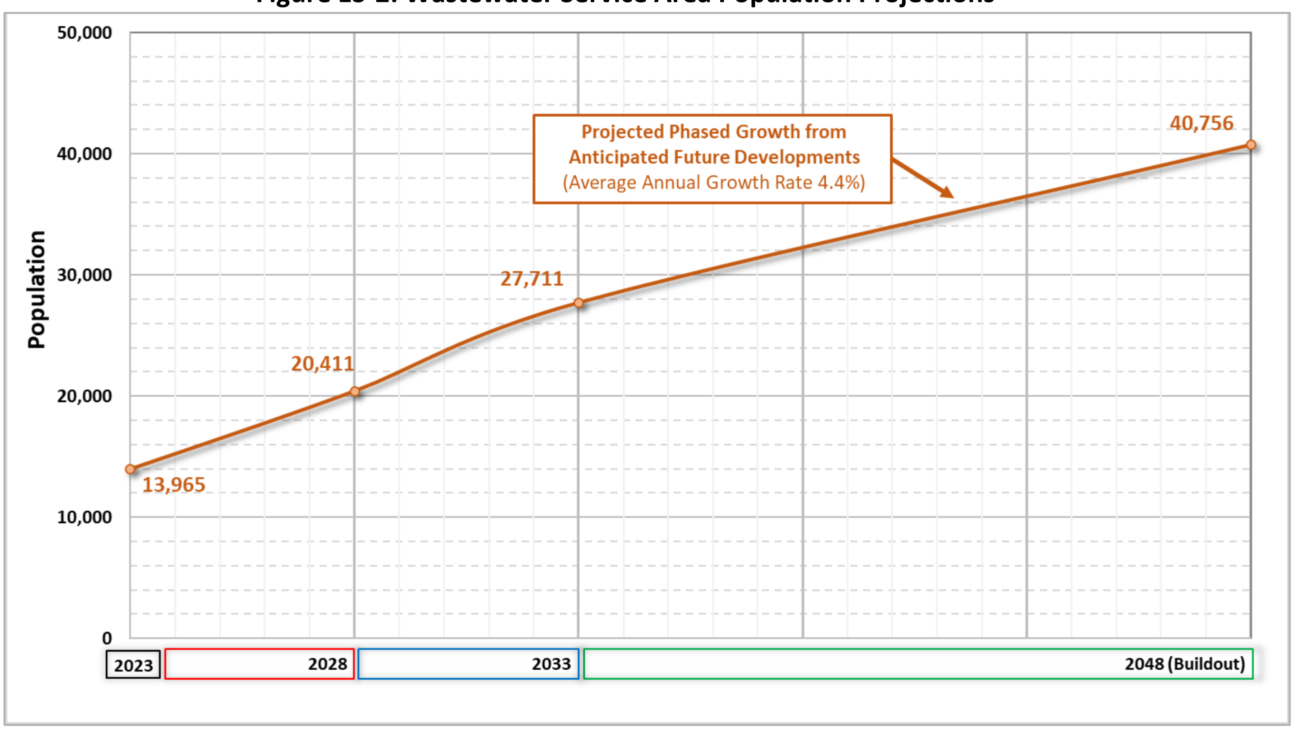


Figure ES-2: Wastewater Service Area Population Projections



3.0 EXISTING WATER SYSTEM

Tomball's water distribution system consists of a network of water lines, two active water plants, and two active elevated storage tanks (ESTs).

Water System Pressure Testing

Pressure testing was conducted between August 8th and 18th, 2021 in Tomball's distribution system as part of the *2022 Water Model Update and Calibration* project. Eight pressure recorders were placed throughout the distribution system to capture pressures and operational conditions during summer demand conditions.

4.0 WATER DEMAND PROJECTIONS

A water utility must be able to supply water at rates that fluctuate over time. Flow rates most important to the hydraulic design and operation of a pump station and distribution system are average day (AD), maximum day (MD), and peak hour (PH) demands.

During this project, FNI developed planning criteria for residential and commercial water demands and projected average day, maximum day, and peak hour demands for the **existing**, **5-year**, **10-year**, and **25-year** planning periods based on the land use assumptions discussed in **Section 2.0**. These demands were utilized in the hydraulic modeling and system planning to develop future water line and facility improvements. **Table ES-1** summarizes the historical and projected water demands for the City of Tomball.

Table ES-1: Projected Water Demands

Year	Average Day Demand(1) (MGD)	MD:AD Peaking Factor (2)	Maximum Day Demand (MGD)	PH:MD Peaking Factor(3)	Peak Hour Demand (MGD)
2023	2.1	2.40	5.1	1.70	8.6
2028	3.8		9.0		15.3
2033	5.3		12.9		21.8
2048	8.1		19.4		32.9

(1) Existing average day demand based on historical water production data. Calculated based on residential planning criteria of 160 gpcd and commercial planning criteria of 1,200 gpad.
(2) Based on historical water production data from 2017 to 2022.
(3) Based on diurnal pattern from calibration process.

5.0 WATER SYSTEM ANALYSES AND HYDRAULIC MODELING

As a public water utility, the City of Tomball must comply with the rules and regulations for public water systems set forth by the Texas Commission on Environmental Quality (TCEQ) in Chapter 290. FNI conducted an existing system evaluation to compare Tomball's existing water supply, storage, and pumping capacity against TCEQ requirements. Hydraulic analyses were conducted to identify deficiencies in the City of Tomball's existing water distribution system and to develop improvement recommendations to reinforce the existing system and meet projected water demands through 2048. The existing system was evaluated to analyze pressure, velocity, headloss, and fire flow under both existing and future demand conditions. Findings from the water system analyses were utilized to develop the CIP recommendations included in Section 6.0.

6.0 WATER SYSTEM CAPITAL IMPROVEMENTS PLAN

A water system capital improvements plan (CIP) was developed for the City of Tomball. The complete water CIP consists of the following components:

- Capacity CIP Projects
- Facility and Water Line Renewal CIP Projects

The CIP recommendations are based on the pressure testing data, land use assumptions, demand projections, hydraulic modeling, and system analyses discussed in this report. The recommended capacity projects provide an increased level of water service to existing residential and commercial customers and provide the required capacity to meet the projected water demands through the 25-year planning period. Where applicable, the recommended capacity projects also address existing condition issues in the water system. The facility and water line renewal projects were developed to improve available fire flow and address aging facilities.

The water capacity CIP is summarized in **Table ES-2**, presenting the cost estimate for each project by phase. The water line renewal CIP replacing lines that are 4-inches or smaller with 8-inch lines is summarized in **Table ES-3,** and the facility renewal CIP is summarized in **Table ES-4**.

Table ES-2: Water Capacity Capital Improvements Plan Summary

Phase	Project Number	Project Name	Capital Cost[1] in 2023 Dollars *(Costs do not include Inflation)*
5-Year	1	16-inch Water Line along Hufsmith Road	$2,353,200
	2	6-Inch Water Line along Clayton St and 12-inch Water Line Along Oak Street	$1,072,000
	3	12-Inch Water Line from Lizzie Lane to FM 2920	$1,130,300
	4	12/16-inch Water Line along Main Street	$4,661,500
	5	12-inch Water Line along Medical Complex Drive	$1,246,100
	6	Water Master Plan & Impact Fee Update	$250,000
		Total 2023 - 2028	**$10,713,100**
10-Year	7	12-inch Telge Water Line	$9,530,700
	8	New West Water Plant Phase 1	$15,157,400
	9	12-inch Water Line along SH 249	$1,028,600
		Total 2029 - 2033	**$25,716,700**
25-Year	10	12-Inch Telge Road and Holderrieth Road Water Line	$5,389,500
	11	FM 2920 Water Plant Pump Station Expansion to add 1,000 gpm Firm Pumping Capacity, 1.5 MG Ground Storage Capacity and 1,600 gpm Supply Capacity	$18,119,900
	12	West Water Plant Expansion to add 1,000 gpm Firm Pumping Capacity, 1.0 MG Ground Storage Capacity, and 500 gpm Water Supply	$11,513,200
	13	16-Inch Parallel Water Line along Ulrich Road	$1,001,700
	14	Replacement 1.5 MG Ulrich EST, Decommissioning of Pine Street EST and new 0.4 MG GST at Pine Street Water Plant.	$10,608,000
	15	East Water Plant Expansion to add 3,000 gpm Pumping, 2.0 MG Ground Storage, and 2,500 gpm Supply Capacity	$22,746,000
	16	12-Inch Water Line along Snook Lane	$2,311,300
		Total 2034 - 2048	**$71,689,600**
Timeline Pending	T1	8-inch Water Line in Corral RV Park	$116,700
	T2	8-inch Water Line along Liberty Lane	$142,100
	T3	8-inch Water Line along Stella Lane	$451,500
	T4	8-inch Water Line along Julia Lane	$403,700
	T5	8-inch Water Line along Helen Lane	$213,800
		Total Timeline Pending Projects Cost	**$1,327,800**
		Total Capacity Wastewater CIP Cost	**$109,447,200**

(1) **Costs are in 2023 dollars and do not include inflation.** Planning level costs were developed for proposed future projects and include construction costs, contingency, and engineering. Additional expenses related to owner's contingency, construction management/inspection, materials testing, and legal fees are not included.

Table ES-3: Water Line Renewal Plan Summary

Project Number	Project Name	Linear Footage	Cost[1] (2023 Dollars)
R1	Renewal Area R1	7,600	$ 2,828,900
R2	Renewal Area R2	7,200	$ 2,688,400
R3	Renewal Area R3	8,800	$ 3,267,500
R4	Renewal Area R4	8,000	$ 2,947,000
R5	Renewal Area R5	7,900	$ 2,923,100
R6	Renewal Area R6	7,500	$ 2,782,600
R7	Renewal Area R7	7,700	$ 2,852,900
R8	Renewal Area R8	7,400	$ 2,758,700
R9	Renewal Area R9	7,700	$ 2,852,900
R10	Renewal Area R10	7,600	$ 2,828,900

(1) Includes 30% contingency and 15% engineering/survey.

Table ES-4: Water Facility Renewal Plan Summary

Facility	Project Name	Cost (2023 Dollars)		
		10-Year Planning Period	Buildout Planning Period	Total
Ulrich EST	Condition Assessment	$25,000		**$1,132,000**
	Facility Rehabilitation[1]	$1,107,000		
Pine Street Water Plant	Condition Assessment	$50,000		**$1,979,000**
	Facility Rehabilitation[1]	$1,929,000		
FM 2920 Water Plant	Condition Assessment		$50,000	**$1,484,000**
	Facility Rehabilitation[1]		$1,434,000	

(1) The facility rehabilitation costs are included for initial budgeting purposes. These costs should be updated based on the results of the facility condition assessments. Costs include 30% contingency and 20% engineering.

7.0 EXISTING WASTEWATER SYSTEM

Tomball's wastewater collection system includes two wastewater treatment plants (WWTPs), approximately 87 miles of gravity wastewater lines ranging from 2-inches to 60-inches in diameter, 12 city-owned and operated lift stations, two influent lift stations at the South WWTP, one influent lift station at the North WWTP, and 21 private lift stations.

8.0 WASTEWATER FLOW MONITORING

FNI conducted city-wide flow monitoring and rainfall data collection as part of this project from November 18, 2022, through January 19, 2023. The flow monitoring and rainfall data were utilized to characterize dry weather and wet weather wastewater flows at key points within the collection system and to calibrate the hydraulic model. The flow and rainfall data were also utilized to quantify inflow and infiltration (I/I) throughout the collection system and prioritize flow meter basins for future sanitary sewer evaluation study (SSES) projects.

The flow meter basins were categorized into **High**, **Moderate**, or **Low** I/I and ranked from 1 (Highest) to 10 (Lowest). The flow meter basin ranking based on the normalized I/I is included in **Table ES-5**.

Table ES-5: Flow Meter Basin Ranking by Normalized I/I

Basin	Linear Footage of Gravity Lines	Average Volume of I/I (MG)	Average I/I (Gal/LF/in)	Basin Ranking by I/I
N-03	47,529	0.37	7.8	1
N-05	7,209	0.07	7.2	2
N-01	19,171	0.11	5.0	3
S-02	64,971	0.32	3.6	4
S-03	40,736	0.19	3.5	5
S-05	23,862	0.09	3.3	6
S-01	17,365	0.04	1.8	7
N-04	85,822	0.17	1.7	8
N-02	75,667	0.14	1.6	9
S-04	63,374	0.14	1.4	10

9.0 WASTEWATER FLOW PROJECTIONS

Planning for future wastewater infrastructure is dependent on the amount of average day and peak wastewater flow that must be collected, conveyed, and treated. FNI developed planning criteria for residential and commercial wastewater flows and projected average day and peak wastewater flows for the existing, **5-year**, **10-year**, and **25-year** planning periods based on the land use assumptions developed as part of this project. The total projected average day wastewater flows within each WWTP service area in each planning period are included in **Table ES-6**.

Table ES-6: Summary of Projected Average Day Wastewater Flows

Service Area	Projected Average Day Wastewater Flows(1) (MGD)			
	2023(1)	2028	2033	2048
North WWTP	0.70	0.83	0.88	1.47
South WWTP	0.93	1.72	2.65	3.80
Total	**1.63**	**2.55**	**3.52**	**5.27**

(1) Existing flows based on historical annual average flow from 2017 to 2022. Effluent data from the City was utilized for 2017 to 2021. Average flows observed during the flow monitoring period were utilized for 2022 flows.

10.0 WASTEWATER MODEL UPDATE AN DSYSTEM ANALYSES

FNI completed an update to the City's hydraulic wastewater model to include new lines and facilities, and calibrated the model based on the 2022/2023 flow monitoring data. Hydraulic analyses were conducted utilizing the updated wastewater collection system model to identify deficiencies in the City's existing wastewater collection system and establish a develop improvement recommendations to address deficiencies in the existing system and accommodate the projected wastewater flows through 2048.

FNI performed existing and future system analyses based on the 2-year, 24-hour design storm event. FNI also evaluated the collection system utilizing a peak flow to average day peaking factor of four. The peaking factor applied represents the wet weather flows in the collection system at the highest intensity point of a storm event. Findings from the wastewater system analyses were utilized to develop the CIP recommendations included in Section 12.0.

11.0 WASTEWATER TREATMENT PLANT CAPACITY ANALYSIS

The wastewater flow projections show that additional treatment capacity is needed within the next 25 years at the South WWTP to treat the projected wastewater flows within the study area. At this time, no capacity expansion of the North WWTP is being recommended.

12.0 WASTEWATER SYSTEM CAPITAL IMPROVEMENTS PLAN

A wastewater system capital improvements plan (CIP) was developed for the City of Tomball. The complete wastewater CIP consists of the following components:

- Capacity CIP Projects
- Sanitary Sewer Evaluation Study (SSES) CIP Projects

The CIP recommendations are based on the wastewater system flow monitoring, land use assumptions, flow projections, hydraulic modeling, and system analyses discussed in this report. The recommended capacity projects improve the collection system's ability to convey existing wastewater flows and provide the required conveyance and treatment capacity to serve the projected residential and commercial growth through the 25-year planning period. Where applicable, the recommended capacity projects also address existing condition issues in the wastewater system. The SSES CIP was developed based on the 2023 flow monitoring results and recommends field work and rehabilitation activities to address areas of the collection system with high levels of I/I.

The wastewater SSES CIP is summarized in **Table ES-7.** The wastewater capacity CIP is summarized in **Table ES-8**, presenting the cost estimate for each project by phase.

Table ES-7: SSES Project Costs

SSES Basin No.	Master Plan Flow Meter Basins			
	Flow Meter Basin No.	Length of Gravity Lines (LF)	No. of Manholes	Total SSES Project Cost (2023 Dollars)
SSES - 1	**N-03**	47,403	196	**$314,000**
SSES - 2	**N-01**	19,171	69	**$268,900**
SSES - 3	**S-02**	65,240	247	**$498,000**
SSES - 4	**S-03**	46,711	224	**$379,400**
SSES - 5	**S-05**	23,862	100	**$293,400**

Table ES-8: Wastewater Capacity Capital Improvements Plan Summary

Phase	Project Number	Project Name	Capital Cost[(1)] in 2023 Dollars *(Costs do not include Inflation)*
5-Year	1	Replacement 10/12-inch Gravity Lines along Alma/James Streets	$3,435,900
	2	Hicks Lift Station (LS) Expansion to 1.2 MGD	$1,223,100
	3	18-Inch South Persimmon Gravity Line	$4,081,400
	4	10/18-inch along Lutheran Church Road and FM 2920 Rd Gravity Line	$5,143,300
	5	Replacement 21/24-inch North Willow Street Gravity Line	$1,835,400
	6	21-inch Gravity Line along Humble Road	$4,790,000
	7	Wastewater Master Plan & Impact Fee Update	$250,000
		Total 2023 - 2028	**$20,509,100**
10-Year	8	New 1.1 MGD Telge Lift Station, 8-inch Force Main, and 21-inch Gravity Main	$5,105,300
	9	Snook Lane Lift Station Expansion to 0.5 MGD	$738,200
		Total 2029 - 2033	**$5,843,500**
25-Year	10	South WWTP 1.5 MGD Expansion to 4.5 MGD	$65,520,000
	11	Replacement 18-Inch Gravity Line Along Inwood Street to West Hufsmith Road	$2,284,400
	12	Hunterwood Lift Station Expansion to 0.22 MGD	$424,400
	13	New 315 gpm Lift Station, 6-Inch Force Main, and 10-Inch Gravity Line and Replacement 12/15-Inch Gravity Line	$3,850,100
	14	Replacement 18-Inch Gravity Line Along Highway 249 near Hicks Lift Station	$1,169,100
	15	Replacement 24-Inch Gravity Line Along Hufsmith Road	$1,190,300
	16	New 0.15 MGD Lift Station and 2-Inch Force Main at Boudreaux Estates	$656,400
		Total 2034 - 2048	**$75,094,700**
Timeline Pending	T1	Wastewater SCADA Master Plan	$200,000
	T2	Wastewater SCADA System	$3,057,600
		Total Timeline Pending Project Cost	**$3,257,600**
		Total Capacity Wastewater CIP Cost	**$104,704,900**

(1) **Costs are in 2023 dollars and do not include inflation.** Planning level costs were developed for proposed future projects and include construction costs, contingency, and engineering. Additional expenses related to owner's contingency, construction management/inspection, materials testing, and legal fees are not included.

1.0 INTRODUCTION

The City of Tomball (City) is located in Harris County, Texas. The City has a population of over approximately 14,000 and is projected to double and grow to over 28,500 in the next 25-years. The focus of this *2023 Water and Wastewater Master Plan Update* was to analyze the existing water and wastewater infrastructure in Tomball and develop improvement recommendations to accommodate the anticipated growth in an efficient and cost-effective manner. This report will provide the City of Tomball with a planning tool that will serve as a guide for short-term and long-term capital improvement projects (CIP) to the water and wastewater infrastructure. This project was performed in conjunction with the City's *2023 Water and Wastewater Impact Fee Update*.

1.1 SCOPE OF WORK

The City of Tomball retained Freese and Nichols, Inc. (FNI) to update their Water and Wastewater Master Plans (project). The City's previous Water Master Plan and Wastewater Master Plan were developed in 2018 and 2017, respectively. FNI also performed a study to update and calibrate the City's water distribution system model in 2022. The goals of this master plan update project included update and calibration of the wastewater collection system model, evaluation of the existing water and wastewater system, and development of capacity and renewal recommendations for 5-year, 10-year, and 25-year water and wastewater capital improvement plans (CIPs). These recommended improvements will serve as a basis for the financing, design, and construction of projects required to meet Tomball's existing and anticipated wastewater capacity and system renewal needs.

As part of this study, FNI conducted the following major tasks:

- City-wide flow monitoring and inflow/infiltration analysis
- Land use assumptions for the City's water and wastewater service areas
- Water demand and wastewater flow projections
- Wastewater model update and calibration
- Existing and future water and wastewater system analyses
- Water and wastewater system capital improvements plan and report

1.2 LIST OF ABBREVIATIONS

The list of abbreviations used in this report are presented in **Table 1-1**.

Table 1-1: List of Abbreviations

Abbreviation	Actual
AD	Average Day
ADF	Average Day Flow
ASCE	American Society of Civil Engineers
CCN	Certificate of Convenience and Necessity
CIP	Capital Improvement Plan
EST	Elevated Storage Tank
ETJ	Extraterritorial Jurisdiction
FM	Farm-to-Market Road
FNI	Freese and Nichols, Inc.
ft	feet
GIS	Geographic Information System
GPTC	Grand Parkway Town Center
gpd	Gallons per day
gpad	Gallons per acre per day
gpcd	Gallons per capita per day
gpm	Gallons per Minute
GST	Ground Storage Tank
LF	Linear Feet
LS	Lift Station
MD	Maximum Day
MG	Million Gallons
MGD	Million Gallons per Day
MSL	Mean seal level
NHCRWA	North Harris County Regional Water Authority
OPCC	Opinion of Probable Construction Cost
PH	Peak Hour
PR	Pressure Recorder
psi	Pounds per Square Inch
SCADA	Supervisory Control and Data Acquisition
SSES	Sanitary Sewer Evaluation Study
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TPDES	Texas Pollutant Discharge Elimination System
WWTP	Wastewater Treatment Plant

2.0 LAND USE ASSUMPTIONS AND POPULATION PROJECTIONS

Population and land use are important elements in the analysis of water distribution and wastewater collection systems. Water demands and wastewater flows are dependent on the residential population and commercial development served by the system and affect the sizing and location of system infrastructure. FNI worked with City staff to develop water and wastewater service areas and corresponding water and wastewater projections for the **5-year**, **10-year**, and **25-year** planning periods for the City of Tomball. These assumptions were utilized throughout this project.

2.1 WATER AND WASTEWATER SERVICE AREAS

The City's water distribution and wastewater collection systems currently provide service to the majority of the City limits. The City has plans to extend water and wastewater service to select areas outside of the City limits and to areas within the City limits that are not currently developed. **Figure 2-1** shows the water service area for this project. The water service area includes the majority of the existing City limits, Tomball's water Certificate of Convenience and Necessity (CCN), and a portion of the City's Extra-Territorial Jurisdiction (ETJ) and adjacent areas near Telge Road, Lutheran Church Road, Farm to Market (FM) 2920, and Medical Complex Drive. The Grand Parkway Town Center (GPTC) development is included in the water service area. **Figure 2-2** shows the wastewater service area for this project. The wastewater service area includes the majority of the existing City limits, wastewater CCN, and a portion of the City's ETJ (and adjacent areas near Telge Road, Lutheran Church Road, FM 2920, and Medical Complex Drive. The GPTC development is excluded from the wastewater service area.

2.2 HISTORICAL POPULATION

Historical City-wide population is presented in **Table 2-1**. The 2023 population within City limits was calculated based on projected census data and 2021 water meter billing data. The historical population data shows that since 2017, Tomball has experienced an approximately 3.4% annual average growth in population.

Table 2-1: Historical Population and Commercial Acreage

Year	City limit Population(1)	Annual Growth Rate
2017	11,653	-
2018	11,687	**0.3%**
2019	11,684	**0.0%**
2020	12,318	**5.4%**
2021	12,810	**4.0%**
2022	13,528	**5.6%**
2023	14,245	**5.3%**
Average Annual Growth Rate		**3.4%**

(1) Population data from the following sources: Census data (2020 census and projections), 2021 Water Meter Billing Data, and Known new construction information

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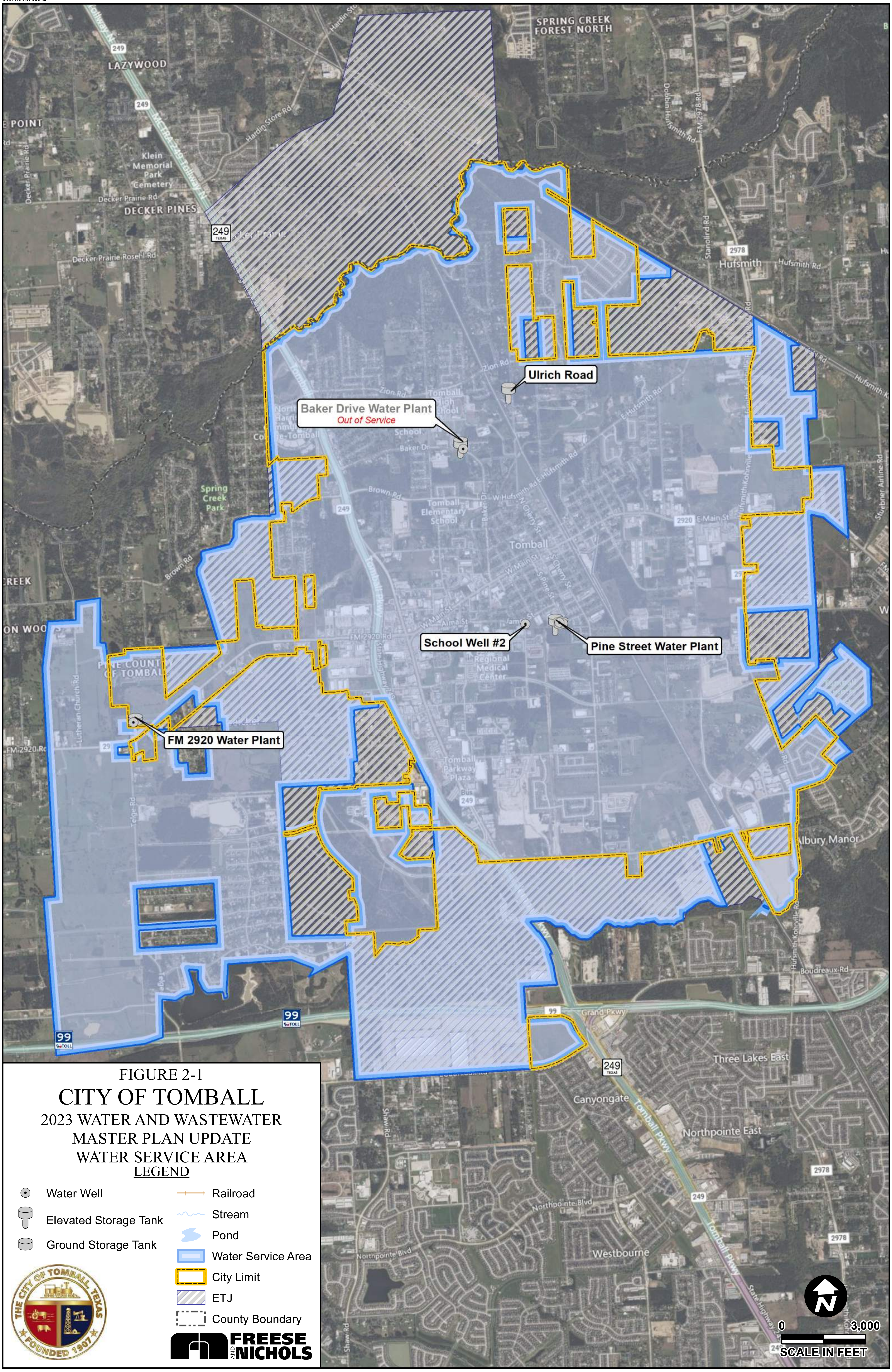

FIGURE 2-1
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
WATER SERVICE AREA

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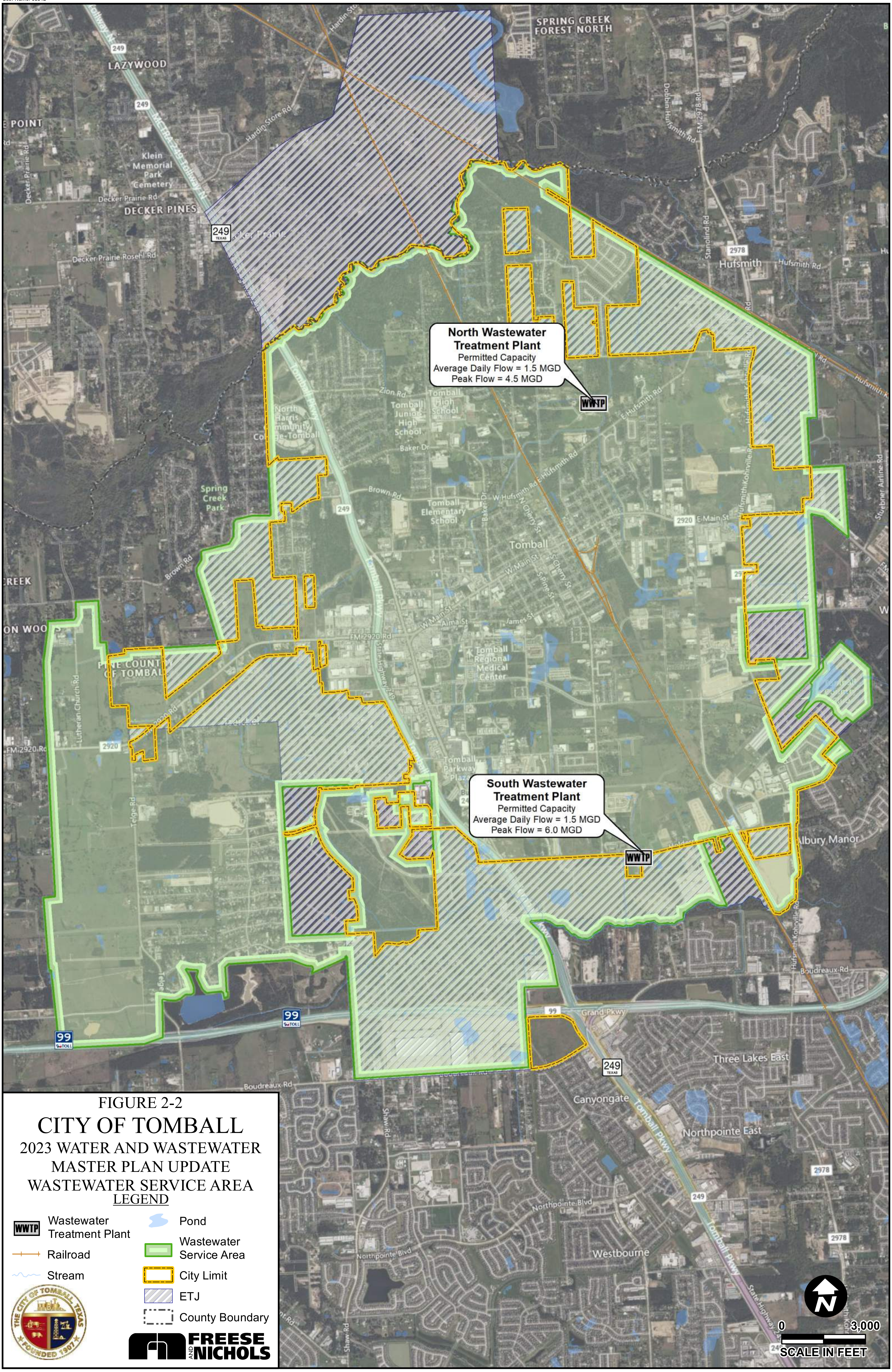

FIGURE 2-2
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
WASTEWATER SERVICE AREA

2.3 PROJECTED FUTURE DEVELOPMENT

The data sets utilized to develop population and commercial acreage projections included:

- Tomball's Future Land Use Plan, revised November 2019
- Information on known developments from the City's Planning Department
- Latest parcel shapefile
- Active water meter billing locations and consumption from September 2021
- Active water meter counts per meter size for April 2023
- Existing well and septic connections within city limits
- Density and growth projection assumptions from the City's 2009 Comprehensive Plan

Utilizing the data sets listed above and in coordination with the City staff, FNI developed projections for the following categories of future growth: **Known Developments**, **Infill Growth**, **Well/Septic Conversions**, and **Additional Areas**. A brief description of the methodology utilized for each of these categories is included below.

Known Developments

City staff identified areas where future residential and non-residential developments are anticipated to occur as well as an expected timeline for each development. These anticipated known developments are shown in **blue** on **Figure 2-3.** Where available, the City supplied development-specific information such as number of single-family lots, number of multi-family units, and commercial acreage. FNI utilized the *November 2019 Future Land Use Plan* and density information from the *2009 Comprehensive Plan* to develop residential population and commercial acreage projections when information was unavailable. The population and commercial acreage projections for the known developments are included in **Appendix C.**

Infill Growth

Where development information was unknown, FNI utilized active water meter locations and future land use information from the City's latest Future Land Use Plan as shown on **Figure 2-4** to identify developable areas. These areas included currently vacant parcels outside of known developments that are not within the *Parks & Open Space* land use type per the *November 2019 Future Land Use Plan* and primarily not within the 100-year flood plain. Density and growth assumptions for infill parcels were developed utilizing the City's *2009 Comprehensive Plan* to calculate projected population and commercial acreage. The majority of the infill parcels are projected to be developed beyond the 10-year period with the exception of parcels in the southeast and northeast portions of the City (shown in solid **purple** on **Figure 2-3)**. The southeast infill parcels within the 10-year planning period are located east of South Cherry Street between Holderrieth Road and Agg Road. The northeast infill parcels within the 10-year planning period are along Hufsmith Road and Rudolph Road. Infill parcels that are projected to be served beyond the 10-year planning period are shown on **Figure 2-3** as **purple**, hatched parcels.

Well/Septic Conversions

This category includes connections that are currently on well and/or septic and are projected to connect to the City's water and wastewater systems in the future. Two areas (R-36 and R-37) west of the existing City limits near Humble Road and Humble Lake Road are currently on wells and septic. These areas are projected to be served water and wastewater by the City within the 10-year planning period and are shown in solid **pink** on **Figure 2-3**. The City also provided the locations of existing septic customers that are being served water by the City. These parcels are shown in dotted **pink** on **Figure 2-3**. For the purposes of this study, it is anticipated that these connections will be served wastewater by the City beyond the 10-year planning period.

Additional Areas

In addition to the areas mentioned above, the City anticipates serving water and wastewater to areas west of the existing city limits along FM 2920, Telge Road, and Lutheran Church Road. These are mostly residential areas and are shown on **Figure 2-3** as Lutheran Church Adjacent in **green** and Telge Tract in **yellow**. The entire Lutheran Church Adjacent area is projected to be developed within the 10-year planning period. The Telge Tract is projected to be developed gradually within the 5-years, 10-year and 25-year periods.

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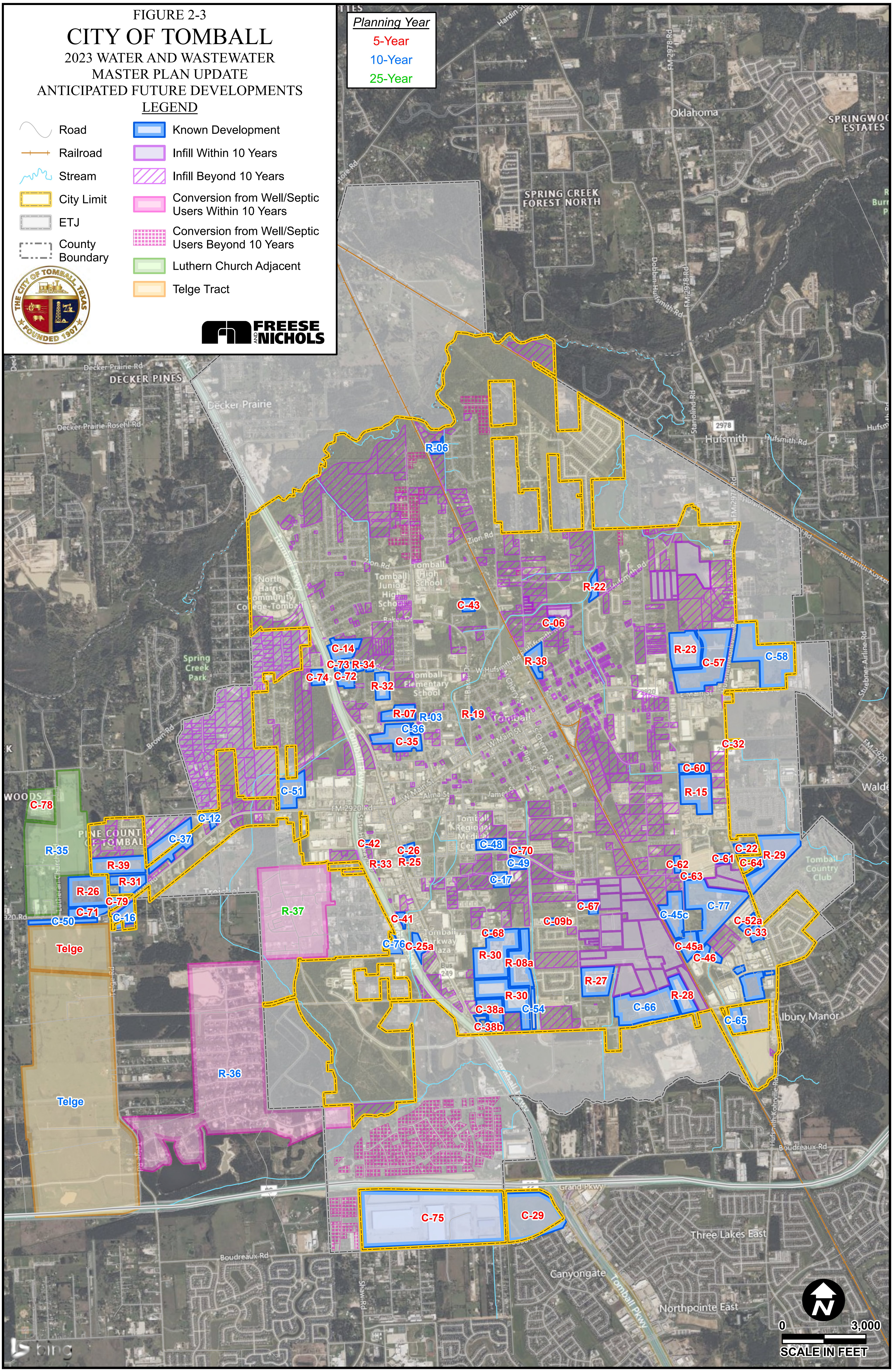

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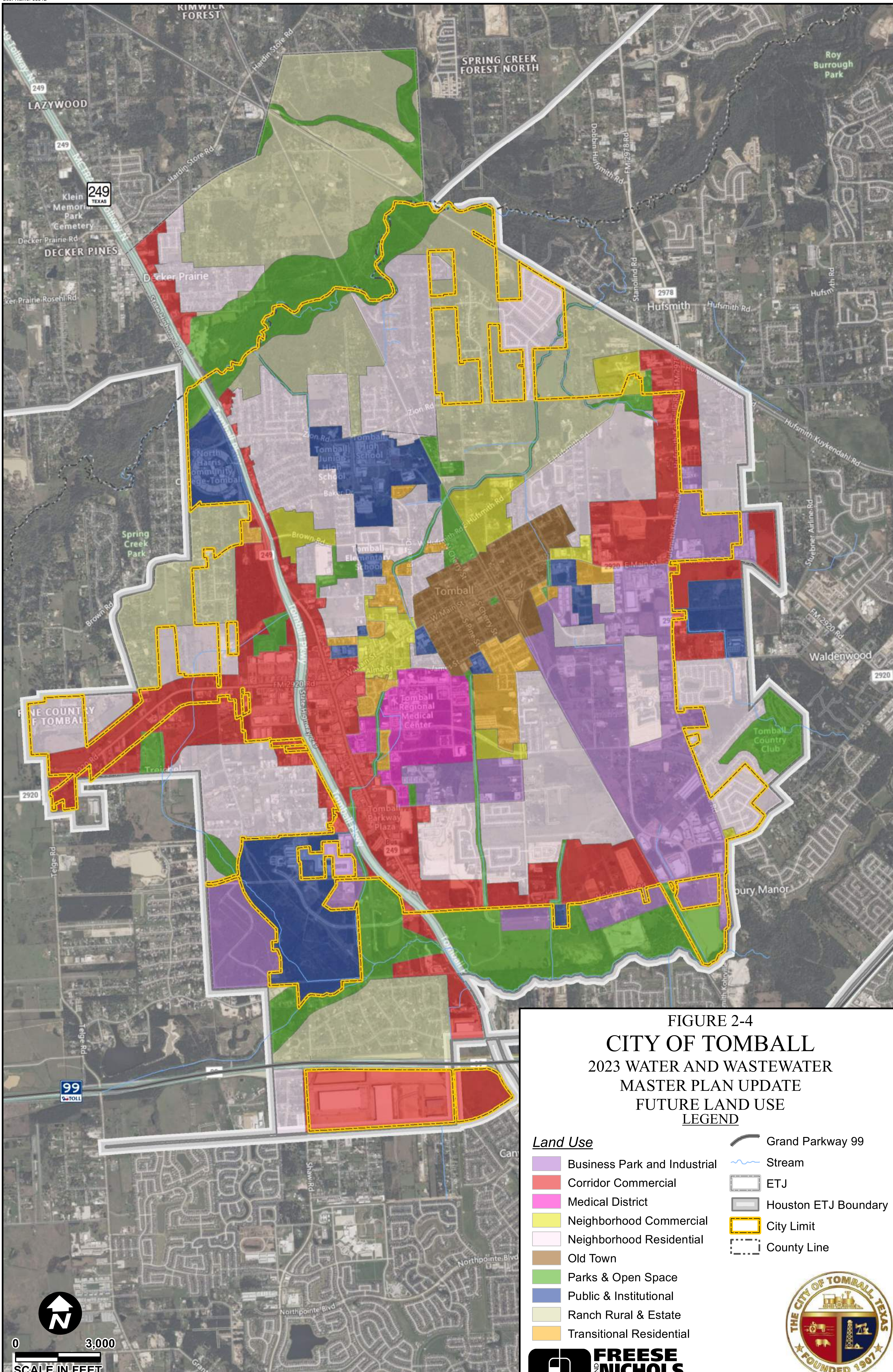


FIGURE 2-4

CITY OF TOMBALL

2023 WATER AND WASTEWATER MASTER PLAN UPDATE

FUTURE LAND USE

LEGEND

Land Use

- Business Park and Industrial
- Corridor Commercial
- Medical District
- Neighborhood Commercial
- Neighborhood Residential
- Old Town
- Parks & Open Space
- Public & Institutional
- Ranch Rural & Estate
- Transitional Residential

- Grand Parkway 99
- Stream
- ETJ
- Houston ETJ Boundary
- City Limit
- County Line

0 3,000
SCALE IN FEET

FREESE AND NICHOLS

THE CITY OF TOMBALL, TEXAS
FOUNDED 1907

The water service area population projections are graphed on **Figure 2-5** and the water service area commercial acreage projections are shown on **Figure 2-6.**

Figure 2-5: Projected Water Service Area Population

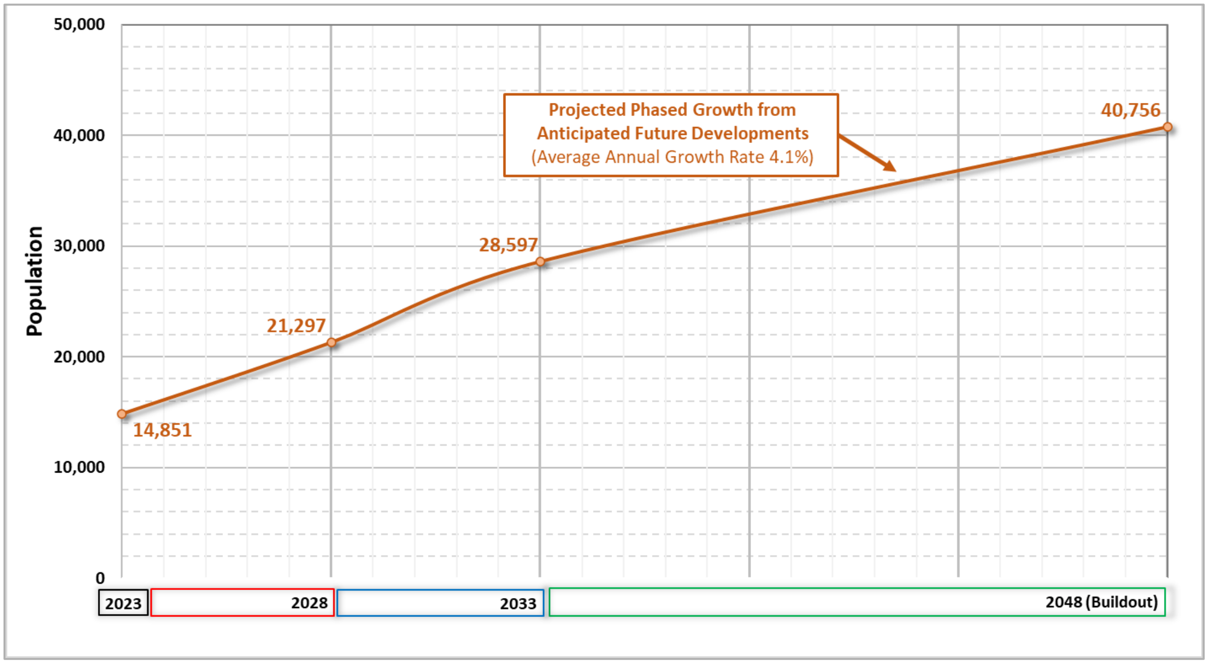
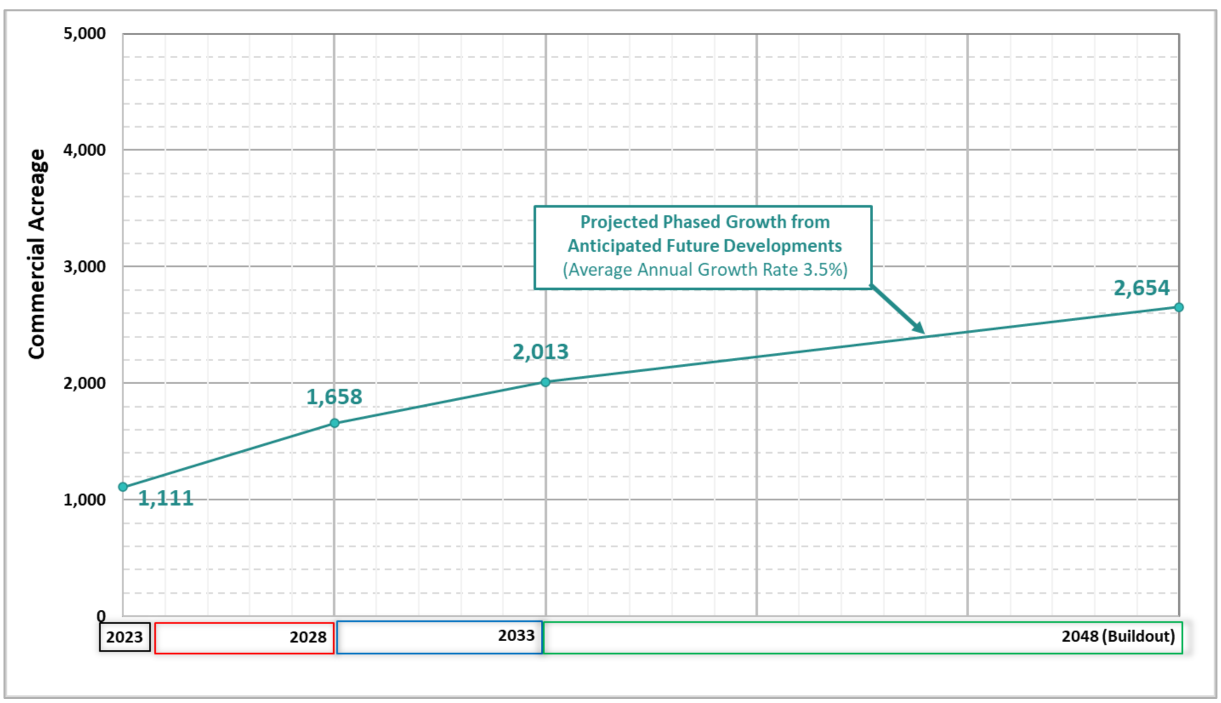


Figure 2-6: Projected Water Service Area Commercial Acreage



The wastewater service area population projections are graphed on **Figure 2-7** and the wastewater service area commercial acreage projections are shown on **Figure 2-8.**

Figure 2-7: Projected Wastewater Service Area Projections

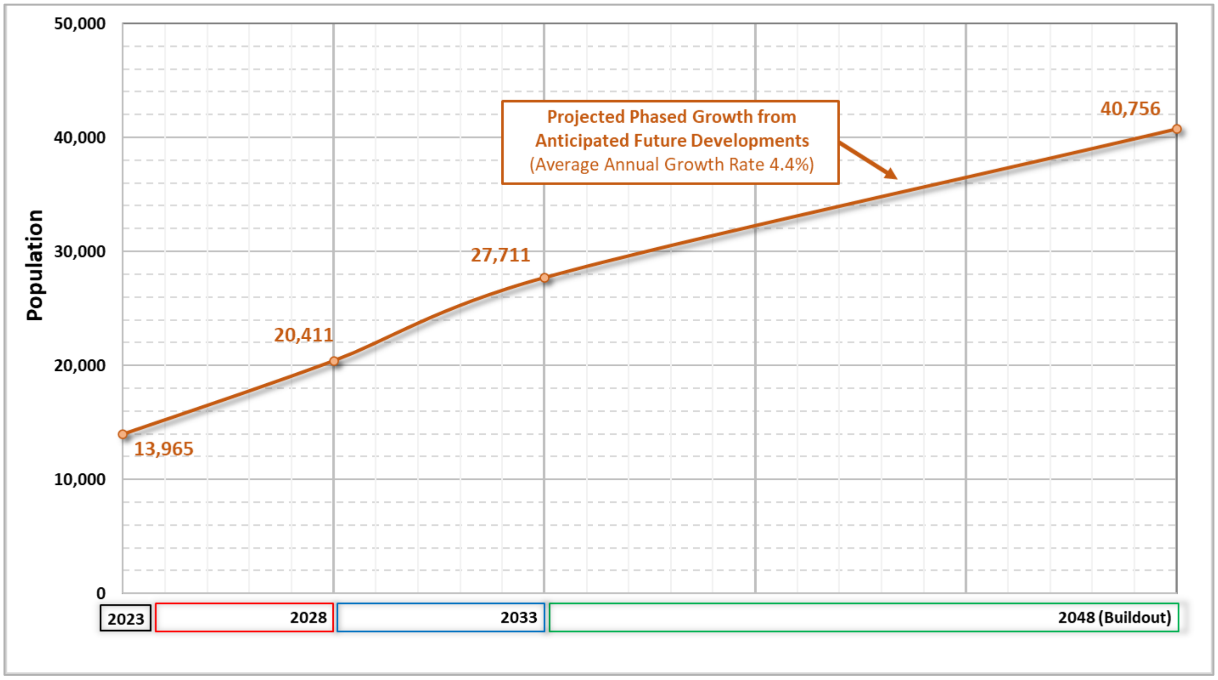
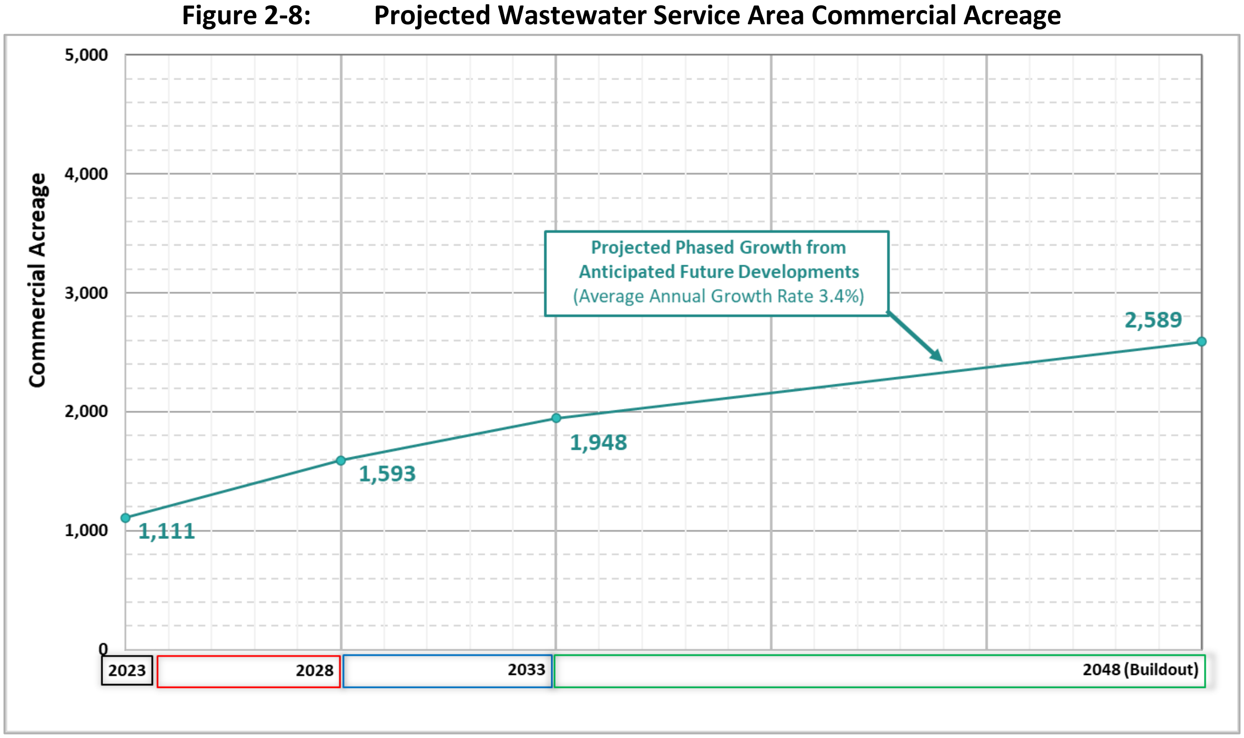


Figure 2-8: Projected Wastewater Service Area Commercial Acreage



3.0 EXISTING WATER SYSTEM

Tomball's water distribution system consists of a network of water lines, two active water plants, and two active elevated storage tanks (ESTs). The sections below discuss the existing water system in additional detail. **Figure 3-1** shows the existing water distribution system infrastructure.

3.1 EXISTING WATER SYSTEM

3.1.1 Pressure Plane

The City's water distribution system has one pressure plane, with ground elevations ranging between 150 feet and 230 feet above mean sea level (MSL). The pressure plane operates at a static hydraulic gradient of 338 feet MSL established by the Pine Street and Ulrich Road elevated storage tanks.

3.1.2 Water Supply

Groundwater

Tomball's water demands are currently served by five active groundwater wells. The existing groundwater well information is provided in **Table 3-1**. The existing wells are associated with either the Pine Street or FM 2920 water plants.

Table 3-1: Existing Groundwater Wells

Plant Name	Well Name	Tested Capacity(1)	
		gpm	MGD
Pine Street Water Plant	Well #1	502	0.72
	Well #2	1,588	2.29
	School Well #2	679	0.98
FM 2920 Water Plant	Well #5	714	1.03
	Well #6	651	0.94
	Total Capacity	**4,134**	**5.95**

(1) Well capacities provided by the City in September 2023.

Surface Water

The City of Tomball falls under the North Harris County Regional Water Authority (NHCRWA), which was established to help water providers comply with groundwater reduction plans set forth by the Harris Galveston Subsidence District. Tomball is not currently served surface water by NHCRWA. Discussion on future surface water supply is included in **Section 5.2.1**.

3.1.3 Pumping and Storage Facilities

Tomball currently has two water plants, each with pumping and storage facilities: Pine Street and FM 2920. Each of the water plants includes one ground storage tank (GST) and three booster pumps. The City has a total system pumping capacity of 8.64 MGD and a firm system pumping capacity of 7.20 MGD, which is the capacity with the largest pump out of service. **Table 3-2** includes a summary of distribution system pumping facilities. In addition to booster pumping, the City also utilizes elevated storage tanks (ESTs) to maintain system pressures. **Table 3-3** provides a summary of storage facilities and their capacities.

Table 3-2: Distribution (Booster) Pumping Facilities

Facility Name	Pump Number	Rated Capacity[1] (gpm)	Rated Capacity[1] (MGD)
Pine Street Water Plant	1	1,000	1.44
	2	1,000	1.44
	3	1,000	1.44
FM 2920 Water Plant	1	1,000	1.44
	2	1,000	1.44
	3	1,000	1.44
	Total	**6,000**	**8.64**
	Firm	***5,000***	***7.20***

(1) Provided by City of Tomball during the *2022 Phase I Water and Wastewater Impact Fee Study Update*: *Water Model Calibration*

Table 3-3: Storage Facilities

Storage Type	Facility Name	Address	Capacity[1] (MG)
Ground	Pine Street Water Plant	802 S Pine Drive	0.40
	FM 2920 Water Plant	15902 FM 2920	0.50
		Total Ground Storage	**0.90**
Elevated	Pine Street Water Plant	802 S Pine Drive	0.75
	Ulrich Road	1331 Ulrich St	0.50
		Total Elevated Storage	**1.25**

(1) Capacity information provided by City of Tomball during the *2022 Phase I Water and Wastewater Impact Fee Study Update: Water Model Calibration*

FIGURE 3-1
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
EXISTING WATER SYSTEM

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Hydropneumatic Tank

Tomball currently has one 5,000 gallon hydropneumatic tank at the FM 2920 Water Plant. It should be noted that for TCEQ system analyses, total storage does not include hydropneumatic tank capacity (TAC §290.45(a)(4)).

Inactive Facilities

Apart from the active water facilities mentioned above, the City has an water plant and a 0.2 MG elevated storage tank at Baker Drive which are currently out of service.

3.1.4 Water Lines

According to the City's water system Geographic Information System (GIS) updated as part of the *2023 Utility GIS Update* project, the City of Tomball's water system consists of 133 miles of active City-owned water distribution lines, with diameters ranging from 1-inch to 18-inches. **Figure 3-2** illustrates the percentage of water line length by diameter and **Figure 3-3** provides a summary of water line materials. **Figure 3-4** illustrates the portion of total water line length by age of the water line.

Figure 3-2: Water Line Diameter by Length

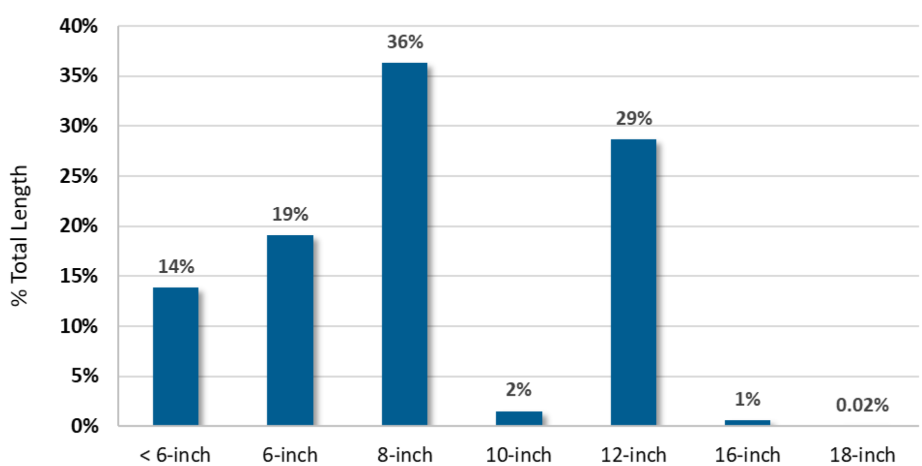
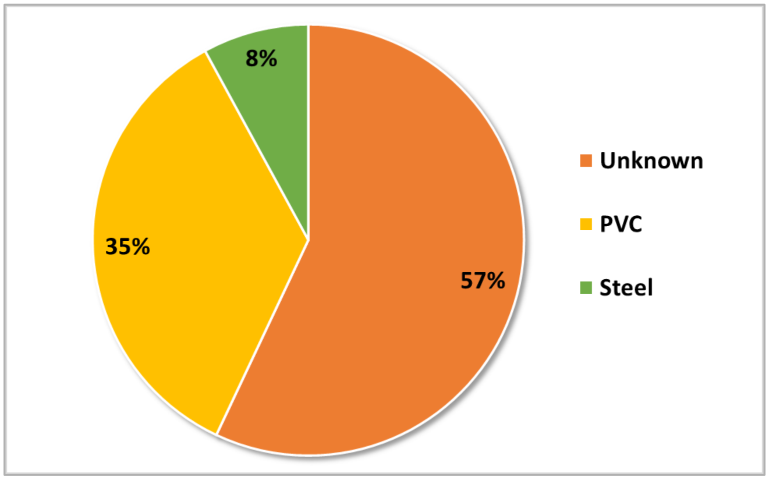
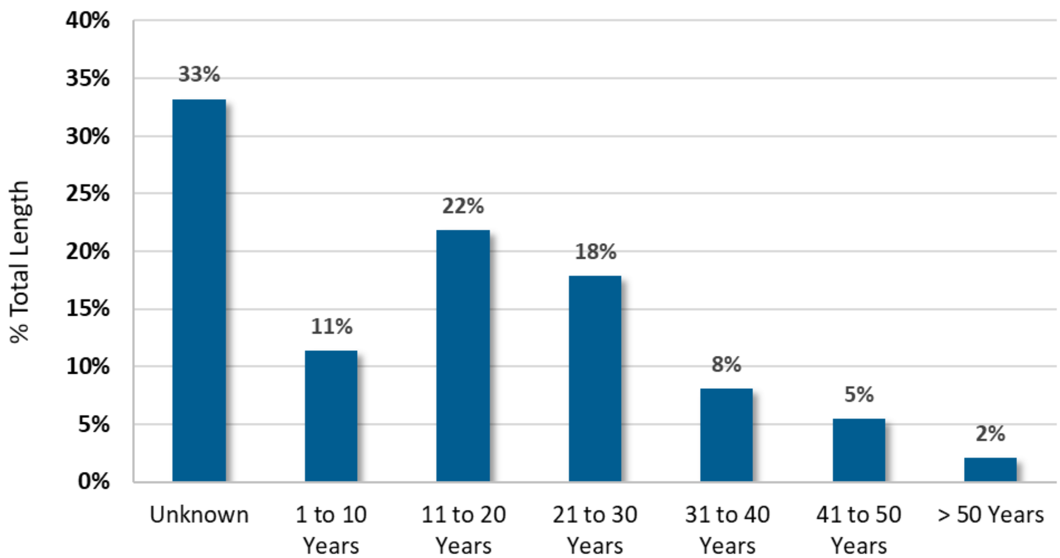


Figure 3-3: Water Line Materials



PVC = Polyvinyl Chloride

Figure 3-4: Water Line Age as of Year 2023



3.2 WATER SYSTEM PRESSURE TESTING

Pressure testing was conducted between August 8th and 18th, 2021 in Tomball's distribution system as part of the *2022 Water Model Update and Calibration* project. Eight pressure recorders were placed throughout the distribution system to capture pressures and operational conditions during summer demand conditions. This pressure recorder data was utilized to calibrate the hydraulic water model that was used as part of this project (discussed further in **Section 5.0**). The pressure testing results are documented in the *Water Model Update and Calibration TM*, included in **Appendix D**.

4.0 WATER DEMAND PROJECTIONS

A water utility must be able to supply water at rates that fluctuate over time. Flow rates most important to the hydraulic design and operation of a pump station and distribution system are average day (AD), maximum day (MD), and peak hour (PH) demands.

- **Average Day** use is the total annual water use divided by the number of days in the year. The average day demand rate is used as a basis for estimating *maximum day* and *peak hour* demands.
- **Maximum day** demand is the maximum quantity of water used on any one day of the year. Water supply facilities are typically designed based on the maximum day demand.
- **Peak hour** use is the peak rate at which water is required during any one hour of the year. Since minimum distribution pressures are usually experienced during peak hour, the sizes and locations of distribution facilities are generally determined based on this condition.

During this project, FNI developed planning criteria for residential and commercial water demands and projected average day, maximum day, and peak hour demands for the **existing**, **5-year**, **10-year**, and **25-year** planning periods based on the land use assumptions discussed in **Section 2.0**. These demands were utilized in the hydraulic modeling and system planning to develop future water line and facility improvements.

4.1 HISTORICAL WATER DEMANDS

Reviewing historical water demands provides insight into selecting design criteria used to project future water demands. Historical daily groundwater well production data (January 2017 to October 2022) was provided by the City. Water meter billing data (January 2020 to September 2021) was also provided by the City during the *2022 Water Model Update and Calibration* project. Historical annual average and max day water production and peaking factors are summarized in **Table 4-1** and included in **Appendix E.**

Table 4-1: Historical Water Production

Year	Average Day Demand(1) (MGD)	Maximum Day Demand(1) (MGD)	MD:AD Peaking Factor
2017	2.09	4.76	2.28
2018	2.04	3.69	1.81
2019	2.11	5.08	2.40
2020	2.13	4.14	1.94
2021(2)	2.07	4.34	2.10
2022(3)	2.79	4.96	1.78
Average	**2.21**	**4.50**	**2.05**
Maximum	**2.79**	**5.08**	**2.40**
Minimum	**2.04**	**3.69**	**1.78**

(1) Water production data from City staff.
(2) Max day demand excludes Winter Storm Uri.
(3) 2022 data from January to October 2022.

FNI utilized the City's pumped and sold water database to attribute percentages of the total water produced to residential and commercial sources. The City's population and commercial acreage was then utilized to calculate historical water demand per person in gallons per capita per day (gpcd) and historical water demand per commercial acre in gallons per acre per day (gpad). This breakdown of historical water production, populations, and commercial acreages and the resulting gpcd and gpad values are shown in **Table 4-2.**

Since the historical average day residential consumption represents the entire City, the City asked FNI to consider the historical water demand of recent residential development in determining future water demands since future residential development will likely use water in a similar manner. The developments evaluated included Pine Country, Raburn Reserve, and Raleigh Creek. **Table 4-3** presents the historical water consumption for these developments based on water meter billing data and the estimated population to determine the per capita demand.

Table 4-2: Historical Water Demand by Usage Type

Year	City-Wide Population(1)	Commercial Acreage(2) (acres)	Average Day Demand(3) (MGD)	Residential		Commercial		Other(6) (MGD)
				Residential Water Demand(3) (MGD)	Per Capita Water Demand (gpcd)	Commercial Water Demand(3) (MGD)	Per Capita Water Demand (gpad)	
2017	11,653	746	2.09	1.11	95	0.90	1,205	0.08
2018	11,687	807	2.04	0.99	85	0.90	1,119	0.14
2019	11,684	868	2.11	1.11	95	0.93	1,075	0.07
2020	12,318	929	2.13	1.18	96	0.88	948	0.07
2021(4)	12,810	989	2.07	1.11	87	0.93	941	0.03
2022(5)	13,528	1,050	2.79	1.60	118	1.16	1,101	0.03
Average	-	-	**2.21**	**1.18**	**96**	**0.95**	**1,065**	**0.07**
Maximum	-	-	**2.79**	**1.60**	**118**	**1.16**	**1,205**	**0.14**

(1) Population data from the following sources: Census data (2020 census and projections), 2021 Water Meter Billing Data, and Known new construction information

(2) Commercial acreage is obtained from GIS based on geocoded 2021 commercial meters and known recently completed developments for 2023. 2017 commercial acreage from commercial meters active between August 2015 and December 2016. 2018 – 2022 acreage calculated using linear interpolation.

(3) Total pumped water data from City's *Pumped and Sold* water database. Residential and commercial metered water usage utilized to calculate contribution to total pumped water demand before losses.

(4) 2021 data excludes Winter Storm Uri.

(5) Production data available through October 2022.

(6) Other includes public/municipal and flushed, pumped, and emergency water demand.

Table 4-3: Historical Water Demand for Recent Developments

Development	Water Consumption(1) (gpcd)		
	2020	2021(2)	Average
Pine Country	166	140	153
Raleigh Creek	193	129	161
Raburn Reserve	-	157	157
Average	**179**	**142**	**157**

(1) Gpcd calculated based on water meter billing data and 2.6 people per connection.
(2) Data available from January through September.

4.2 WATER DEMAND PROJECTIONS

Water demands were projected for the **existing**, **5-year**, **10-year**, and **25-year** planning periods. The evaluation of historical data presented in **Table 4-2** and **Table 4-3** served as the basis for establishing the planning criteria used to project water demands. Based on the review of this data, FNI recommends a future average day demand of 160 gpcd for projected population and 1,200 gpad for projected commercial acreage. These city-wide planning criteria are presented in **Table 4-4**.

Table 4-4: Water Planning Criteria

Demand Type	Planning Criteria
Residential	160
Commercial	1,200

Maximum Day to Average Day Peaking Factor

FNI reviewed historical peaking factors for the City of Tomball. Historical water usage data indicated the maximum day to average day peaking factor ranged from 1.81 to 2.40. FNI selected a peaking factor of 2.40 for future demand projections.

Peak Hour to Maximum Day Peaking Factor

After reviewing data recorded during pressure testing, FNI recommends using a peaking factor of 1.7 to project the peak hour demand. Pressure testing and diurnal pattern development is discussed further in the *2022 Water Model Update and Calibration* TM (**Appendix D**).

Projected Water Demands

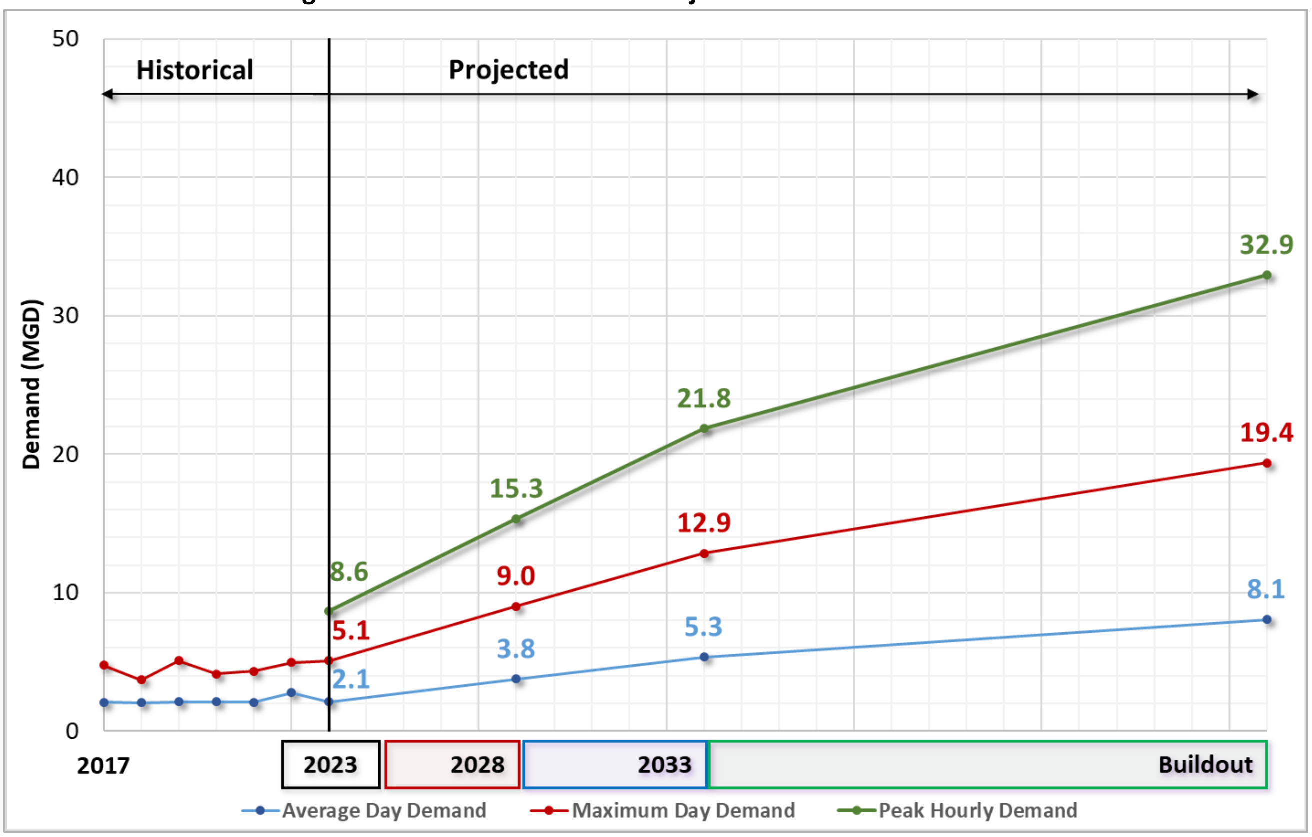
FNI utilized the planning criteria presented in **Table 4-4** and the peaking factors to develop water demand projections for the **5-year**, **10-year**, and **25-year** planning periods. **Table 4-5** summarizes the projected water demands and **Figure 4-1** provides a graphical illustration of the historical and projected water demands for the City of Tomball.

Table 4-5: Projected Water Demands

Year	Average Day Demand(1) (MGD)	MD:AD Peaking Factor(2)	Maximum Day Demand (MGD)	PH:MD Peaking Factor(3)	Peak Hour Demand (MGD)
2023	2.1	2.40	5.1	1.70	8.6
2028	3.8		9.0		15.3
2033	5.3		12.9		21.8
2048	8.1		19.4		32.9

(1) Existing average day demand based on historical water production data. Calculated based on residential planning criteria of 160 gpcd and commercial planning criteria of 1,200 gpad.
(2) Based on historical water production data from 2017 to 2022.
(3) Based on diurnal pattern from calibration process.

Figure 4-1: Historical and Projected Water Demands



5.0 WATER SYSTEM ANALYSES AND HYDRAULIC MODELING

5.1 HYDRAULIC WATER MODEL

Tomball's existing water distribution system hydraulic model is in the InfoWater® software by Innovyze. This modeling software has GIS interoperability and makes use of engineering equations and mathematical algorithms to determine the hydraulic parameters, such as flows and velocities that would occur in a distribution system under a specified set of conditions. The water model was originally developed by FNI in 2018 during the City's *2018 Water Master Plan* project.

During the *2022 Water Model Update and Calibration*, FNI updated the City's hydraulic water model based on the recent utility GIS update work and recalibrated the model to pressure testing data recorded in August of 2021. The model update is documented in the *2022 Water Model Update and Calibration TM,* included in **Appendix D**. This hydraulic model was utilized for system analyses throughout this study.

5.2 WATER SYSTEM ANALYSES

As a public water utility, the City of Tomball must comply with the rules and regulations for public water systems set forth by the Texas Commission on Environmental Quality (TCEQ) in Chapter 290. FNI conducted an existing and future system evaluation to compare Tomball's water supply, storage, and pumping capacity against TCEQ regulations based on the population and commercial acreage projections discussed in **Section 2.0**. The population and commercial acreage projections were converted to connections and were utilized for the TCEQ analysis, discussed further in the following sections.

5.2.1 Water Supply

The City is required to provide sufficient water supply to meet the projected future maximum day demands and TCEQ minimum water supply requirement of 0.6 gpm per connection. Tomball's tested water supply capacity was provided by the City and utilized for this analysis. **Table 5-1** presents the water supply requirements by planning year for Tomball's water system with recommended supply improvements.

Table 5-1: TCEQ Water Supply Capacity Requirements

Planning Year	Connections(2)	Total Existing Supply Capacity(3) (MGD)		TCEQ Requirement 0.6 gpm/con(1) (MGD)	Maximum Day Demand (MGD)	Total Recommended Supply (MGD)
2023	6,933	**5.95**	<	6.0	5.1	-
2028	11,053		<	9.5	9.0	**10.3**
2033	14,926		<	12.9	12.9	**13.2**
2048	21,525		<	18.6	19.4	**19.8**

(1) According to 290.45(b)(1)(D)(i).
(2) Existing connections based on 2021 water meters and apartment unit counts. Projected connections based on 2.6 people/connection and 3 connections per commercial acre.
(3) Based on tested well capacity provided by the City.

According to the analysis in **Table 5-1**, the City is able to meet the existing maximum day demand with their existing supply capacity but are not able to meet the calculated TCEQ requirement utilizing the 0.6 gpm/connection criteria. Therefore, it is recommended that the City pursue an alternative capacity requirement for water supply from TCEQ.

The existing water supply capacity is not adequate to meet projected future maximum day water demand. It is recommended that the City implement the following water supply projects as shown on **Figure 5-1**:

- **5-year planning period:** Add a new 1,000 gpm groundwater well(s) at Baker Drive Water Plant and 2,000 gpm groundwater well(s) at East Water Plant (*note: City has begun design to implement these improvements*)
- **10-year planning period**: Add a new 2,000 gpm groundwater well(s) at West Water Plant
- **25-year planning period:** Add additional 2,500 gpm off-site groundwater well(s) at East Water Plant, 500 gpm groundwater well(s) at Telge Water Plant, and 1,600 gpm groundwater well(s) at FM 2920 Water Plant

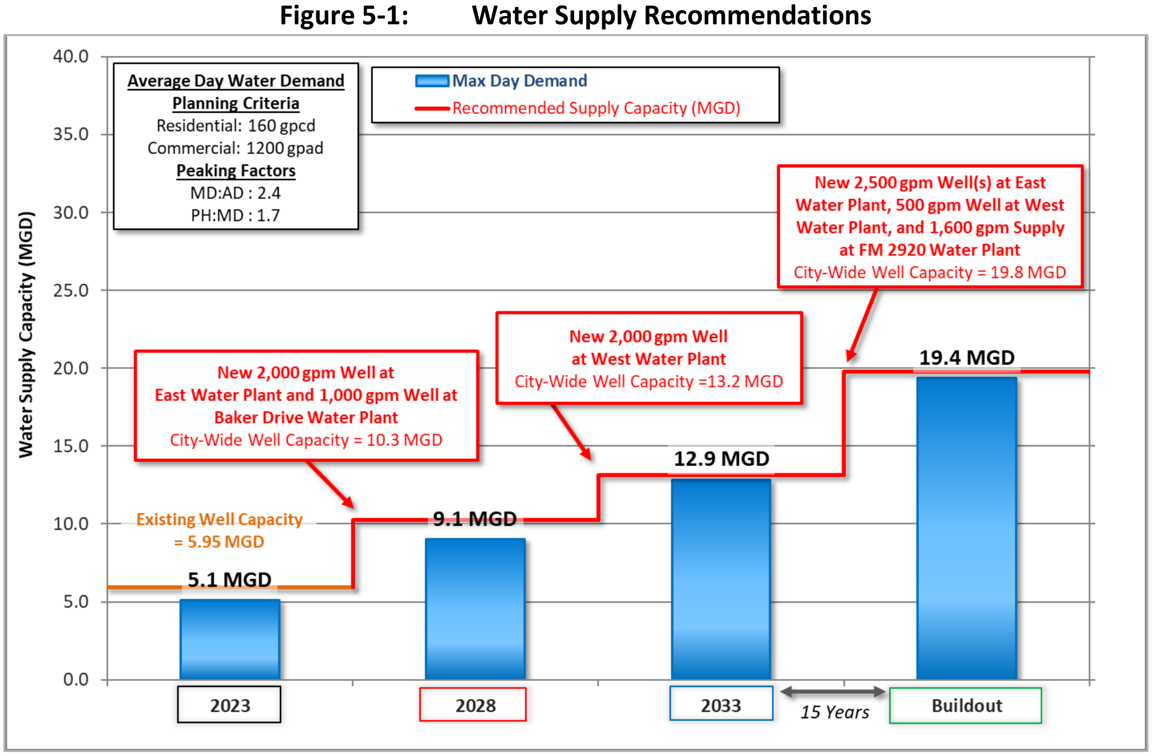
Unless otherwise noted, water facility projects assume the required yield can be provided from onsite wells and do not include costs for offsite wells and associated well supply lines. It is recommended to drill test wells to verify available yield. If the groundwater yield is less than the recommended supply capacity, additional wells would be needed.

Surface Water

The City of Tomball is within the boundaries of the North Harris County Regional Water Authority (NHCRWA), which was established to help water providers comply with groundwater reduction requirements set forth by the Harris-Galveston Subsidence District. NHCRWA develops and maintains infrastructure to convey treated surface water from the City of Houston Northeast Water Purification Plant to customers in North Harris County. During the development of this 2023 master plan study, Tomball staff met with NHCRWA to discuss the anticipated timeline for surface water delivery to the City of Tomball. The next NHCRWA milestone for surface water conversion is 2035, and the City of Tomball is identified as a customer in this conversion timeline.

For the purposes of this 2023 Master Plan CIP and the City's current budgeting efforts, the City has elected to include groundwater supply projects in the CIP to meet the projected buildout water system demands. It should be noted that this assumes the available groundwater yield exists to supply the City's future water demands, and is it recommended to drill test wells to verify available yield. It is also recommended that the City's long-term water supply CIP continue to be evaluated during the next master plan update and as more information on NHCRWA's infrastructure and conversion plan becomes available. Proposed water CIP projects are discussed in **Section 6.0**.

Figure 5-1: Water Supply Recommendations



5.2.2 Storage Capacity

The City is required to meet the TCEQ minimum total storage capacity requirement of 200 gallons per connection and minimum elevated storage capacity requirement of 100 gallons per connection per Chapter 290. **Table 5-2** presents the storage requirements for Tomball's water system with recommended improvements.

Based on the TCEQ regulations, Tomball's existing water system is currently in compliance with the minimum requirements for total and elevated storage. The system has more than 100 gallons of elevated storage per connection, but less than 200 gallons. With projected future growth, the existing storage capacity will be adequate to meet TCEQ minimum total storage or elevated requirements; however, based on the hydraulic modeling analysis, a replacement larger capacity EST at the Ulrich location and decommissioning of the existing Pine Street EST is recommended. This will help the system meet the projected peak hour demands and minimum pressure requirements and will provide improved hydraulics. Elevated storage recommendations are included on **Figure 5-2** and total storage is included on **Figure 5-3.** To meet the TCEQ requirements, the following are recommended:

- **5-year planning period:** Addition of the 1.0 MG Grand Parkway EST (*currently under construction*), New 0.5 MG GST at Baker Drive Water Plant (*currently under design*), and 1.0 MG GST at East Water Plant (*currently under design*)
- **10-year planning period:** New 0.75 MG GST at West Water Plant
- **25-year planning period**: New 2.0 MG GST capacity at East Water Plant, new 1.5 MG GST capacity at FM 2920 Water Plant, new 1.0 MG GST capacity at West Water Plant, new 0.4 MG GST at Pine Street, new 1.5 MG Ulrich EST, and decommissioning of the 0.75 MG Pine Street EST

Table 5-2: TCEQ Storage Requirements

Planning Year	Connections(1)	Total Storage(2) (MG) Existing		Total Storage(2) (MG) Required (200 gal/con)	Total Storage(2) (MG) Recommended Capacity (MGD)	Elevated Storage(2) (MG) Existing		Elevated Storage(2) (MG) Required (100 gal/con)	Elevated Storage(2) (MG) Optional (200 gal/con)	Elevated Storage(2) (MG) Recommended Capacity (MGD)
2023	6,933	2.15	>	1.4	-	1.25	>	0.69	1.4	-
2028	11,051	2.15	<	2.2	4.7			1.1	2.2	2.25
2033	14,923			3.0	5.4	1.25	<	1.5	3.0	
2048	21,522			4.4	10.2			2.2	4.4	2.50

(1) Existing connections based on 2021 water meters and apartment unit counts. Projected connections based on 2.6 people/connection and 3 connections per commercial acre.
(2) According to 290.45 (b)(1)(D)(ii and iv).

Figure 5-2: Elevated Storage Capacity Requirements

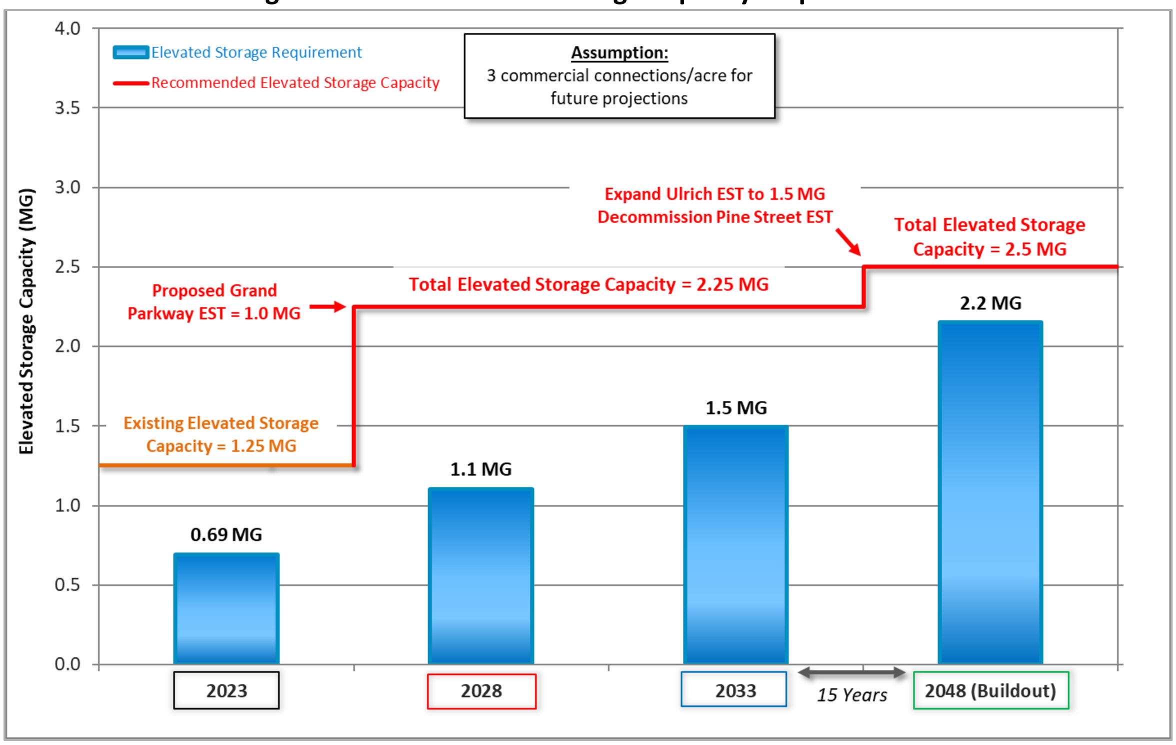
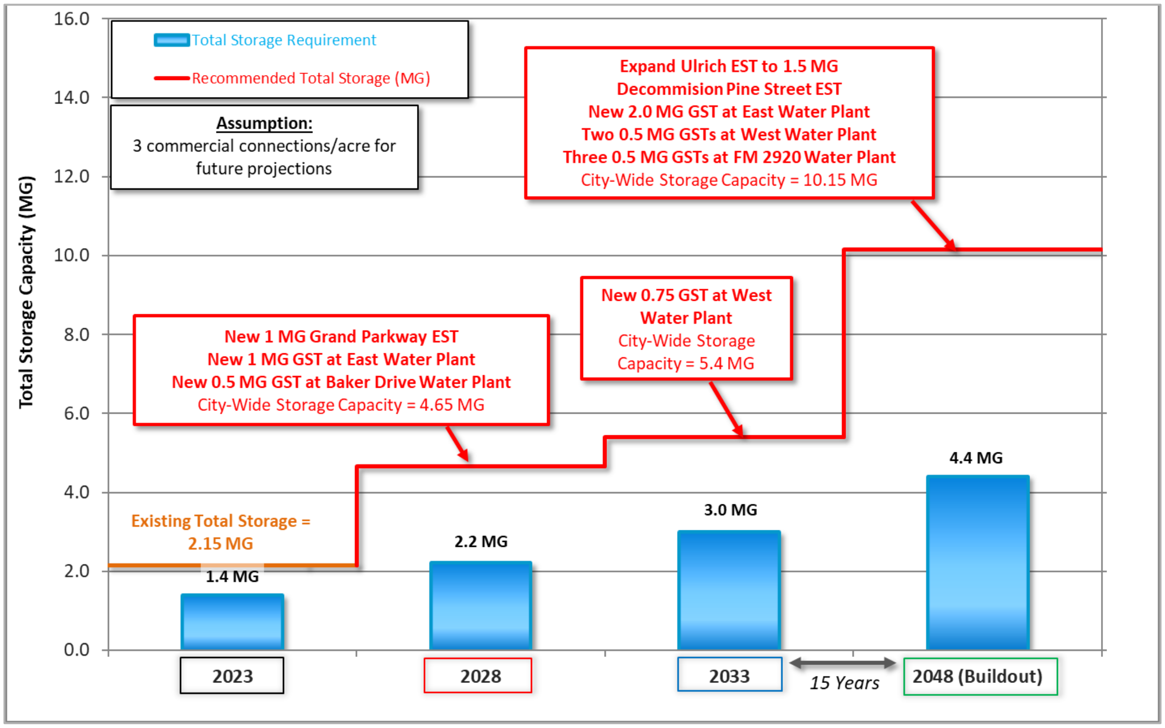


Figure 5-3: Total Storage Capacity Requirements



5.2.3 Pumping Capacity

In addition to storage and water supply requirements, the City is also required to meet the service pumping capacity requirements presented in **Table 5-3** per TCEQ.

Table 5-3: General TCEQ Service Pumping Requirements

Condition		Service Pumping Capacity Requirement (1)
1.	If providing at least 200 gallons per connection of elevated storage	Two service pumps with a minimum combined capacity of 0.6 gpm per connection at each pressure plane
2.	If providing less than 200 gallons per connection of elevated storage	**The Lesser of (a) or (b):**
		(a) Total pumping capacity of 2.0 gpm per connection
		(b) Total capacity of at least 1,000 gpm and the ability to meet peak hourly demands with the largest pump out of service

(1) According to 290.45(b)(1)(D)(iii).

The City of Tomball does not have greater than 200 gallons per connection of elevated storage; therefore *Condition 1* is not satisfied. Based on the City's elevated storage capacity, *Condition 2b* is lesser of *Condition 2* and governs the City's service pumping capacity. Model results included in **Appendix F** show that the City is not able to meet peak hourly demands with the largest pump out of service and maintain minimum pressure of at least 35 psi throughout the water system. However, this is due to high elevations and small water lines resulting in head loss and is not due to a lack of firm pumping capacity. **Section 6.0** outlines recommendations to reduce head loss and increase the City's water system pressure by constructing new water lines and improving connectivity.

Based on the hydraulic model analysis, additional pumping would be needed in future planning periods to maintain minimum pressures of at least 35 psi throughout the system. To meet the service pumping requirements, the following are recommended:

- **5-year planning period:** New 1.4 MGD (1,000 gpm) firm capacity pump station at Baker Drive Water Plant, new 4.3 MGD (3,000 gpm) firm capacity pump station at East Water Plant (*note: City has began design to implement these improvements*)
- **10-year planning period**: New 3.6 MGD (2,500 gpm) firm capacity pump station at West Water Plant
- **25-year planning period**: Additional 1.4 MGD (1,000 gpm) firm capacity at FM 2920 Water Plant, additional 4.3 MGD (3,000 gpm) firm capacity at East Water Plant, and additional 1.4 MGD (1,000 gpm) firm capacity at West Water Plant

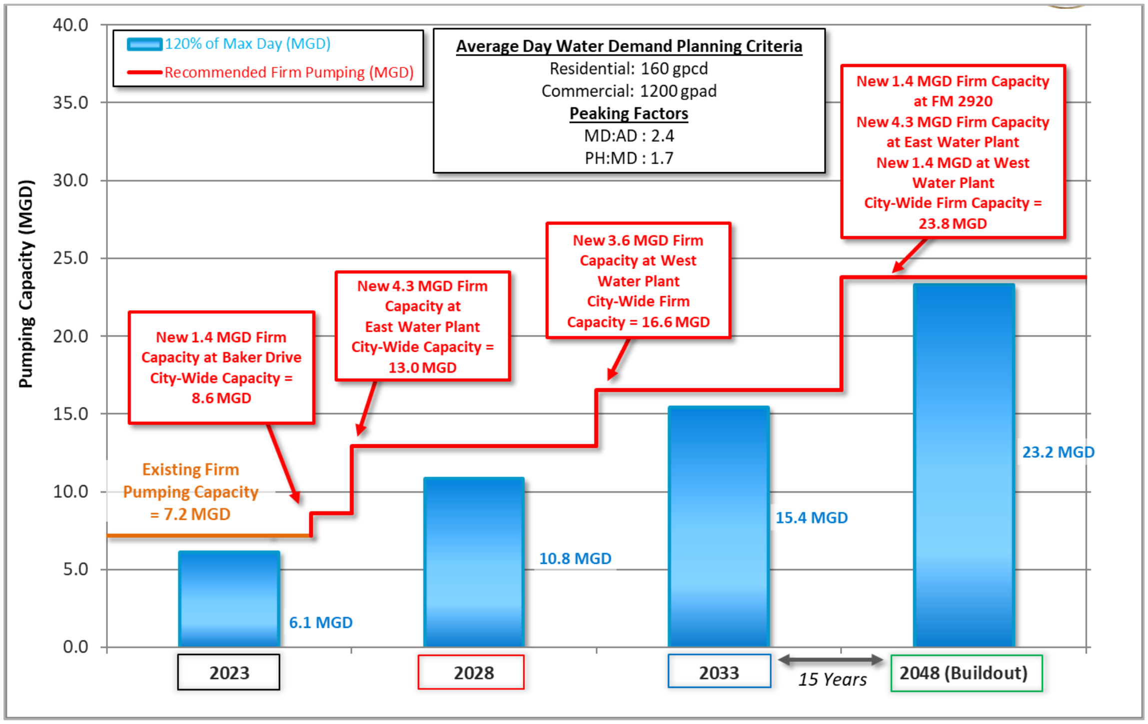
Table 5-4 shows the City's service pumping capacity, FNI's recommended planning criteria of 120% of max day demand, and the recommended pumping capacity for future planning periods. **Figure 5-4** shows the future pumping recommendations.

Table 5-4: Service Pumping Capacity Requirements

Planning Year	Connections(1)	Total Existing Firm Pumping Capacity(2) (MGD)		Planning Criteria of 120% of MD (MGD)	Recommended Pumping (MGD)
2023	6,933	**7.4**	>	6.1	-
2028	11,053	**7.4**	<	10.8	**13.0**
2033	14,926		<	15.4	**16.6**
2048	21,525		<	23.2	**23.8**

(1) Existing connections based on 2021 water meters and apartment unit counts. Projected connections based on 2.6 people/connection and 3 connections per commercial acre.
(2) Based on capacities provided by City.

Figure 5-4: Service Pumping Capacity



5.2.4 Hydraulic Analysis

A 24-hour EPS hydraulic model analysis was performed on the distribution system under maximum day demand conditions. By examining the distribution system under these various operating conditions, it is possible to determine where issues with pressures occur, if tanks are filling or draining properly, and if the service pumping facilities are adequate to meet the required demand at acceptable pressures.

A maximum day EPS model run evaluates the ability of the system to provide adequate supply to meet demands while maintaining levels in storage facilities. During a maximum day EPS analysis, the peak hour demand is also simulated through the use of the diurnal patterns. Peak hour demand represents the single hour of the year with the highest system demand. Peak hour simulations are used to assess the ability of the distribution system to maintain minimum residual pressures. Lower demand periods throughout the day are simulated in EPS modeling as well. This is when the system's ability to replenish storage tanks is evaluated.

Color-coded pressure maps were prepared to illustrate the residual pressure calculated at model junctions. The maps helped identify potential problem areas in the system and were used as a tool to check that reasonable pressure ranges were maintained throughout the system. Maps showing the minimum pressures under maximum day demands can be found in **Appendix F**. Minimum pressures shown on the maps represent the lowest value of the pressures experienced during the 24-hour simulation, usually occurring during the peak hour demand.

High elevation areas near the northwest area of the City are shown to experience low water system pressure. Water lines throughout the downtown area are shown to experience excessive head loss due to undersized water lines, which contribute to low water system pressure. Water system recommendations are discussed further in **Section 6.0**.

5.2.5 Fire Flow Analysis

To evaluate the fire suppression capabilities of the system, a fire flow model analysis was conducted under maximum day demand conditions. TCEQ requires a minimum residual pressure of 20 psi is maintained while delivering the fire flow demand. For this analysis, a steady-state model run was utilized to calculate the available fire flow at each fire hydrant node in the system with a pressure of 20 psi. A fire flow contour map was also prepared to show the available fire flow throughout the distribution system. Areas shown to have an available fire flow less than 1,000 gpm include small lines (less than 6-inches) and dead-end lines. The majority of the City has an available fire flow greater than 1,500 gpm. The fire flow maps for existing system conditions can be found in **Appendix F**.

6.0 WATER SYSTEM CAPITAL IMPROVEMENTS PLAN

A water system capital improvements plan (CIP) was developed for the City of Tomball. The complete water CIP consists of the following components:

- Capacity CIP Projects – documented in ***Section 6.1***
- Facility and Water Line Renewal CIP Projects – documented in ***Section 6.2***

The CIP recommendations are based on the pressure testing data, land use assumptions, demand projections, hydraulic modeling, and system analyses discussed in this report. The recommended capacity projects provide an increased level of water service to existing residential and commercial customers and provide the required capacity to meet the projected water demands through the 25-year planning period. Where applicable, the recommended capacity projects also address existing condition issues in the water system. The facility and water line renewal projects were developed to improve available fire flow and address aging facilities.

6.1 CAPACITY CIP PROJECTS

The recommended 5-, 10-, and 25-year water projects are shown in **Table 6-1** and **Figure 6-1**. The planning level OPCCs in 2023 dollars for each project are included in **Appendix A**. **Table 6-2** lists the **5-year** capacity and rehabilitation CIP (discussed in **Section 6.2**) and includes projects costs in future dollars. Water projects currently under design or construction by the City are not included in the CIP and are shown in **orange** on **Figure 6-1** Projects anticipated to be constructed and paid for by developers are shown in **purple** and timeline pending water line projects are shown in **light blue** on **Figure 6-1.** The water CIP projects are arranged and prioritized by planning period (**5-year**, **10-year**, and **25-year**) based on projected timing of development and the priority of the projects. The projects and planning periods are shown as follows:

- **5-Year Projects**: These are shown **in red** and are recommended to be designed, constructed, and placed into service within the next 5 years (by 2028).
- **10-Year Projects**: These are shown **in blue** and are recommended to be designed, constructed, and placed into service within the next 10 years (by 2033).
- **25-Year Projects**: These are shown **in green** and are recommended to be designed, constructed, and placed into service within the next 25-years (by 2048).

It is recommended that these projects be constructed generally in the order presented; however, development patterns may make it necessary to construct some projects sooner than anticipated. Locations shown for new lines and facilities are generalized for hydraulic analyses. Specific alignments and sites will be determined as part of the design process. Unless otherwise noted, water facility projects assume the required yield can be provided from onsite wells and the OPCCs do not include costs for offsite wells and associated well supply lines. It is recommended to drill test wells to verify available yield. The sections below include the project description and driver for each capacity CIP project.

Table 6-1: Water Capital Improvements Plan Summary

Phase	Project Number	Project Name	Capital Cost[(1)] in 2023 Dollars *(Costs do not include Inflation)*
5-Year	1	16-inch Water Line along Hufsmith Road	$2,353,200
	2	6-Inch Water Line along Clayton St and 12-inch Water Line Along Oak Street	$1,072,000
	3	12-Inch Water Line from Lizzie Lane to FM 2920	$1,130,300
	4	12/16-inch Water Line along Main Street	$4,661,500
	5	12-inch Water Line along Medical Complex Drive	$1,246,100
	6	Water Master Plan & Impact Fee Update	$250,000
		Total 2023 - 2028	**$10,713,100**
10-Year	7	12-inch Telge Water Line	$9,530,700
	8	New West Water Plant Phase 1	$15,157,400
	9	12-inch Water Line along SH 249	$1,028,600
		Total 2029 - 2033	**$25,716,700**
25-Year	10	12-Inch Telge Road and Holderrieth Road Water Line	$5,389,500
	11	FM 2920 Water Plant Pump Station Expansion to add 1,000 gpm Firm Pumping Capacity, 1.5 MG Ground Storage Capacity and 1,600 gpm Supply Capacity	$18,119,900
	12	West Water Plant Expansion to add 1,000 gpm Firm Pumping Capacity, 1.0 MG Ground Storage Capacity, and 500 gpm Water Supply	$11,513,200
	13	16-Inch Parallel Water Line along Ulrich Road	$1,001,700
	14	Replacement 1.5 MG Ulrich EST, Decommissioning of Pine Street EST and new 0.4 MG GST at Pine Street Water Plant.	$10,608,000
	15	East Water Plant Expansion to add 3,000 gpm Pumping, 2.0 MG Ground Storage, and 2,500 gpm Supply Capacity	$22,746,000
	16	12-Inch Water Line along Snook Lane	$2,311,300
		Total 2034 - 2048	**$71,689,600**
Timeline Pending	T1	8-inch Water Line in Corral RV Park	$116,700
	T2	8-inch Water Line along Liberty Lane	$142,100
	T3	8-inch Water Line along Stella Lane	$451,500
	T4	8-inch Water Line along Julia Lane	$403,700
	T5	8-inch Water Line along Helen Lane	$213,800
		Total Timeline Pending Projects Cost	**$1,327,800**
		Total Capacity Wastewater CIP Cost	**$109,447,200**

(1) **Costs are in 2023 dollars and do not include inflation.** Planning level costs were developed for proposed future projects and include construction costs, contingency, and engineering. Additional expenses related to owner's contingency, construction management/inspection, materials testing, and legal fees are not included.

Table 6-2: 5-Year Capacity and Rehabilitation CIP

Project No.	Project Name	Total Cost[1]	Component	FY2024 Cost (2023 Dollars)	FY2025 Cost (2024 Dollars)	FY2026 Cost (2025 Dollars)	FY2027 Cost (2026 Dollars)	FY2028 Cost (2027 Dollars)
					Costs include inflation			
A	East Water Plant	**$19,541,000**	Property Acquisition	$500,000				
			Engineering/Survey	$1,406,000				
			Construction		$9,861,000	$6,574,000		
B	Baker Drive Water Plant	**$10,179,000**	Engineering/Survey	$1,000,000	$200,000			
			Construction	$4,842,000	$3,487,000			
1	16-Inch Water Line along Hufsmith Road	**$2,517,000**	Engineering/Survey	$307,000				
			Construction		$2,210,000			
2	Replacement Clayton and Oak Street Water Line	**$1,147,000**	Engineering/Survey		$140,000			
			Construction		$1,007,000			
3	12-Inch Water Line from Lizzie Lane to FM 2920	**$1,618,000**	Engineering/Survey		$198,000			
			Construction			$1,420,000		
4	12/16-inch Water Line along Main Street	**$5,100,000**	Engineering/Survey		$622,000			
			Construction			$4,478,000		
5	12-inch Water Line along Medical Complex Drive	**$1,673,000**	Easement Acquisition				$101,000	
			Engineering/Survey				$192,000	
			Construction					$1,380,000
	5-Year Water Total	**$41,775,000**		**$8,055,000**	**$17,725,000**	**$12,472,000**	**$293,000**	**$1,380,000**

(1) Costs include prior year expenditures.

Development of Capital Costs

Planning level opinions of probable construction costs (OPCCs) were developed for all recommended improvements in 2023 dollars based on previous similar engineering experience and include allowances for the following:

- **Contingencies:** A 30% contingency was utilized for all future projects. This is the cost assigned to the unknowns in the definition of the project. The contingency is intended to account for construction costs that have not yet been identified due to the project's maturity and should be expected to be fully utilized during construction.

- **Engineering/Survey:** For this study, engineering and survey was set at 20% for projects including facilities and at 15% for line-only projects. The engineering and survey portion of the OPCC accounts for costs projected to be incurred for design, geotechnical, subsurface utility engineering, environmental engineering, and survey tasks during the design of a project.

Costs in 2023 dollars shown on **Table 6-1** do not include financing, inflation, individual service connections, or subdivision lines. Costs for easements and land acquisition are included where specifically noted on the OPCCs. The unit costs utilized for water storage and pumping facilities, as well as for water lines, are shown in **Table 6-3.**

Table 6-3: Water Capital Improvements Plan Unit Costs

Item	Unit	Cost/Unit
Elevated Storage Tank (EST)	Gallon	$4.50
Ground Storage Tank (GST)	Gallon	$1.85
Water Line and Appurtenances	Diam-in/LF	$20.00
New Pump Station - Firm Pumping Capacity	gpd	$1.50
New Groundwater Well	gpd	$1.00
Easement Acquisition	LF	$25.00
Contingency		**Percentage**
All Projects		30%
Engineering & Survey		**Percentage**
Pump Stations and Storage Facilities		20%
Water Lines		15%

FIGURE 6-1
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
WATER CAPITAL IMPROVEMENTS PLAN

6.1.1 Ongoing Wastewater Capital Improvement Projects

The following projects are under design or planned to begin design in 2023. A brief description of planned improvements is provided for each project below:

Project A - Rudolph Road Water Line

This project includes the construction of a new 8-inch water line along Rudolph Road.

Project B - East Water Plant Phase I

This project includes design and construction of a new East Water Plant with a 3,000 gpm pump station, up to 2,000 gpm well, and 1 MG of ground storage.

Project C – Baker Drive Water Plant

This project includes design and construction of improvements at the Baker Drive Water Plant with a 1,000 gpm firm capacity pump station, up to 1,000 gpm well, and 0.5 MG of ground storage.

Project D – South Persimmon Water Line Extension

This project includes construction of a new 12-inch water line along South Persimmon Road from the Medical Complex Drive to Sutton Lane.

Project E – South Persimmon Water Line Extension

This project includes construction of a 12-inch water line along South Persimmon Road from Sutton Lane to Lizzie Lane. This project will replace the existing 6-inch and 8-inch water lines along South Persimmon Road.

Project F – Grand Parkway Elevated Storage Tank

This project includes design and construction of a 1 MG elevated storage tank south of SH 99 Grand Parkway and a 16-inch water line connection to the existing system along Boudreaux Road.

6.1.2 Capacity CIP: Five Year Projects (2023 - 2028)

Project 1 – 16-inch Water Line along Hufsmith Road

Project Description: This project includes the construction of a new 16-inch water line along Hufsmith Road from Ulrich Road to Timber Trails Lake Place.

Project Driver: The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for maintaining the Ulrich Elevated Storage Tank water level and increasing available fire flow. This project will help alleviate areas of low water system pressure in the northwest area of the City.

Project 2 – 6-Inch Water Line along Clayton St and 12-inch Water Line Along Oak Street

Project Description: This project includes the construction of new 6-inch Water Lines to replace the existing 2-inch water lines along Clayton Street and a 12-inch water line to replace the existing 6-inch water line along Oak Street.

Project Driver: The recommended water lines along Clayton Street will replace the existing small diameter line and improve existing system capacity restrictions. The 12-inch water line along Oak Street is sized to serve existing and future peak hourly demand and increase available fire flow.

Project 3 – 12-Inch Water Line from Lizzie Lane to FM 2920

Project Description: This project includes the construction of a 12-inch water line to replace the existing 6-inch water line along South Persimmon St from Medical Complex Dr to FM 2920. The project also includes construction of a 16-inch water line connection from South Persimmon Street to the East Water Plant.

Project Driver: The recommended water lines are sized to convey water from the East Water Plant to the system and future peak hourly demand.

Project 4 – 12/16-inch Water Line along Main Street

Project Description: This project includes the construction of a 12-inch water line to replace the existing 6-inch water line along Main Street from near Persimmon Street to Snook Lane. This project also includes the construction of a 16-inch water line to replace the existing 6-inch water line along Main Street from Oak Street to Snook Lane.

Project Driver: The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for maintaining the Ulrich Elevated Storage Tank water level and increasing available fire flow.

Project 5 – 12-inch Water Line along Medical Complex Drive

Project Description: This project includes the construction of a 12-inch water line along Medical Complex Drive from near South Persimmon St to Mulberry St to coincide with Medical Complex Drive expansion.

Project Driver: The recommended water line will connect the existing 12-inch water lines along Agg Road and is sized to meet future peak hourly demands.

Project 6 – Water Master Plan and Impact Fee Update

Project Description: This project includes an update to the City's Water Master Plan and Impact Fee study.

Project Driver: Texas Local Government Code (TLGC) Chapter 395 requires 5-year updates to the water and wastewater impact fees.

6.1.3 Capacity CIP: Ten Year Projects (2029 - 2033)

Project 7 – 12-inch Telge Water Line

Project Description: This project includes the construction of a 12-inch water line along Telge Road at the western part of the City.

Project Driver: This water line will connect the City's existing water distribution system along FM 2920 with water lines along Boudreaux Road to create a loop and connect the system with the future Telge Water Plan (**Project 8**). This project will help serve peak hour demand in the City's system and future Telge area customers.

Project 8 – New West Water Plant Phase 1

Project Description: This project includes the construction of a new water plant in the southwest of the city limits near Telge Road and SH 99 Grand Parkway intersection with 2,000 gpm water supply, a 2,500 firm capacity pump station and a 0.75 MG ground storage tank.

Project Driver: This new water plant will help meet the future projected demands in the City's water distribution system.

Project 9 – 12-inch Water Line along SH 249

Project Description: This project includes the construction of a 12-inch water line along SH 249 from Humble Road towards Holderreith Road.

Project Driver: The recommended water line will improve connectivity and is sized to serve future peak hourly demand and increase available fire flow.

6.1.4 Capacity CIP: Twenty-Five Year-Projects (Through 2048)

Project 10 – 12-Inch Telge Road and Holderrieth Road Water Line

Project Description: This project includes the construction of a 12-inch water line along Holderreith Road and Humble Road to Telge Road.

Project Driver: The recommended water line will connect the existing system water lines to the proposed future Telge water line (**Project 7**) and is sized to serve future peak hourly demand and increase available fire flow.

Note: The timing of this project should be evaluated based on the timeline for development along Telge Road.

Project 11 – FM 2920 Water Plant Pump Station Expansion to add 1,000 gpm Firm Pumping Capacity, 1.5 MG Ground Storage Capacity and 1,600 gpm Supply Capacity

Project Description: This project includes an expansion of the FM 2920 pump station to 4,000 gpm firm capacity. This project also includes the construction of an additional 1.5 MG ground storage capacity and an additional 1,600 gpm of water supply. This project also includes the construction of a new 16-inch water line parallel to the existing 16-inch.

Project Driver: The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Project 12 – West Water Plant Expansion to add 1,000 gpm Firm Pumping Capacity, 1.0 MG Ground Storage Capacity, and 500 gpm Water Supply

Project Description: This project includes the expansion of the West Water Plant pump station to 3,500 gpm firm capacity. This project also includes the construction of additional 1.0 MG ground storage capacity and additional 500 gpm of supply.

Project Driver: The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Project 13 – 16-Inch Parallel Water Line along Ulrich Road

Project Description: This project includes the construction of a parallel 16-inch water line from the Ulrich Road elevated storage tank to Zion Road.

Project Driver: The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for increasing available fire flow. This project will help alleviate areas of low water system pressure in the northwest area of the City.

Project 14 – Replacement 1.5 MG Ulrich EST, Decommissioning of Pine Street EST and new 0.4 MG GST at Pine Street Water Plant.

Project Description: This project includes the construction of a new 1.5 MG EST at Ulrich Road, demolition of the existing Ulrich Road and Pine Street ESTs, and construction of a new 0.4 MG ground storage tank at Pine Street Water Plant.

Project Driver: The new larger Ulrich Road EST tank is sized to meet the future elevated storage capacity requirements in the city's water system and improve system hydraulics. The new GST at the Pine Street Water Plant will provide additional ground storage at the Pine Street Water Plant.

Project 15 – East Water Plant Expansion to add 3,000 gpm Pumping, 2.0 MG Ground Storage, and 2,500 gpm Supply Capacity

Project Description: This project includes the expansion of the East Water Plant pump station from 3,000 gpm firm capacity to 6,000 gpm firm capacity. This project also includes the construction of one 2.0 MG ground storage tanks and two 1,250 gpm off-site groundwater wells.

Project Driver: The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Project 16 – 12-Inch Water Line along Snook Lane

Project Description: This project includes the construction of a 12-inch water line replacing the existing 6-inch water lines along Snook Lane from Huffsmith Road to Main Street.

Project Driver: The recommended water line is sized to serve future peak hourly demand and improve available fire flow.

6.1.5 Timeline Pending Water Projects

Project T1: 8-inch Water Line in Corral RV Park

Project Description: This project includes the construction of a new 8-inch water line from the 8-inch Corral RV Park water line to the 12-inch water line along Medical Complex Drive.

Project Driver: The recommended water lines are sized to increase available fire flow and serve future peak hourly demand.

Project T2: 8-inch Water Line along Liberty Lane

Project Description: This project includes the construction of an 8-inch water line from the 6-inch water line along Liberty Lane to the 12-inch water line along Hufsmith Road.

Project Driver: The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Project T3: 8-inch Water Line along Stella Lane

Project Description: This project includes the construction of 8-inch water lines along Stella Lane from Camille Drive to Capella Circle.

Project Driver: The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Project T4: 8-inch Water Line along Julia Lane

Project Description: This project includes the construction of 8-inch water lines along Julia Lane from Lost Creek Road to Quinn Road.

Project Driver: The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Project T5: 8-inch Water Line along Helen Lane

Project Description: This project includes the construction of 8-inch water lines along Helen Lane to Spring Hollow Drive.

Project Driver: The water line is recommended to connect existing dead end water lines and increase available fire flow.

6.2 FACILITY AND WATER LINE RENEWAL CIP PROJECTS

6.2.1 Water Line Renewal Program

Approximately 14% of Tomball's distribution system water lines are 4-inches or smaller in diameter. These lines limit distribution system pressures and fire flows in the existing water system. It is recommended to conduct a water line renewal program to systematically replace these small diameter lines with 8-inch lines, improving system pressures and available fire flows.

The recommended water line renewal CIP includes ten projects that were identified based on geographic area and a target annual budget of approximately $3.0 million. Small diameter dead-end water lines serving only neighborhood streets were excluded from the water line renewal program, as well as lines that are recommended to be upsized as part of the capacity CIP projects (discussed in **Section 6.1**). **Figure 6-2** illustrates the water line renewal projects, and **Table 6-4** lists the planning level costs in 2023 dollars for the water line renewal. City staff noted that some of the small diameter water lines in the renewal project areas may have been previously abandoned. It is recommended that the City verify that the water lines within each renewal area are currently active during the preliminary engineering phase of each project.

Table 6-4: Water Line Renewal Plan Summary

Project Number	Project Name	Linear Footage	Cost(1) (2023 Dollars)
R1	Renewal Area R1	7,600	$ 2,828,900
R2	Renewal Area R2	7,200	$ 2,688,400
R3	Renewal Area R3	8,800	$ 3,267,500
R4	Renewal Area R4	8,000	$ 2,947,000
R5	Renewal Area R5	7,900	$ 2,923,100
R6	Renewal Area R6	7,500	$ 2,782,600
R7	Renewal Area R7	7,700	$ 2,852,900
R8	Renewal Area R8	7,400	$ 2,758,700
R9	Renewal Area R9	7,700	$ 2,852,900
R10	Renewal Area R10	7,600	$ 2,828,900

(1) Includes 30% contingency and 15% engineering/survey.

6.2.2 Facility Renewal Projects

This study focused on capacity assessment of the water system and did not include a condition assessment of the City's water facilities. However, based on the age of the facilities, it is recommended to budget for a condition assessment and facility rehabilitation of the Ulrich EST, the Pine Street Water Plant, and the FM 2920 Water Plant. A condition assessment should be conducted at each facility to inform the needed upgrades, develop rehab costs, and identify any critical components that should be addressed prior to the full facility rehab. Budgetary costs in 2023 dollars for the condition assessment and facility rehabilitation projects are included in **Table 6-5.**

Table 6-5: Water Facility Renewal Budgetary Costs

Facility	Project Name	Cost (2023 Dollars)		
		10-Year Planning Period	Buildout Planning Period	Total
Ulrich EST	Condition Assessment	$25,000		**$1,132,000**
	Facility Rehabilitation(1)	$1,107,000		
Pine Street Water Plant	Condition Assessment	$50,000		**$1,979,000**
	Facility Rehabilitation(1)	$1,929,000		
FM 2920 Water Plant	Condition Assessment		$50,000	**$1,484,000**
	Facility Rehabilitation(1)		$1,434,000	

(1) The facility rehabilitation costs are included for initial budgeting purposes. These costs should be updated based on the results of the facility condition assessments. Costs include 30% contingency and 20% engineering.

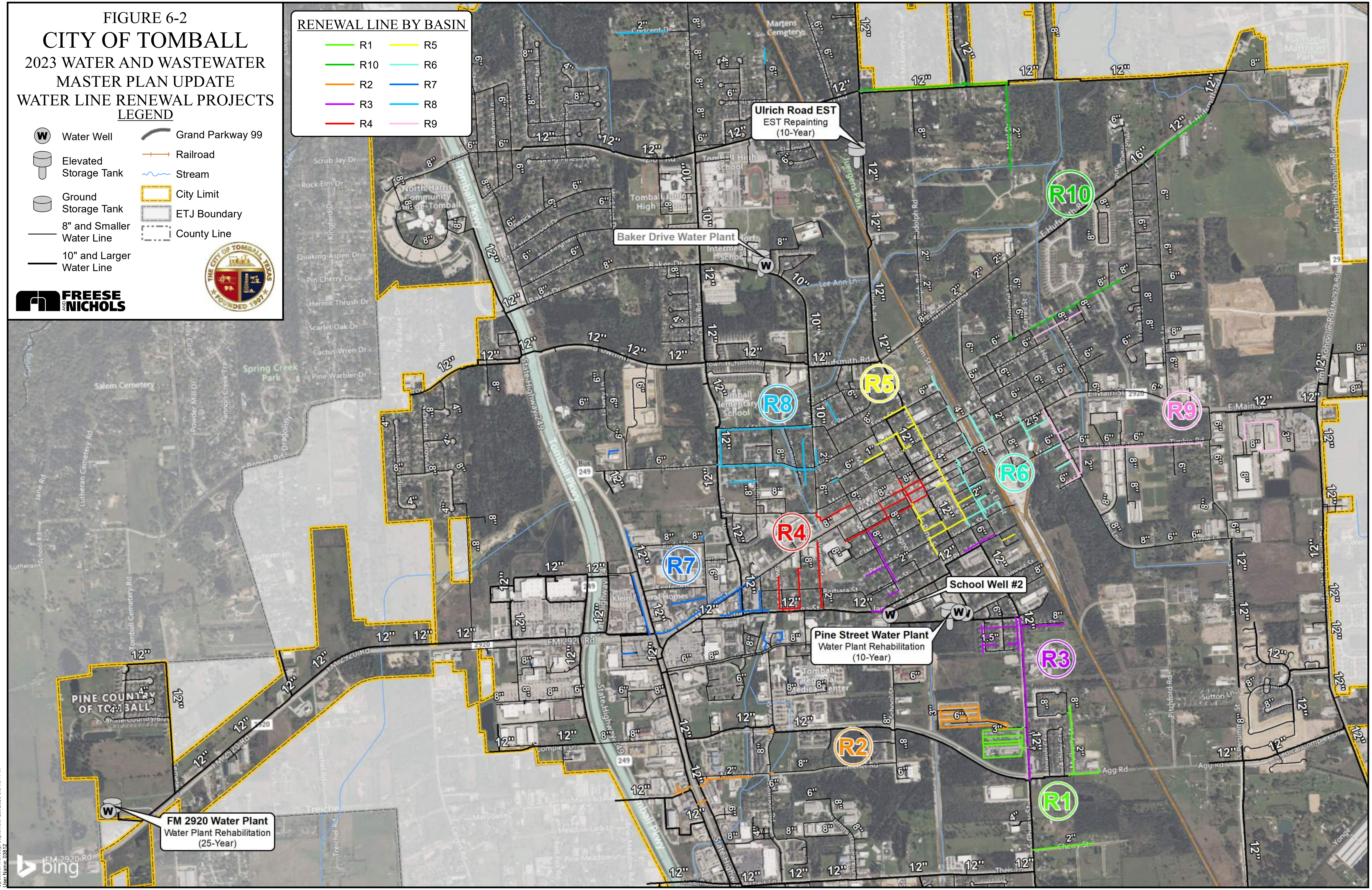


FIGURE 6-2
CITY OF TOMBALL
2023 WATER AND WASTEWATER
MASTER PLAN UPDATE
WATER LINE RENEWAL PROJECTS
LEGEND
Water Well
Elevated Storage Tank
Ground Storage Tank
8" and Smaller Water Line
10" and Larger Water Line
Grand Parkway 99
Railroad
Stream
City Limit
ETJ Boundary
County Line
FREESE AND NICHOLS
THE CITY OF TOMBALL TEXAS
FOUNDED 1907
RENEWAL LINE BY BASIN
R1
R10
R2
R3
R4
R5
R6
R7
R8
R9
Ulrich Road EST
EST Repainting
(10-Year)
Baker Drive Water Plant
School Well #2
Pine Street Water Plant
Water Plant Rehabilitation
(10-Year)
FM 2920 Water Plant
Water Plant Rehabilitation
(25-Year)
Tomball High School
Tomball Junior High School
North Harris Community College-Tomball
Spring Creek Park
Salem Cemetery
Martens Cemetery
Samuel Matthews Park
Pine Country of Tomball
Tomball Regional Medical Center
Tomball Elementary School
State Highway 249
Tomball Pkwy
FM 2920 Rd
E Main St
Agg Rd
Cherry St
bing

7.0 EXISTING WASTEWATER SYSTEM

Tomball's wastewater collection system includes two wastewater treatment plants (WWTPs), approximately 87 miles of gravity wastewater lines ranging from 2-inches to 36-inches in diameter, 12 city-owned and operated lift stations, two influent lift stations at the South WWTP, one influent lift station at the North WWTP, and 21 private lift stations. The sections below discuss the existing wastewater system in additional detail. **Table 7-1** shows the wastewater collection system infrastructure.

7.1 WASTEWATER TREATMENT PLANT FACILITIES AND SERVICE AREAS

Tomball owns and operates the following two WWTPs:

- North Wastewater Treatment Plant
- South Wastewater Treatment Plant

Table 7-1 summarizes the permitted capacities of each treatment facility.

Table 7-1: Wastewater Treatment Plant Information

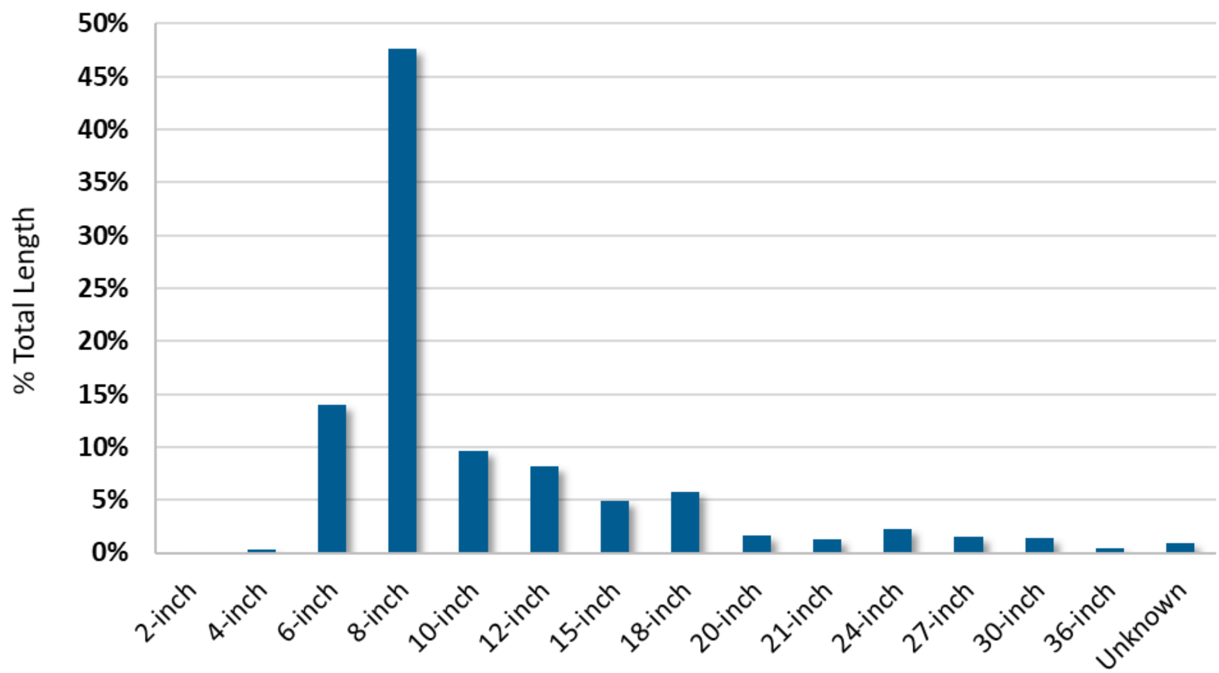
WWTP Name TPDES Permit No.	Permitted Capacities			
	Average Day Flow (MGD)	Peak Flow (MGD)	Peaking Factor	Outfall
North WWTP WQ0010616001	1.5	4.5	3	HCFCD ditch J231-00-00, thence to Bogs Gully, thence to Spring Creek
South WWTP WQ0010616002	1.5	6.0	4	HCFCD ditch M121-00-00, thence to Willow Creek, thence to Spring Creek

FIGURE 7-1
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
EXISITNG WASTEWATER SYSTEM

7.2 GRAVITY LINES

According to the City's water system GIS updated as part of the *2023 Utility GIS Update* project, Tomball's existing wastewater system includes approximately 87 miles of gravity collection lines. Pipeline diameters range in size from 2-inches to 36-inches. **Figure 7-2** illustrates the percentage of pipe length by diameter.

Figure 7-2: Gravity Line Length by Diameter



7.3 LIFT STATIONS AND FORCE MAINS

As of August 2023, the City owns and maintains 12 lift stations located throughout both WWTP service areas. These public lift stations have approximately 6 miles of associated force mains, with diameters ranging from 2-inches to 8-inches. The total number of public lift stations per service area is as follows:

- North WWTP Service Area: 11 lift stations
- South WWTP Service Area: 1 lift stations

Lift Station Inventory and Schematic

During the City's *2018 Wastewater Master Plan*, FNI assembled a lift station inventory and schematic. The lift station inventory included information about the pumping capacities, wet well geometry, influent lines, and other available information for each of the City's lift stations. During the current project, FNI updated the wastewater lift station inventory based on updated pump information and construction drawings for newly constructed lift stations. The updated lift station inventory is included in **Table 7-2.** Additionally, the schematic of the City's lift stations was updated based on the wastewater GIS network and information provided during discussions with City staff. The lift station schematic shows the WWTP service areas, relative lift station hierarchy, and firm pumping capacity of each lift station and is illustrated on **Figure 7-3**.

City of Tomball

2023 Water and Wastewater Master Plan Update

Table 7-2: Existing Lift Station Inventory

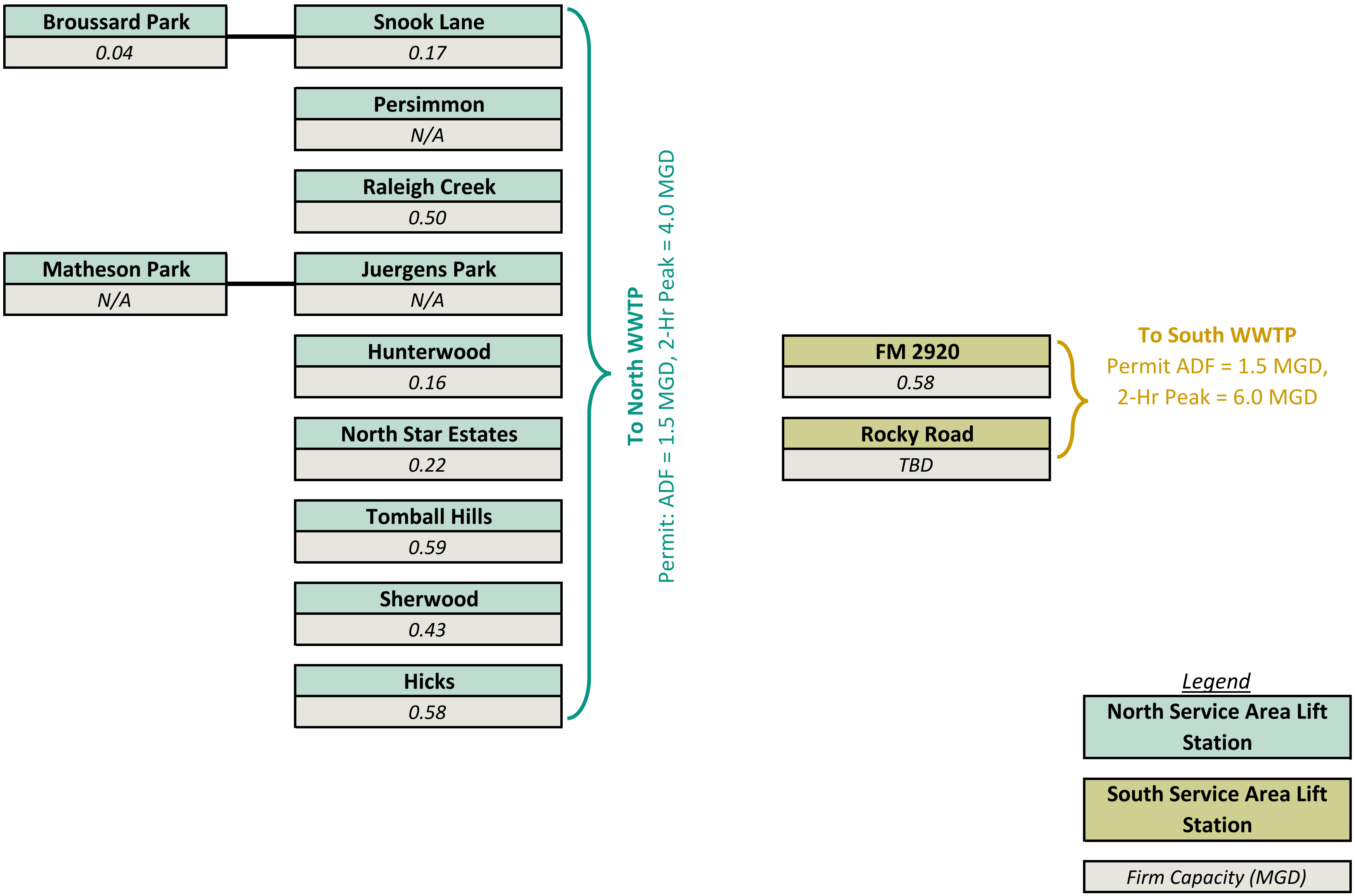
Lift Station No.	Lift Station Name	Address	Wet Well					Force Main		Pump							
			Diameter (ft)	Ground Elevation (MSL)	Bottom of Wet Well (MSL)	Influent Pipe Diameter (in)	Influent Pipe Flowline(s) (MSL)	Force Main Diameter (in)	Force Main Length (ft)	Number of Pumps	Model/ Manufacturer/ Serial	Firm Capacity (gpm)	Horse Power	TDH (ft)	1st Pump ON level (MSL)	2nd Pump ON level (MSL)	Pump OFF level (MSL)
1	North Star Estates	31530 Capella Circle	8 x 8	164.67	144.67	8	158.34	8	5480	2	Flygt 3140.180-0628	150	15	-	153	155	151
2	Sherwood Forest	30203 Wickford Dr.	4	210.32	191.65	6 / 12 / 10	195.61 (N) / 203.32 (S)	6	480	2	Flygt 3102 Hydromatic Pump Serial 16503 Model 40 MMP Imp Dia: 7.5"	300	5	-	203.5	204.5	203
3	Hunterwood	13406 Julia Lane	6	181.87	164	8	168.5	4	4610	2	Flygt NP 3127 HT-3 - Adaptive 489	112	7.5	63	167	167.5	165
4	Snook Lane	1035 E. Hufsmith Rd.	5	172	152.25	8	168.17 (N) / 167.17 (S)	4	580	2	Flygt 3085.120-830362	115	2	-	174	194	141
5	Tomball Hills	28106 Chris Lane	8	168.5	141.5	15	145.3	6	4670	2	Flygt Model Np 3171.185 Submersible	410	35	140	144.63	145.3	143
6	Persimmon	303 S.Persimmon	4	179.2	158.8	6 / 8 / 8	6" (NE) 167.25 8" (S) 163.16 8" (E) 163.15	4	120	2	NP3085 Flygt 3085.181-4345	-	3	-	164	170	161.25
7	Juergens Park	Ulrich Rd. at Jergens Park	3	-	-	6	-	2	660	2	Myers 7200 - 0175 H4HN	-	2	-	-	-	-
8	Matheson Park	Ulrich Rd. at Matheson Park	4	-	-	8	-	4	2550	2	Myers 4V50M4-21	-	5	-	-	-	-
9	FM 2920	15303 FM 2920	6	173.93	153.93	12	158.305-W / 159.013-E	8	7950	2	Flygt 3140.090-6068	400	15	77	194	205	179
10	Hicks	1519 Hicks St.	8	181	157.1	8	163.88	8	1470	2	Flygt NP3127 LT 3-422	400	7.5	36	161.1	162.1	158.1
11	Raleigh Creek	30615 Raleigh Creek Dr.	8	170	138	12	142	6	185	2	EBARA Submersible Pumps Model 100DLMFU63.7	350	5	30	145	155	142
12	Broussard Park	1414 E Hufsmith	5	178.37	158.14	8	160	2	2,891	2	-	30	5	111	160	161	162
13	Rocky Road	*Lift Station Under Design*															

Data Sources	
As-Built Data	GIS Data
Information From City	Estimate from Pump Vendor Curves
Contour Data	
Field Survey Data	Model Assumption

City of Tomball

2023 Water and Wastewater Master Plan Update

Figure 7-3: Lift Station Schematic



8.0 WASTEWATER FLOW MONITORING

FNI conducted city-wide flow monitoring and rainfall data collection as part of this project. The flow monitoring and rainfall data were utilized to characterize dry weather and wet weather wastewater flows at key points within the collection system and to calibrate the hydraulic model. The flow and rainfall data was also utilized to quantify inflow and infiltration (I/I) throughout the collection system and prioritize flow meter basins for future sanitary sewer evaluation study (SSES) projects, discussed further in **Section 12.** The sections below summarize the field collected flow and rainfall data, as well as the characterization of I/I levels within the City's collection system.

8.1 FIELD DATA COLLECTION

Dry weather and wet weather system responses within the City's two WWTP service areas were evaluate by installing flow meters to observe and document existing flow conditions. Rainfall data was also collected using rain gauges. A total of ten (10) flow meters and two (2) rain gauges were used for this study throughout the City's wastewater collection system. ADS Environmental Services, Inc. (ADS) was retained by FNI to install and maintain the flow monitors and rain gauges and provide an evaluation of the flow meter and rainfall data. The field data collection period began on November 18, 2022 and continued through January 19, 2023, for a total duration of 62 days.

8.1.1 Flow Meter and Rain Gauge Placement

The flow meter locations were chosen in coordination with the City to support the goal of developing capacity and renewal CIPs for this project. These locations generally matched those utilized during the City's *2017 Wastewater Master Plan* with updated locations due to existing system hydraulics and to capture flows directly upstream of the WWTPs. Consideration was also given to areas of the wastewater system with known or suspected I/I issues and proximity to lift stations. The rain gauges were installed in each WWTP service areas to capture rainfall during the field testing period.

The flow meter installation locations and corresponding gravity line diameters and GIS manhole IDs are provided in **Table 8-1.** The rain gauge installation locations are provided in **Table 8-2.** All flow monitoring and rain gauge locations are shown on **Figure 8-1**. Flow meter and rain gauge site installation reports with more detailed location information are provided in the *Sewer System Performance Report* (by ADS) located in **Appendix G.** A flow meter schematic organized by WRF Service Area is shown on **Figure 8-2**.

Table 8-1: Flow Meter Locations

WWTP Basin	Flow Meter ID	Pipe Inner Diameter[1] (in)	Address/Location	GIS Manhole ID
North	N-01	9.3	1107 Bending Trail Drive	MH_567
	N-02	20.5	723 Hospital Street	MH_602
	N-03	36.0	540 East Hufsmith Road	MH_606
	N-04	20.0	1330 Neal Drive	MH_251
	N-05	12.0	Across 29230 Tomball Pkwy	MH_200
South	S-01	29.0	Along Holderrieth Road west of South Cherry Street	MH_741
	S-02	23.0	On South Cherry Street near Hometowne at Tomball	MH_97
	S-03	26.3	11807 Holderrieth Road	MH_39
	S-04	16.8	North of 12806 Spruce Circle	MH_885
	S-05	13.8	Behind 501 James Street	MH_447

(1) Diameters from *Sewer System Performance Report* by ADS (Appendix G) measured during installation of flow meters.

Table 8-2: Rain Gauge Locations

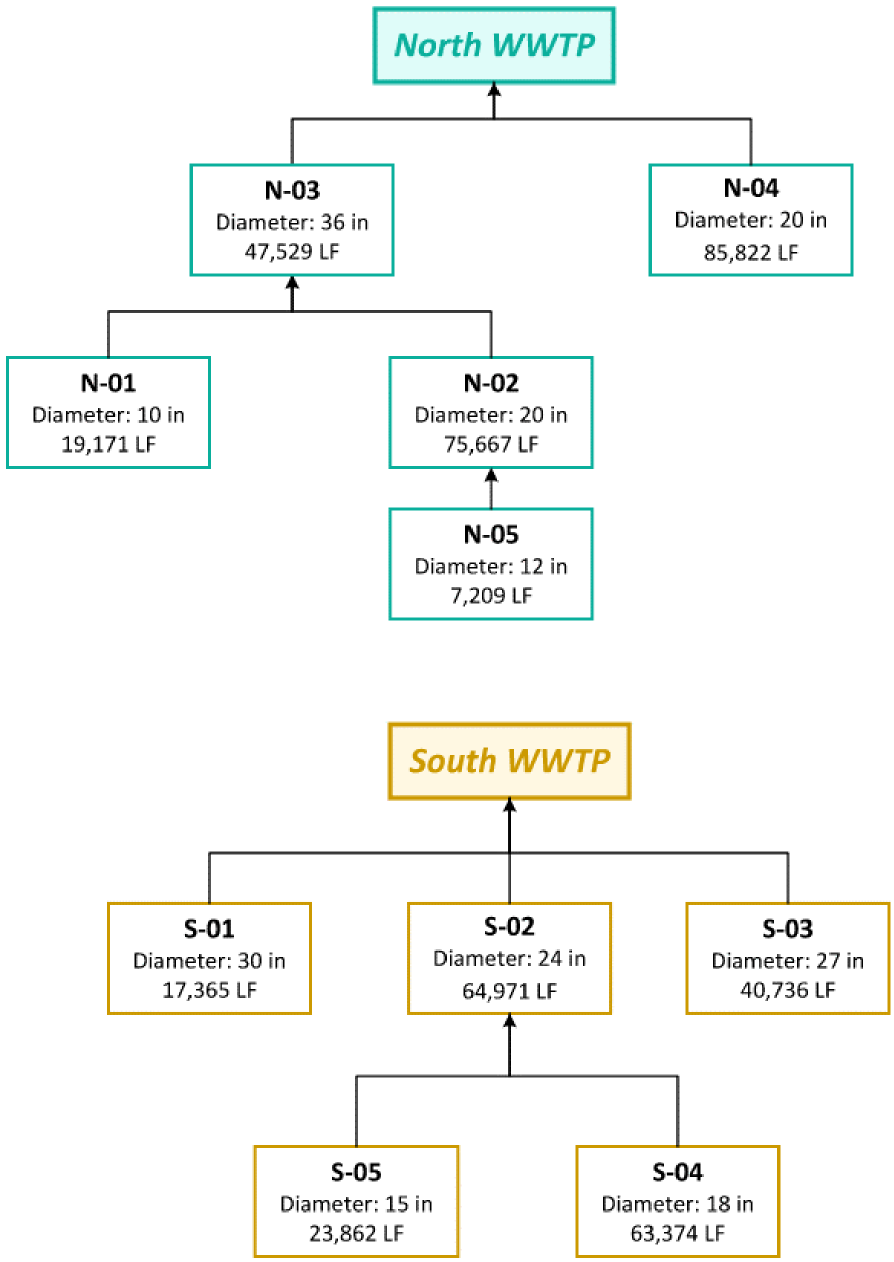
WWTP Basin	Rain Gauge ID	Address/Location	Installed Facility
North	RG-01	West of 15215 Farm to Market 2920	North WWTP
South	RG-02	South of 12618 Holderreith Rd	South WWTP

8.1.2 Flow Meter Basins

FNI utilized the City's wastewater geographic information system (GIS) database and the flow meter locations to delineate 10 flow meter basins. These basins represent the portion of the collection system upstream of each flow meter and were utilized for wastewater flow projections, hydraulic model calibration, and system wide I/I analysis. **Figure 8-1** shows the 10 flow meter locations and their associated flow meter basins.

FIGURE 8-1
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
FLOW METER AND RAIN GAUGE LOCATIONS

Figure 8-2: Flow meter Schematic



8.1.3 Flow Meter and Rain Gauge Data

Flow monitoring and rain gauge data were collected in 5-minute time step intervals. Hydrographs and flow depth plots for each flow meter site are provided in **Appendix H**. The hydrographs display flow rate data vs. time for the duration of the field testing period, along with the observed rainfall intensities. Similarly, the depth plots show the depth of flow vs. time.

8.1.4 Flow Meter and Rain Gauge Equipment

Wastewater flow monitoring was performed utilizing Triton+® flow meters manufactured, installed, and maintained by ADS. Flow meters were mounted near the top of each manhole and were connected to depth and velocity sensors positioned in the incoming wastewater pipe. Each flow meter was equipped with an ultrasonic depth sensor and a velocity sensor. A pressure depth sensor was also mounted at or near the invert to measure water depths during surcharge events. Rainfall during the study period was captured using ADS RainAlert III rainfall monitors and tipping buckets. **Figure 8-3** shows an ADS Triton+ flow meter and RainAlert III rainfall monitor.

Figure 8-3: ADS Flow Monitor and Rain Gauge Equipment

8.2 FLOW METER AND RAIN GAUGE DATA EVALUATION

FNI reviewed and evaluated the flow meter and rain gauge data collected during the field testing period. The following sections discuss the evaluation of the observed dry weather flow, wet weather flow, and rainfall data.

8.2.1 Rain Gauge Data Evaluation

A total of five (5) rainfall events were observed during the flow monitoring period and utilized during the inflow and infiltration evaluation. This rainfall data and associated flow responses were utilized to calibrate the hydraulic model to the observed wet weather conditions. Total rainfall depths and durations for the observed rainfall events during the field-testing period are shown in **Table 8-3**. The observed 5-minute rainfall intensities are plotted along with the flow meter data on the hydrographs in **Appendix H**.

Table 8-3: Observed Rainfall Events During Flow Monitoring

Rain Event Date	Duration (hours)	Total Rainfall(1) (in)
11/24/2022	12	0.55
11/25/2022	12	1.26
12/10/22	6	2.38
12/29/2022	1	0.87
1/7/2023	6	1.25

(1) Total rainfall based on the average of data collected by the two rain gauges.

8.2.2 Flow Meter Data Evaluation

Flow Rates and Peaking Factors

The average dry weather and peak wet weather flow rates observed at each flow meter site are provided in **Table 8-4.** Dry weather flow conditions are characterized by evaluating flow meter data during normal and repeatable conditions, excluding wet weather events and the periods associated with the recovery from these events. The wet weather to dry weather peaking factors is also provided in **Table 8-4**. Wet weather peaking factors greater than 4 are generally considered to be high and are highlighted in **red** in **Table 8-4.**

Table 8-4: Dry Weather and Wet Weather Flow Data

Flow Meter ID	Average Dry Weather Flow (MGD)	Peak Wet Weather Flow (MGD)	Wet Weather Peaking Factor Peak Wet Flow / Average Dry Flow
N-01	0.03	0.51	17.0
N-02	0.40	2.16	5.4
N-03	0.53	2.99	5.6
N-04	0.35	2.70	7.7
N-05	0.26	0.66	2.5
S-01	0.07	0.40	5.7
S-02	0.70	3.17	4.5
S-03	0.20	0.78	3.9
S-04	0.38	1.22	3.2
S-05	0.10	0.44	4.4

Dry Weather Depths (d/D)

The American Society of Civil Engineers (ASCE) and the Water Environment Federation (WEF) recommend that sewers with diameters up to 15 inches be designed to flow with dry weather d/D ratios of ≤ 0.5, and sewers with diameters 18 inches and larger be designed to flow with dry weather d/D ratios of ≤ 0.75. The dry weather d/D ratios for all flow meter locations meet the recommended criteria. This indicates adequate capacity in the system to convey dry weather flows.

Wet Weather Depths (d/D)

Wet weather d/D ratios should not exceed 1.0, as this indicates surcharging in the collection system. **Five sites recorded wet weather d/D ratios greater than 1.0, indicating insufficient capacity to convey the observed maximum wet weather flows**. These ratios are **highlighted brown** in **Table 8-5**.

Surcharge Height and Depth from Rim

The last two columns in **Table 8-5** show the maximum **surcharge height** above the top of the gravity pipe, as well as the resulting **depth** from the rim (top) of the manhole. Six (6) of the meter sites indicated a surcharge above the top of the gravity pipe during the flow monitoring period. The water level did not rise to within three feet of the manhole rim at any of the ten locations, indicating lower risk of potential sanitary sewer overflows.

Table 8-5: Flow Depths and Surcharging Summary

Flow Meter ID	Pipe Inner Diameter(1) (in)	Manhole Depth(1) (ft)	Dry Weather		Wet Weather		Surcharge Height Water Level Above Pipe (ft)	Depth Water Level from MH Rim (ft)
			Max Flow depth (in)	depth/ Diameter d/D	Max Flow depth (in)	depth/ Diameter d/D		
N-01	9.3	9.8	2.2	0.24	17.7	1.9	0.7	8.3
N-02	20.5	9.8	3.8	0.19	21.8	1.1	0.1	8.0
N-03	36.0	18.9	5.5	0.15	131.0	3.6	7.9	8.0
N-04	20.0	14.0	4	0.20	110.0	5.5	7.5	4.8
N-05	12.0	14	2.1	0.18	2.8	0.2	-	13.6
S-01	29.0	10	2.7	0.09	4.6	0.2	-	9.5
S-02	23.0	13.8	8.8	0.38	18.1	0.8	-	12.2
S-03	26.3	23.6	2.5	0.10	64.5	2.5	3.2	18.2
S-04	16.8	9.9	5.5	0.33	8.0	0.5	-	9.2
S-05	13.8	9.9	2.9	0.21	4.7	0.3	-	9.5

(1) Field measured diameters and manhole depths measured during flow monitor installations. Source: *Sewer System Performance Report* by ADS (Appendix G)

8.2.3 Infiltration and Inflow Analysis

A wet weather analysis was performed to calculate the rate of inflow and infiltration (I/I) observed in each flow meter basin. This I/I analysis is utilized to indicate whether future sanitary sewer evaluation study (SSES) projects are needed for I/I reduction efforts.

Discrete I/I generated within each of the flow meter basins was calculated by subtracting I/I from any upstream flow meter basins. These discrete I/I volumes were then normalized based on the linear footage of gravity sewer lines within each meter basin and the rainfall from each rainfall event.

The results of the analyses are shown below. **Table 8-6** shows the volume (in millions of gallons) of I/I generated within each flow meter basin during each rainfall event. **Table 8-7** show the normalized I/I generated within each flow meter basin during each rainfall event. The results are shown in gallons of I/I per linear foot of sewer line per inch of rainfall (Gal/LF/in).

Table 8-6: Million Gallons (MG) of I/I per Rainfall Event

Flow Meter Basin	Linear Footage of Gravity Lines	November 24, 2022	November 25, 2022	December 10, 2022	December 29, 2022	January 7, 2023
N-01	19,171	0.03	0.11	0.14	0.11	0.15
N-02	75,667	0.04	0.18	0.25	0.1	0.12
N-03	47,529	0.18	0.3	0.51	0.46	0.41
N-04	85,822	0.05	0.18	0.35	0.08	0.21
N-05	7,209	0	0.09	0.14	0.03	0.08
S-01	17,365	0.01	0.05	0.06	0.04	0.04
S-02	64,971	0.15	--	0.71	0.23	0.2
S-03	40,736	0.02	0.35	0.15	0.15	0.28
S-04	63,374	--	0.17	0.19	0.09	0.09
S-05	23,862	0.05	0.12	--	--	--

Table 8-7: Normalized I/I (Gal/LF/in) per Rainfall Event

Flow Meter Basin	Linear Footage of Gravity Lines	November 24, 2022	November 25, 2022	December 10, 2022	December 29, 2022	January 7, 2023	Average I/I (Gal/LF/in)
N-01	19,171	3.45	4.96	2.87	7.35	6.56	5.0
N-02	75,667	1.43	2.09	1.32	1.59	1.39	1.6
N-03	47,529	9.43	5.59	4.41	12.18	7.52	7.8
N-04	85,822	1.49	1.88	1.67	1.2	2.14	1.7
N-05	7,209	0.99	11.22	7.93	6.01	9.97	7.2
S-01	17,365	1.2	2	1.59	2.48	1.67	1.8
S-02	64,971	3.42	--	4.77	3.78	2.31	3.6
S-03	40,736	0.84	6.04	1.61	3.89	5.14	3.5
S-04	63,374	--	1.85	1.27	1.52	1	1.4
S-05	23,862	3.03	3.53	--	--	--	3.3

8.2.4 Inflow and Infiltration (I/I) Summary

The flow meter basins were categorized into **High**, **Moderate**, or **Low** I/I and ranked from 1 (Highest) to 10 (Lowest). The categories are based on the rate of I/I as gallons per linear foot per inch of rainfall (Gal/LF/in) calculated within each basin. **Table 8-8** shows the categories of I/I.

Table 8-8: Categories of I/I

I/I (Gal/LF/in)	Description
I/I Greater than 4.0	High I/I
I/I between 2.0 – 3.9	Moderate I/I
I/I less than 2.0	Low I/I

Ranking of the 10 flow meter basins based on calculated normalized I/I is shown in **Table 8-9**.

Table 8-9: Flow Meter Basin Ranking by Normalized I/I

Basin	Linear Footage of Gravity Lines	Average Volume of I/I (MG)	Average I/I (Gal/LF/in)	Basin Ranking by I/I
N-03	47,529	0.37	7.8	1
N-05	7,209	0.07	7.2	2
N-01	19,171	0.11	5.0	3
S-02	64,971	0.32	3.6	4
S-03	40,736	0.19	3.5	5
S-05	23,862	0.09	3.3	6
S-01	17,365	0.04	1.8	7
N-04	85,822	0.17	1.7	8
N-02	75,667	0.14	1.6	9
S-04	63,374	0.14	1.4	10

In summary, the meter basin I/I ranking results are:

- 3 basins with **high** levels of I/I
- 3 basins with **moderate** levels of I/I
- 4 basin with a **low** level of I/I

This basin I/I ranking was utilized in the development of the updated SSES Program recommendations, discussed in **Section 12.**

Figure 8-4: Plot of Normalized I/I by Flow Meter Basin (Gal/LF/in)

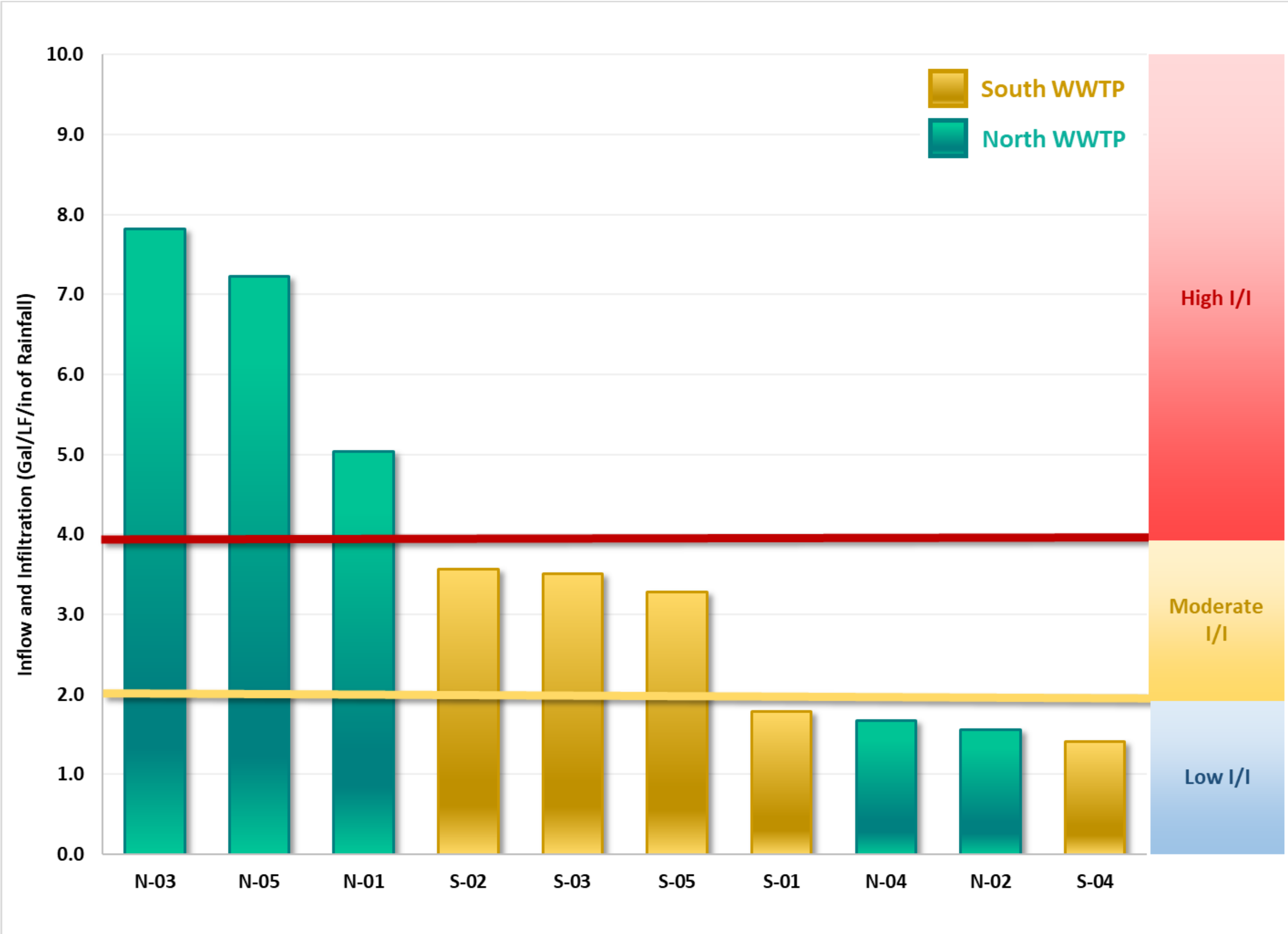


FIGURE 8-5
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
NORMALIZED I/I BY FLOW METER BASIN (GAL/LF/IN)

9.0 WASTEWATER FLOW PROJECTIONS

Planning for future wastewater infrastructure is dependent on the amount of average day and peak wastewater flow that must be collected, conveyed, and treated. Wastewater treatment plants are sized based on average day flows, while the collection system infrastructure, including lift stations, is sized to convey peak wastewater flows. During this project, FNI developed planning criteria for residential and commercial wastewater flows and projected average day and peak wastewater flows for the existing, **5-year**, **10-year**, and **25-year** planning periods based on the land use assumptions discussed in **Section 2.0**. These flows were utilized in the hydraulic modeling and system planning to develop future wastewater treatment and collection system improvements.

9.1 HISTORICAL WASTEWATER FLOWS

Reviewing historical wastewater flows provides insight into selecting design criteria used to project future wastewater flows. The City provided average day effluent flow data from 2017 through 2022 for the **North** and **South** WWTPs, as summarized in **Table 9-1.** Historical annual average wastewater flows from 2017 to 2022 are graphed against the current TCEQ permitted capacity for the **North** and **South** WWTPs on **Figure 9-1** and **Figure 9-2**, respectively.

FNI utilized the City's pumped and sold water database to attribute percentages of total WWTP effluent flow to residential and commercial sources. The City's population and commercial acreage was then utilized to calculate historical wastewater flows per person (gpcd) and per commercial acre (gpad). This breakdown of historical WWTP flows, populations, commercial acreages, and the resulting gpcd and gpad values are shown in **Table 9-2**.

Table 9-1: Historical WRF Effluent Flows

Year	Annual Average Day Effluent Flow(1) (MGD)		
	North WWTP	South WWTP	Total
2017	0.58	1.00	1.58
2018	0.70	0.98	1.68
2019	0.62	0.94	1.55
2020	0.54	0.76	1.31
2021	0.67	0.91	1.58
2022	0.60	0.84	1.44
Average	**0.62**	**0.91**	**1.52**
Maximum	**0.7**	**1.0**	**1.7**

(1) Annual average day effluent flow based on data received from City.

Figure 9-1: North WWTP Historical Annual Average Wastewater Flow

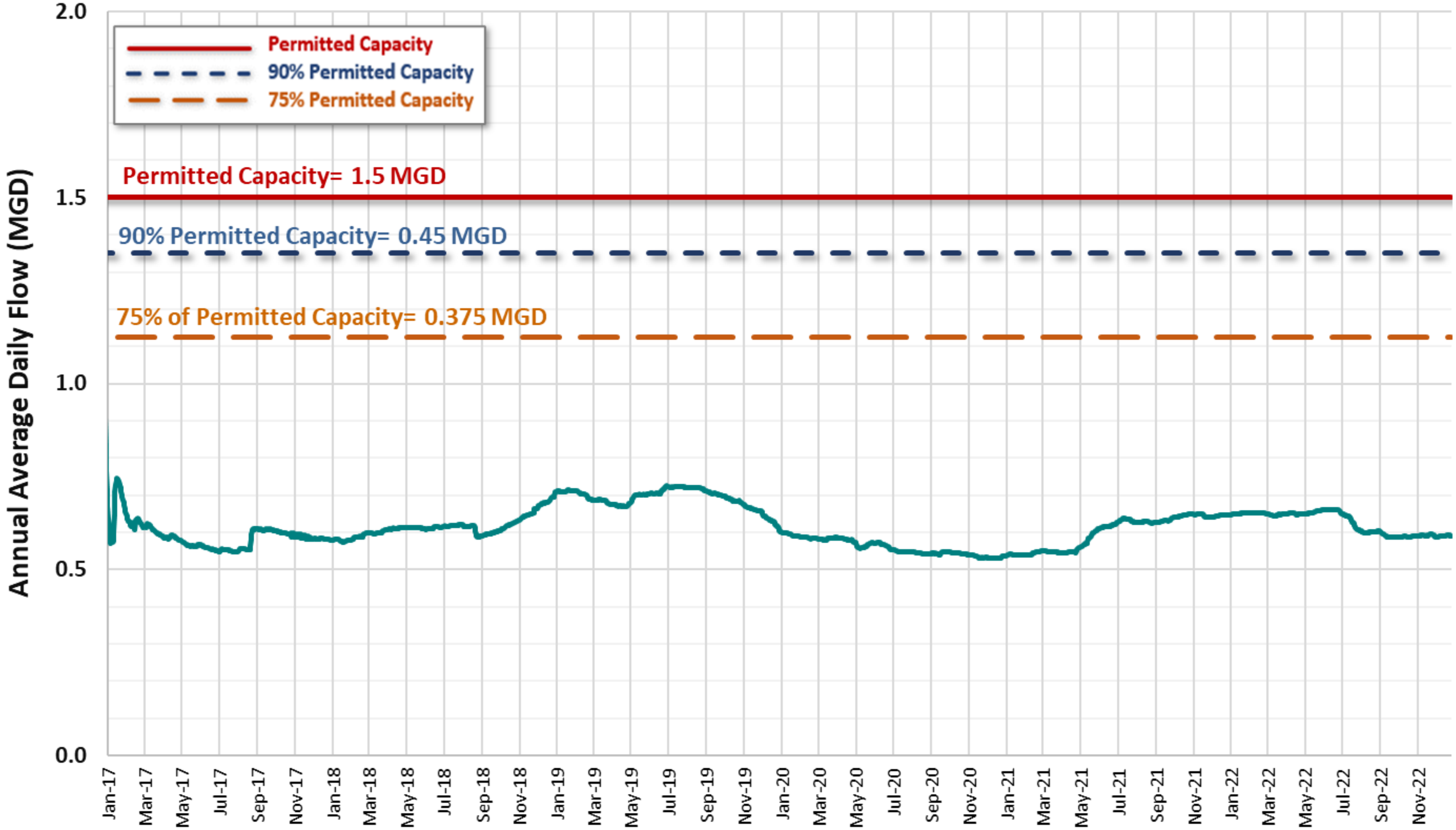


Figure 9-2: South WWTP Historical Annual Average Wastewater Flow

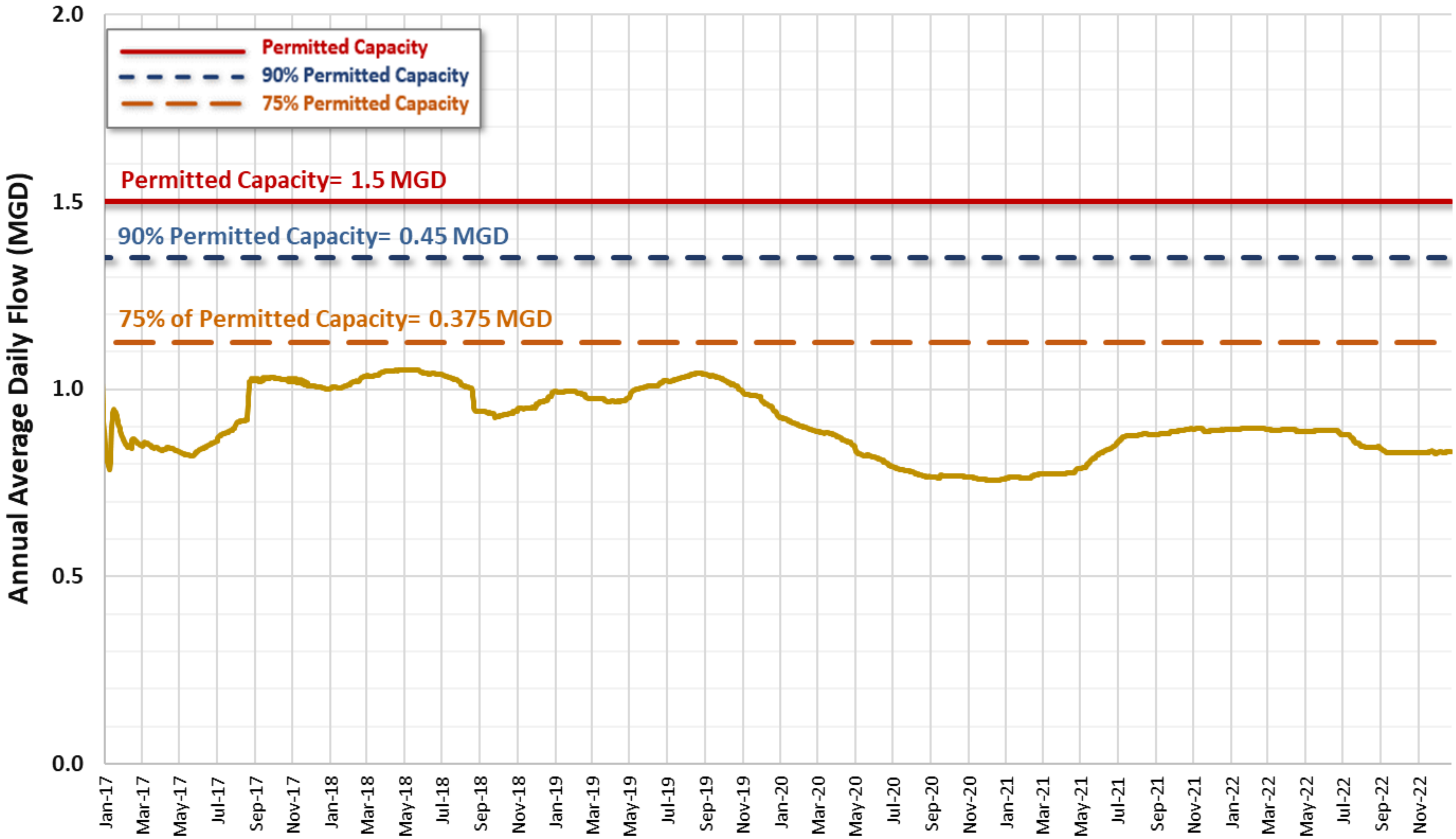


Table 9-2: Wastewater Planning Criteria Analysis

Year	City Population(1)	Total Wastewater Effluent(2) (MGD)	Residential			Commercial Flow %			Other(4) (MGD)
			Residential Flow %(3)	Residential WW Flow (MGD)	Per Capita WW Flow (gpcd)	Commercial Flow %(3)	Commercial WW Flow (MGD)	Commercial WW Flow (gpad)	
2017	11,372	1.58	53%	0.84	74	43%	0.68	914	0.06
2018	11,406	1.68	49%	0.82	72	44%	0.74	920	0.12
2019	11,403	1.55	53%	0.82	72	44%	0.69	791	0.05
2020	12,037	1.31	55%	0.72	60	41%	0.54	581	0.04
2021	12,529	1.58	54%	0.85	68	45%	0.71	721	0.02
2022	13,528	1.44	58%	0.83	61	42%	0.60	569	0.01
Average		**1.52**		**0.81**	**68**		**0.66**	**749**	**0.05**
Maximum		**1.68**		**0.85**	**74**		**0.74**	**920**	**0.12**

(1) 2020 City-wide population based on census data. 2017-2019 and 2021 City-wide population based on projected census data. Historical population from census data (2020) and projections (2017-2019 and 2021). 2023 City-wide populations calculated utilizing 2021 projected census data and comparing 2021 geocoded water meter data from to recently constructed developments identified via historical aerial imagery. The septic users within City limits were subtracted from the 2017-2021 and 2023 population. 2022 population interpolated based on 2021 and 2023 data.

(2) Combined average day flow observed at North and South Wastewater Treatment Plants (from Historical Daily Monitoring Records).

(3) Based on Historical Water Meter and Water Pumped data from the City.

(4) Other includes Government and Public facilities

9.2 WASTEWATER FLOW PROJECTIONS

Wastewater flows were projected for the **existing**, **5-year**, **10-year**, and **25-year** planning periods. The evaluation of historical data presented in **Table 9-2** provided a basis for establishing the planning criteria utilized to project wastewater flows. Based on the review of this data, FNI recommends a future average day flow of 85 gpcd for projected population and 1,000 gpad for projected commercial acreage. These city-wide planning criteria are presented in **Table 9-3**.

Table 9-3: Wastewater Planning Criteria

Wastewater Flow Type	Planning Criteria
Residential	85 gpcd
Commercial	1,000 gpad

The future population and commercial acreage discussed in **Section 2.0** were utilized to develop flow projections utilizing the methodology described below. The population and commercial acreage were broken down by WWTP service area, as shown in **Table 9-4** based on the location of the developments. Projections were also broken down by flow meter basin, discussed further below.

Table 9-4: Population and Commercial Acreage Growth by Service Area

WWTP Service Area	2028		2033		2048	
	Population Growth	Comm. Acreage Growth	Population Growth	Comm. Acreage Growth	Population Growth	Comm. Acreage Growth
North WWTP	670	68	582	1	4,685	194
South WWTP	5,777	300	6,718	353	8,358	448
Total	**6,447**	**368**	**7,300**	**354**	**13,043**	**642**

Average Day Wastewater Flows

Future average day wastewater flows were calculated by applying the planning criteria in **Table 9-3** to only the new residential population and commercial acreage. The average day wastewater flow projections for future anticipated residential and commercial developments were added to the existing flows to calculate the total projected average day wastewater flows for each future planning period. The existing wastewater flows are based on the flow monitoring data discussed in **Section 8.0** and the historical effluent data.

Peak Wastewater Flows

Based on guidance from the Texas Commission on Environmental Quality (TCEQ) regulations in the Texas Administrative Code (TAC) Chapter 217, a peak flow to average day peaking factor of 4.0 was applied to all future wastewater flows.

Projected Flow Summary

The projected growth in residential populations, growth in commercial acreage, and average day flows for each flow meter basin within the North and South WWTP service areas are presented in **Table 9-6**. The infrastructure recommendations discussed in **Section 12.0** are based on the projected average day and peak wastewater flows per planning period.

9.3 SUMMARY OF FLOW PROJECTIONS BY WWTP

The total projected average day wastewater flows within each WWTP service area in each planning period are included in **Table 9-5** and are graphed on **Figure 9-3** and **Figure 9-4**. **The projected average day wastewater flows show that additional wastewater treatment capacity will be needed at the South WWTP within the 25-year planning period.** Wastewater treatment plant capacity analyses and recommended capacity expansions are discussed in **Section 11.0**.

Table 9-5: Summary of Projected Average Day Wastewater Flows

Service Area	Projected Average Day Wastewater Flows(1) (MGD)			
	2023(1)	2028	2033	2048
North WWTP	0.70	0.83	0.88	1.47
South WWTP	0.93	1.72	2.65	3.80
Total	**1.63**	**2.55**	**3.52**	**5.27**

(1) Existing flows based on historical annual average flow from 2017 to 2022. Effluent data from the City was utilized for 2017 to 2021. Average flows observed during the flow monitoring period were utilized for 2022 flows.

TCEQ Evaluation Criteria (75/90 Rule)

Figure 9-3 and **Figure 9-4** each include three lines showing the **permitted average day flow (ADF) capacity of the WWTP**, **90% of the permitted ADF capacity**, and **75% of the permitted ADF capacity**. These are based on TCEQ §305.126, commonly referred to as the 75/90 rule, which requires a WWTP permit holder to begin planning for expansion of the treatment facility when the average day or average annual flow reaches 75% of the permitted capacity for three consecutive months. When the average day or average annual flow reaches 90% of the permitted capacity, the permit holder shall obtain necessary authorization from the Commission to commence construction of the necessary additional treatment facilities.

Table 9-6: Projected Wastewater Flows

	Flow Meter Basin	Existing (2023)	5-Year (2028)			10-Year (2033)			25-Year (2048)		
		Average Dry Weather Flow(1) (MGD)	Population Growth	Commercial Acreage Growth	Average Dry Weather Flow(2) (MGD)	Population Growth	Commercial Acreage Growth	Average Dry Weather Flow(2) (MGD)	Population Growth	Commercial Acreage Growth	Average Dry Weather Flow(2) (MGD)
North WWTP	N-01	0.02	0	0	0.02	492	0	0.07	772	41	0.17
North WWTP	N-02	0.11	667	70	0.24	16	1	0.24	660	90	0.39
North WWTP	N-03(2)	0.08	-5	-4	0.07	0	0	0.07	498	52	0.17
North WWTP	N-04	0.28	0	0	0.28	74	0	0.29	2,731	4	0.52
North WWTP	N-05	0.21	0	0	0.21	0	0	0.21	17	7	0.22
North WWTP	Unmetered(3)	0.001	8	2	0.003	0	0	0.003	7	0	0.004
North WWTP	**North Subtotal**	**0.70**	**670**	**68**	**0.82**	**582**	**1**	**0.88**	**4,685**	**194**	**1.47**
South WWTP	S-01	0.07	328	103	0.2	3,224	11	0.48	5,806	37	1.01
South WWTP	S-02	0.21	169	12	0.23	1,751	26	0.41	869	91	0.57
South WWTP	S-03	0.19	1,386	139	0.44	0	158	0.6	214	120	0.74
South WWTP	S-04	0.36	3,517	46	0.7	1,743	76	0.93	1,445	177	1.23
South WWTP	S-05	0.09	0	0	0.09	0	9	0.1	24	21	0.13
South WWTP	Unmetered(3)	0.02	377	0	0.05	0	72	0.12	0	2	0.13
South WWTP	**South Subtotal**	**0.94**	**5,777**	**300**	**1.71**	**6,718**	**352**	**2.64**	**8,358**	**448**	**3.81**
Total		**1.64**	**6,447**	**368**	**2.53**	**7,300**	**353**	**3.52**	**13,043**	**642**	**5.28**

(1) Average day flow based on 2022 flow monitoring data and historical effluent.

(2) Population and commercial acreage decreases in N-03 due to flow diversion of Persimmon Lift Station to the South WWTP service area (S-03)

(3) Unmetered flow based on planning criteria of 85 gpcd and 1,000 gpad.

Figure 9-3: North WWTP Projected Average Day Wastewater Flows

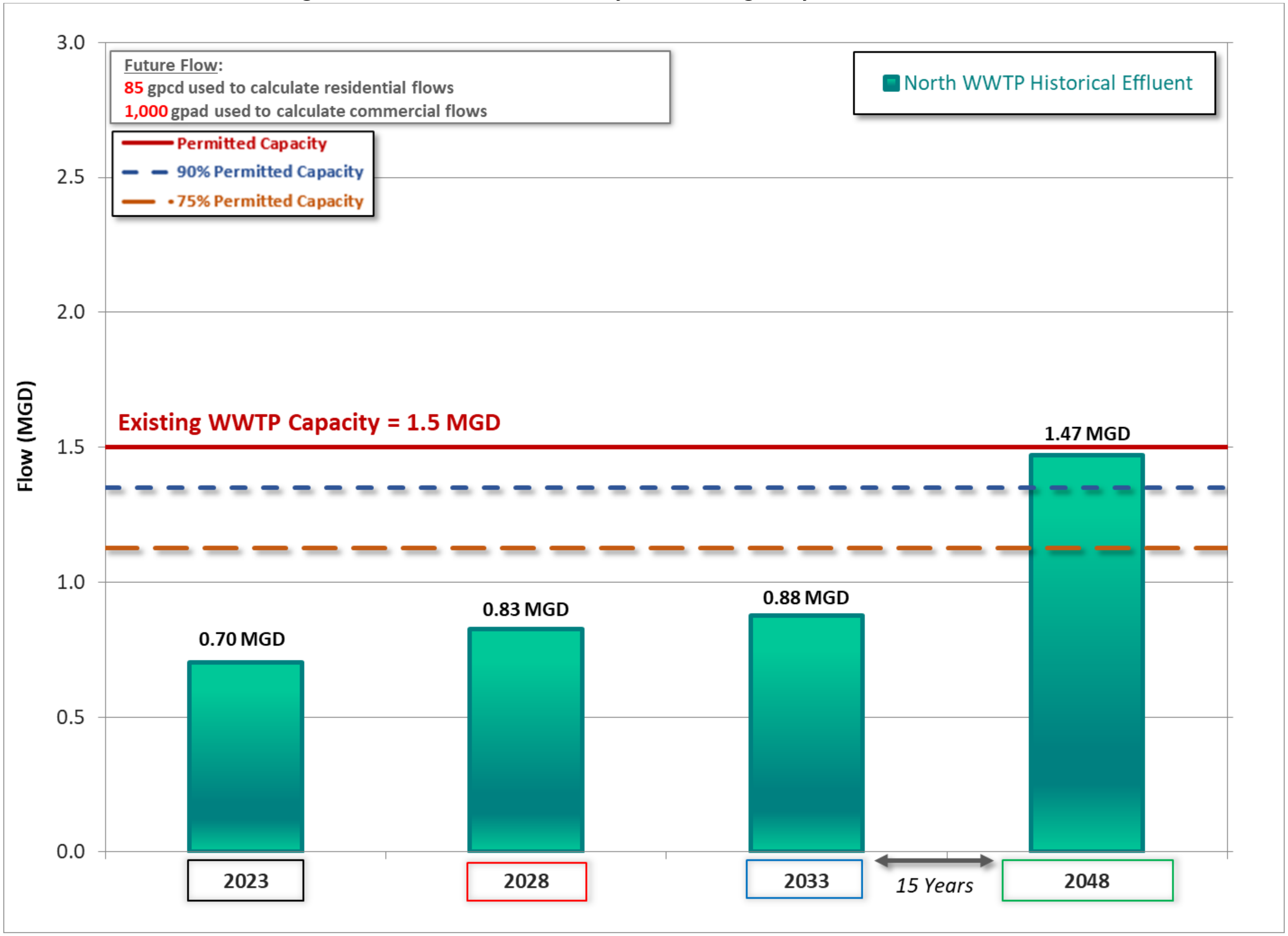
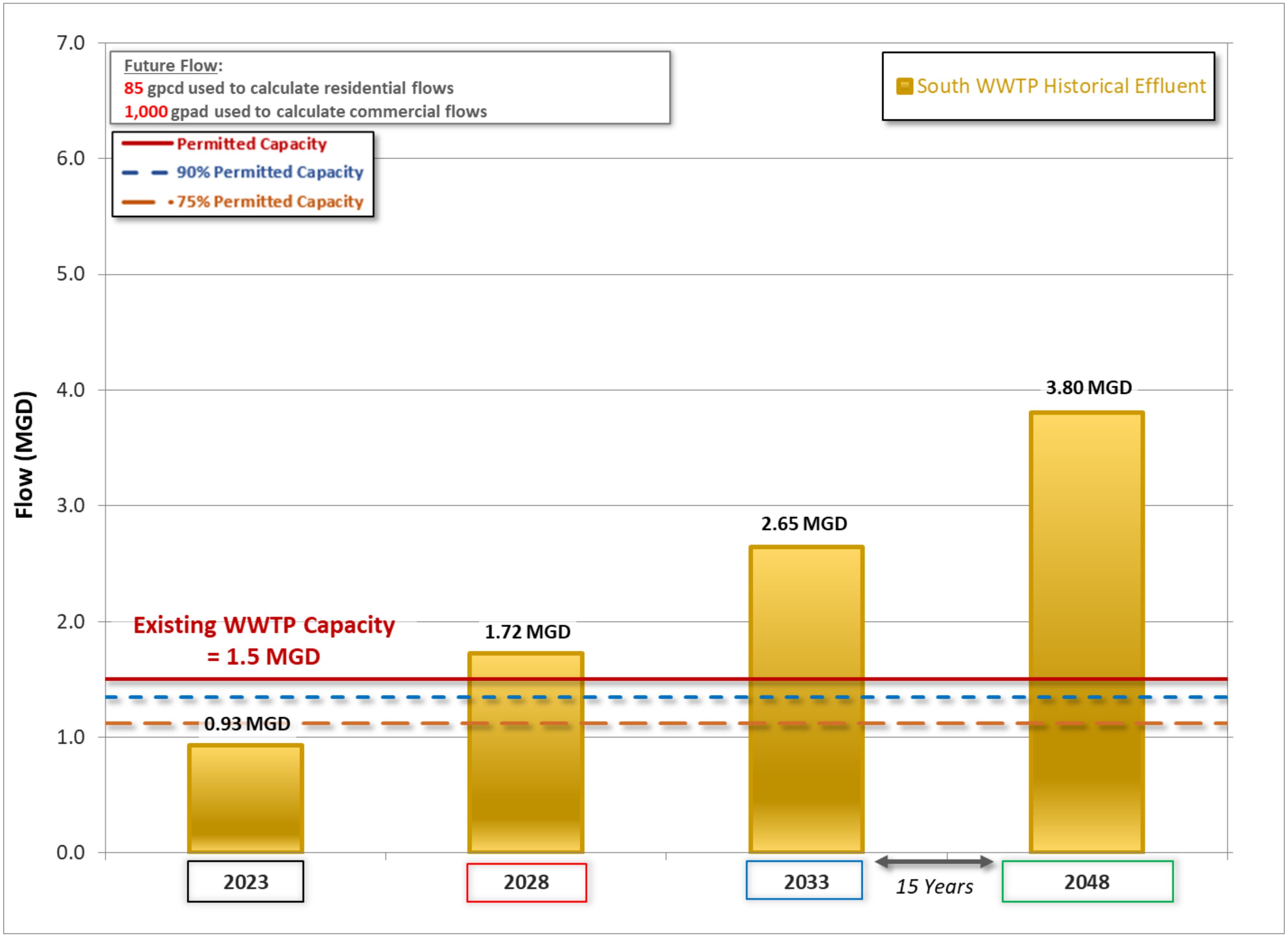


Figure 9-4: South WWTP Projected Average Day Wastewater Flows



10.0 WASTEWATER MODEL UPDATE AND SYSTEM ANALYSES

10.1 HYDRAULIC MODEL DEVELOPMENT

Tomball's current wastewater collection system hydraulic model is in the InfoSewer® software by Innovyze. This software has GIS interoperability and makes use of engineering equations and mathematical algorithms to determine the flows and velocities that would occur in a collection system under a specified set of conditions. The wastewater model was originally developed by FNI in 2017 during the City's *2017 Wastewater Master Plan* project. As part of this 2023 project, FNI completed an update to the City's hydraulic wastewater model to include new lines and facilities. Updated and newly added model components include:

- Updated gravity lines based on the City's latest GIS, updated as part of the *2023 Utility GIS Update* project
- Updated wastewater loads based on geocoded meter billing and flow monitoring data
- Updated pumping and operations information

Following the model update process, FNI calibrated the hydraulic wastewater model utilizing the field collected flow monitoring and rainfall data discussed in **Section 8.0**. The model was then utilized to conduct system analyses and to develop wastewater capital improvement plan (CIP) projects.

10.2 GIS UPDATE

FNI updated the City's GIS with recently constructed utility lines as part of the *2023 Utility GIS Update* and *2021 Utility GIS Update* projects based on as-built plans and record drawings. Recent as-built drawings provided by the City were utilized to update Tomball's water, wastewater, gas, and stormwater shapefiles. The updated wastewater system shapefiles were utilized in the hydraulic model update process, as described in **Section 10.3**.

10.3 MODELED NETWORK UPDATE

FNI updated the hydraulic wastewater model with all 10-inch or larger gravity lines that were constructed since the *2017 Wastewater Master Plan*. The gravity wastewater lines that were incorporated into the model are presented in **Table 10-1**. FNI also updated gravity line invert information based on the City's latest GIS, and lift station pump information received from the City.

Table 10-1: Updated Gravity Lines in InfoSewer Model

Plan/File Name	Diameter (in)	WWTP Service Area
2001-10002 School Street Extension	10	South
2006-10001 Southern Extension of School Street	10/12	South
2011-10019 Medical Complex Segment 3 Plans	10	South
2013-10013 Zion Rd Utility Extension (Raleigh Creek)	12/18	North
2013-10015 Valero Utility Relocations (Gas_Water_SanSwr)	10	South
2013-10020 Raleigh Creek Section One (Paving, Drainage, Utilities) Oct_Nov 2013 Plans	12	North
2015-10015 Reserve at Spring Lake Section Two	12	North
2015-10020 Medical Complex Dr Utilities Extension (West of SH 249)	10	South
2015-10026 Yaupon Trails Section One	10	North
2020-10012 Raburn Reserve	10/12	South

The model consists of approximately 755 links including 16 pumps, and 798 nodes, including 4 outfalls, and 8 lift stations. Approximately 220,000 LF (41.7 miles) of gravity wastewater line within the City's collection system is included in the wastewater model.

10.4 COLLECTION SYSTEM UNIQUE IDENTIFIERS

Unique IDs are required by modeling software and are a best practice for maintaining and updating utility system assets in a GIS database. FNI created and assigned unique IDs for all new modeled wastewater system assets (manholes, gravity lines, and force mains). The unique IDs were assigned to each element during the model build process, based on the format established and utilized during the *2017 Wastewater Master Plan* as shown in **Table 10-2.**

Table 10-2: Format of Unique IDs for Wastewater Collection System Components

Wastewater System Component	Unique ID Format
Manholes	MH_####
Gravity Main	SS_###
Force Main	FM_Lift Station Name_#

10.5 MODEL LOAD ALLOCATION

FNI allocated wastewater loads to the hydraulic model based on geocoded water meter billing data. GIS tools were utilized to associate the geocoded meter billing data (loads) with the model manholes. The loading was then adjusted during the model calibration process.

10.6 HYDRAULIC MODEL CALIBRATION

10.6.1 Dry Weather Calibration

Dry weather calibration is conducted so that the hydraulic model closely matches observed dry weather flows. These dry weather flows represent residential, commercial, and groundwater flows during a period without any additional measurable I/I due to rainfall. FNI chose a weekday period from December 6 to December 12, 2022, for the dry weather calibration.

Diurnal patterns for each flow meter basin were developed and loaded into the model, based on the patterns observed during the flow monitoring period (included in **Appendix I**). The loading based on the geocoded water meter billing data was then factored as necessary until the aggregate flows in each flow monitor basin closely matched the observed flow monitor data. For this study, a tolerance of +/- 10% between observed and modeled average day flow was selected for dry weather calibration, and this was achieved at all 10 flow meter sites. Calibration results are discussed in **Section 10.6.3** and individual plots demonstrating the dry weather model calibration results are provided in **Appendix J.**

10.6.2 Wet Weather Calibration

Wet weather calibration builds upon the dry weather calibration and is performed so that the model closely matches observed wet weather flows during rainfall. These wet weather flows represent the sum of the dry weather flows plus the additional I/I that enters the wastewater system during a rainfall event. FNI utilized a storm event that occurred on December 11, 2022 to perform the wet weather calibration.

FNI utilized the RTK hydrograph method to model the additional flows that entered the wastewater system during the observed calibration storms. This method utilizes three hydrographs that each contain three parameters which are adjusted to achieve calibration: flow of water into the system (R), the time to peak flow (T), and the ratio of time until normalization of flow to time to peak (K). The combination of the three component hydrographs forms the total response (additional I/I) that is observed in the wastewater system. The RTK parameters and the component hydrographs are illustrated on **Figure 10-1** and **Figure 10-2**.

Figure 10-1: RTK Parameters

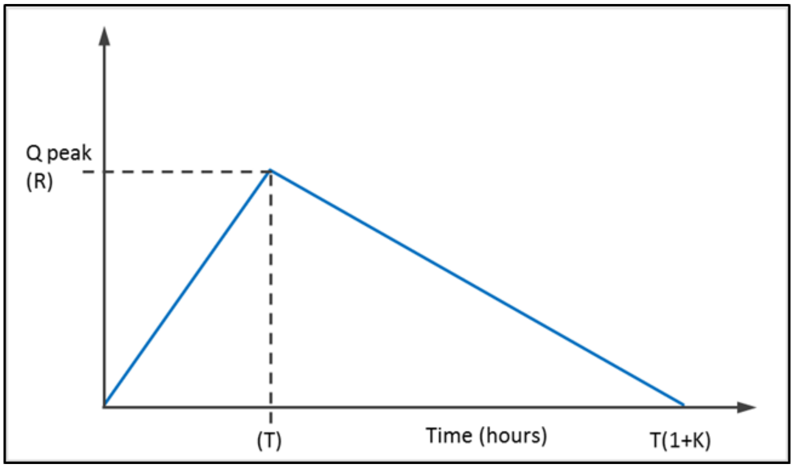
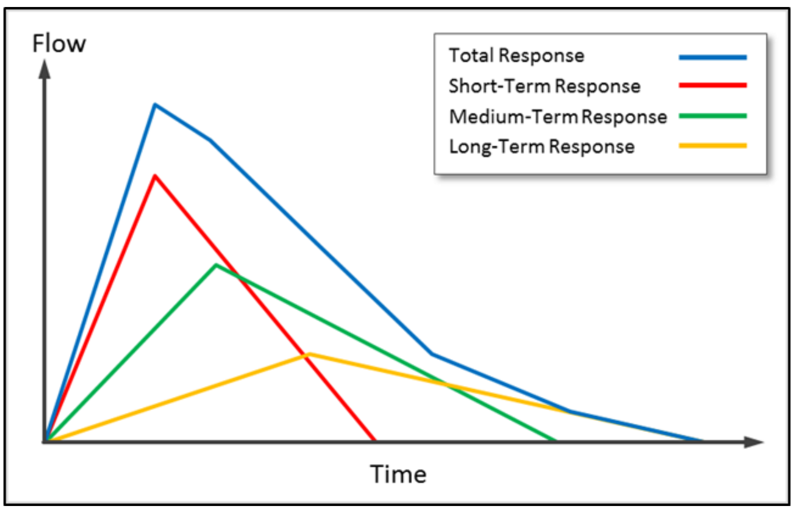


Figure 10-2: RTK Component Hydrographs



Separate RTK hydrographs were developed for each flow meter basin to account for the different land uses, soil properties, amounts of impervious cover, and condition of the wastewater lines in each basin. In the InfoSewer® model, the RTK hydrographs were applied to the manholes in each wastewater basin. The observed rainfall hyetographs measured during the calibration rainfall events were then applied to the model. The model calculates the I/I that enters the wastewater system utilizing the values in the RTK hydrographs and the contributing area of each catchment. These values were adjusted until the modeled wet weather flows closely matched the observed wet weather flows. For this project, a tolerance of +/- 20% of the observed peak flows was selected for wet weather calibration, and this was achieved at all 10 flow monitoring sites. Calibration results are discussed in **Section 10.6.3** and individual plots demonstrating the wet weather model calibration results are provided in **Appendix J**.

10.6.3 Calibration Results

The summary of calibration results is presented in **Table 10-3** and on **Figure 10-3** and **Figure 10-4.** The dry and wet weather calibration results provide a high level of confidence that the model is closely matching real world conditions and is suitable to use for hydraulic analyses and CIP development.

Table 10-3: Summary of Calibration Results

Flow Meter	Average Dry Weather Flow (MGD)			Peak Wet Weather Flow (MMGD)		
	Flow Meter Data	Modeled Data	Difference (%)	Flow Meter Data	Modeled Data	Difference (%)
N-01	0.03	0.03	**-1.4%**	0.55	0.54	**-2.2%**
N-02	0.41	0.40	**-3.3%**	1.94	1.87	**-3.3%**
N-03	0.52	0.50	**-3.6%**	2.89	3.00	**3.9%**
N-04	0.37	0.37	**-0.7%**	1.68	1.76	**4.6%**
N-05	0.25	0.25	**2.8%**	0.66	0.67	**1.6%**
S-01	0.07	0.07	**-1.9%**	0.40	0.40	**-0.03%**
S-02	0.68	0.70	**1.8%**	3.20	3.01	**-5.9%**
S-03	0.21	0.22	**2.5%**	1.25	1.18	**-5.4%**
S-04	0.39	0.39	**1.2%**	1.17	1.10	**-6.1%**
S-05	0.10	0.10	**-4.4%**	0.43	0.44	**2.5%**

Figure 10-3: Dry Weather Calibration Results

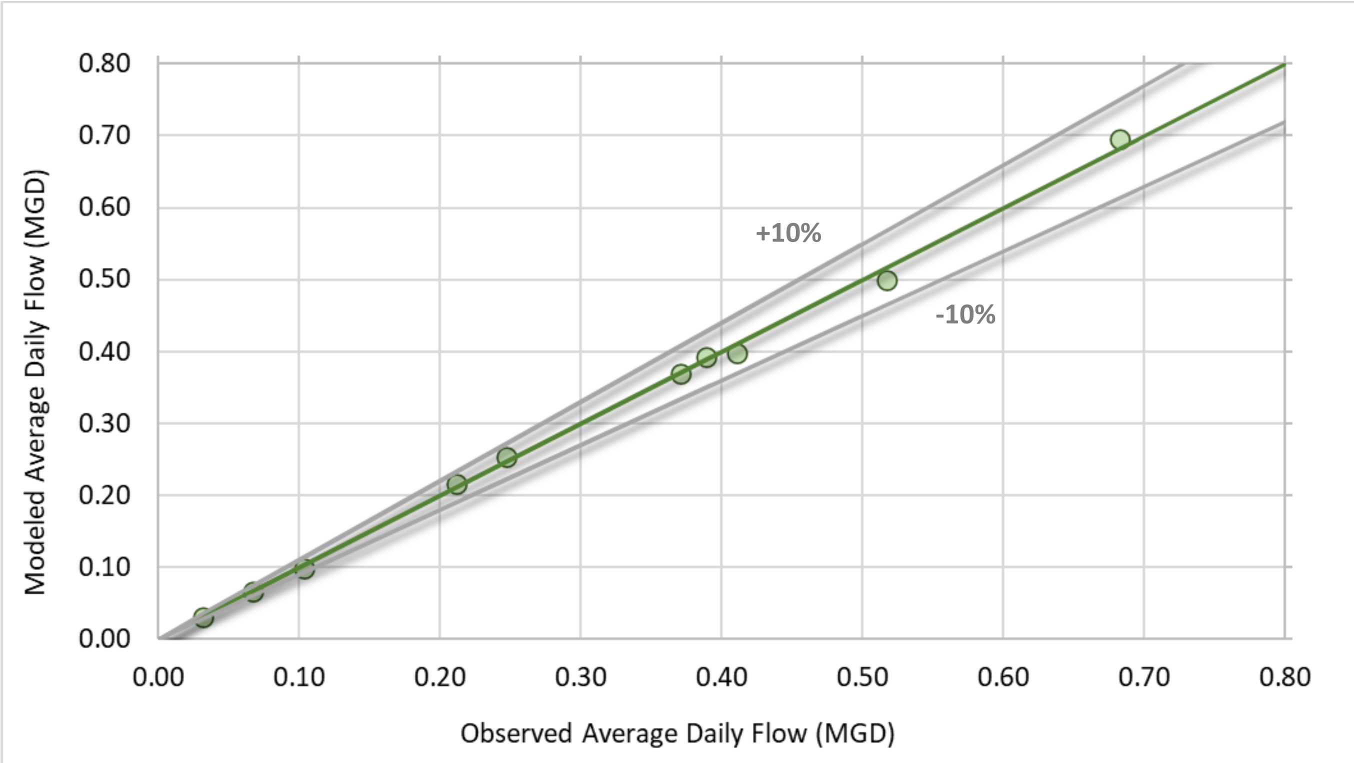
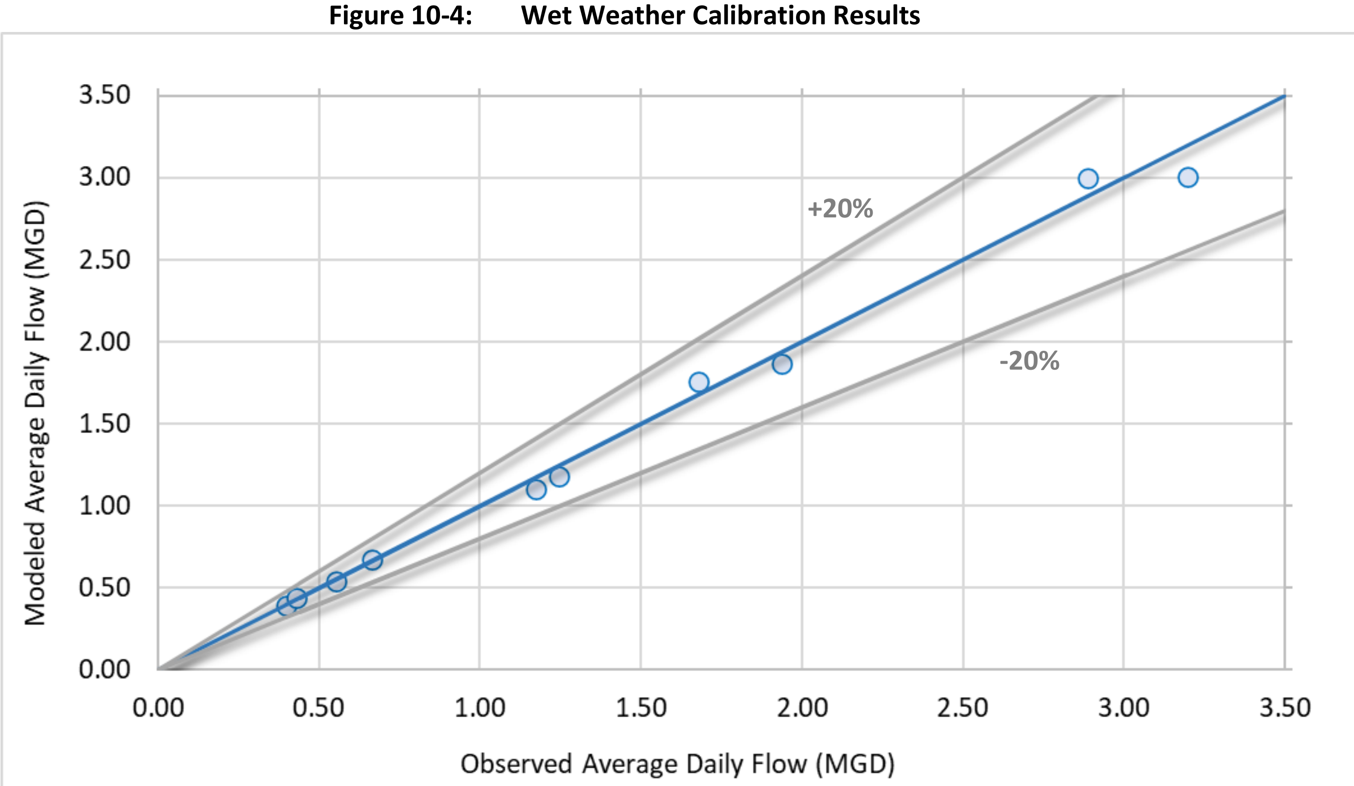


Figure 10-4: Wet Weather Calibration Results



10.7 WASTEWATER SYSTEM ANALYSES

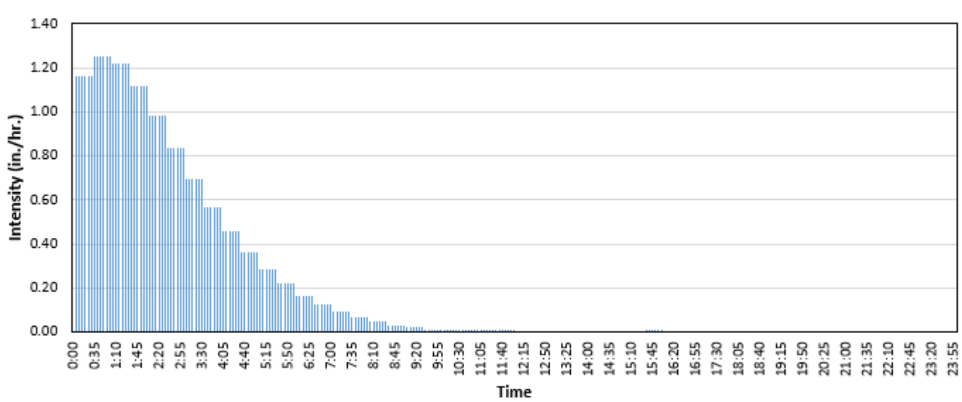
This project conducted hydraulic capacity analyses of the Tomball collection system to identify existing capacity deficiencies and assess the need for improvements to convey and treat projected wastewater flows through the 25-year planning period. The data documented in this report, including the flow monitoring results and wastewater flow projections, were utilized in the capacity analyses. Wastewater hydraulic modeling was performed to assess peak wet weather flows.

Various combinations of improvements and modifications were investigated to assess the most appropriate approach for conveying the projected peak wastewater flows and treating the projected annual average wastewater flows. Considerations in developing the wastewater capacity CIP included increasing system reliability, simplifying system operations, conveying peak wet weather flows, and reducing surcharging and sanitary sewer overflows.

10.7.1 Design Storm

Design storms are utilized in wastewater hydraulic models to develop peak wastewater flows that inform the sizing and cost of capital improvements. A 2-year, 24-hour design storm was utilized for this study. This design storm is commonly used in Texas and provides a reasonable balance between level of service and wastewater infrastructure cost. Information from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 database was utilized to develop the depth, peak intensity, and distribution characteristics of the 2-year, 24-hour design storm for analyzing Tomball's collection system. The two-year 24-hour design storm for the City of Tomball is an approximately 4.86-inch rainfall event. The 2-year 24-hour design storm hyetograph is shown on **Figure 10-5.**

Figure 10-5: 2-Year, 24-Hour Design Storm Hyetograph



10.7.2 Existing and Future System Hydraulic Analyses

The critical flow condition for analyzing a wastewater collection system is peak wet weather. Flow, depth, and velocity are important factors when analyzing peak wet weather simulations. FNI performed existing and future system analyses based on the 2-year, 24-hour design storm event. FNI also evaluated the collection system utilizing a peak flow to average day peaking factor of four. The peaking factor applied represents the wet weather flows in the collection system at the highest intensity point of a storm event. During future system analyses, projected 25-year average day flows were distributed throughout the model where anticipated developments are predicted to occur.

Color-coded maps were prepared to illustrate the surcharged state of modeled lines and manholes under existing and future peak conditions for the City of Tomball based on the four peaking factor analyses. These maps are included in **Appendix K.** The **orange lines** indicate 90-99% of the capacity in the line is being utilized to convey the modeled peak flows. The **red lines** indicate surcharging above the pipe. This can occur due to a lack of capacity in that gravity line segment or a downstream restriction (i.e., insufficient lift station pumping or insufficient capacity in a downstream line). Locations where the predicted maximum hydraulic grade line (HGL) rises to within 3 feet of the manhole rim are shown as **yellow circles** on the map. The locations of predicted sanitary sewer overflows as a result of peak flows are shown as **red circles** on the map.

10.7.3 Design Criteria

The Texas Commission on Environmental Quality (TCEQ) provides specific design criteria for new lift stations and wastewater gravity lines. FNI utilized these design criteria to develop the wastewater system improvements.

Design Criteria for Lift Stations and Force Mains

TCEQ design criteria §217.61 (c) states "The firm pumping capacity of a lift station must handle the peak flow." Firm pumping capacity is defined as the maximum pumping capacity with the largest pumping unit out of service. TCEQ §217.67 (a) also states that force mains shall be sized to convey the lift station pumping capacity at a minimum velocity of 3 feet/second for duplex lift stations and 2 feet/second with one pump operating at a lift station with three or more pumps.

At lift stations where expansion in firm pumping capacity is recommended, the existing wet wells were evaluated for capacity based on the TCEQ minimum pump cycle times. These cycle times are listed in **Table 10-4.**

Table 10-4: TCEQ Minimum Pump Cycle Times

Pump Horsepower	Minimum Cycle Times (minutes)
< 50	6
50 – 100	10
> 100	15

The proposed wastewater lines, force mains, and lift station firm pumping capacities in the wastewater CIP (**Section 12.0**) are sized to convey the projected peak wastewater flows in accordance with these TCEQ criteria.

<u>Design Criteria for Gravity Lines</u>

When determining the size of proposed wastewater lines, the TCEQ provides specific design criteria. TCEQ §217.53 (l)(1) dictates that collection systems must be designed to maintain a minimum velocity of 2 feet/second. Maintaining these velocities discourages the settling of solids. In accordance with this, the TCEQ has established minimum slope guidelines in §217.53 (l)(2)(A). These are shown in **Table 10-5**. Additionally, TCEQ §217.53 (j)(3) states "An owner must ensure that the collection system has capacity to prevent a surcharge."

Table 10-5: TCEQ Minimum Slopes

Diameter of Pipe (in)	Minimum Slope (ft/ft)
6	0.00500
8	0.00335
10	0.00250
12	0.00200
15	0.00150

When determining the number of manholes for proposed wastewater lines, the TCEQ provides specific design criteria. TCEQ §217.55 (g) dictates the manhole spacing requirements found in **Table 10-6.**

Table 10-6: TCEQ Manhole Diameter and Maximum Spacing

Diameter of Pipe (in)	Manhole Diameter (in)	Maximum Manhole Spacing (ft)
6	48	500
8	48	500
10	48	500
12	48	500
15	60	500

11.0 WASTEWATER TREATMENT PLANT CAPACITY ANALYSIS

The wastewater flow projections developed in **Section 9.0** show that additional treatment capacity is needed within the next 25 years to treat the projected wastewater flows within the study area. The projected wastewater flows and existing/recommended WWTP capacities for both the North and South WWTP service areas are shown on **Figure 11-1** and **Figure 11-2**, respectively.

11.1 TCEQ EVALUATION CRITERIA (75/90 RULE)

Lines showing the **permitted average day flow (ADF) capacity**, **90% of the permitted ADF capacity**, and **75% of the permitted ADF capacity** are shown on **Figure 11-1** and **Figure 11-2.** These lines are based on TCEQ §305.126, commonly referred to as the 75/90 rule, which requires a WWTP permit holder to begin planning for expansion of the treatment facility when the average day or average annual flow reaches 75% of the permitted capacity for three consecutive months. When the average day or average annual flow reaches 90% of the permitted capacity, the permit holder shall obtain necessary authorization from the commission to commence construction of the necessary additional treatment facilities.

11.2 FUTURE WASTEWATER TREATMENT CAPACITY

North WWTP

The flow projections for the North WWTP are shown on **Figure 11-1** and reflect the plan to divert the Persimmon Lift Station from the North WWTP to the South WWTP service area. The flow diversion project was recommended in order to consolidate the Persimmon Lift Station, discussed further in **Section 12.0**. At this time, no capacity expansion of the North WWTP is being recommended. FNI recommends that the wastewater flows and flow projections within the North WWTP service area continue to be evaluated in future master planning studies to evaluate future need for WWTP capacity expansion.

South WWTP

The flow projections for the South WWTP shown on **Figure 11-2** indicate a lack of available capacity to treat the projected 25-year flows. The City is currently in the process of designing an expansion of the South WWTP from 1.5 MGD to 3.0 MGD that is anticipated to be in service within the 5-year planning period (by 2028). An additional, future expansion from 3.0 MGD to 4.5 MGD is recommended in the 25-year planning period to serve the projected flows in the South WWTP service area. Based on the wastewater flow projections, FNI recommends that the City begin planning for the future South WWTP expansion from 3.0 to 4.5 MGD by 2031 in order to have the facility in service by 2037.

The treatment capacity expansion recommendations were developed based on the projected average day wastewater flows and the capacity requirements in TCEQ §305.126. It should be noted that the proposed treatment capacity expansion is based on best available data, incorporating the projected wastewater flows and planning criteria discussed previously. If development locations, timing, or projected flows differ from those assumed in this project, the recommended WWTP capacities and/or timing of expansions should be re-evaluated.

Figure 11-1: North WWTP Projected Average Day Flows

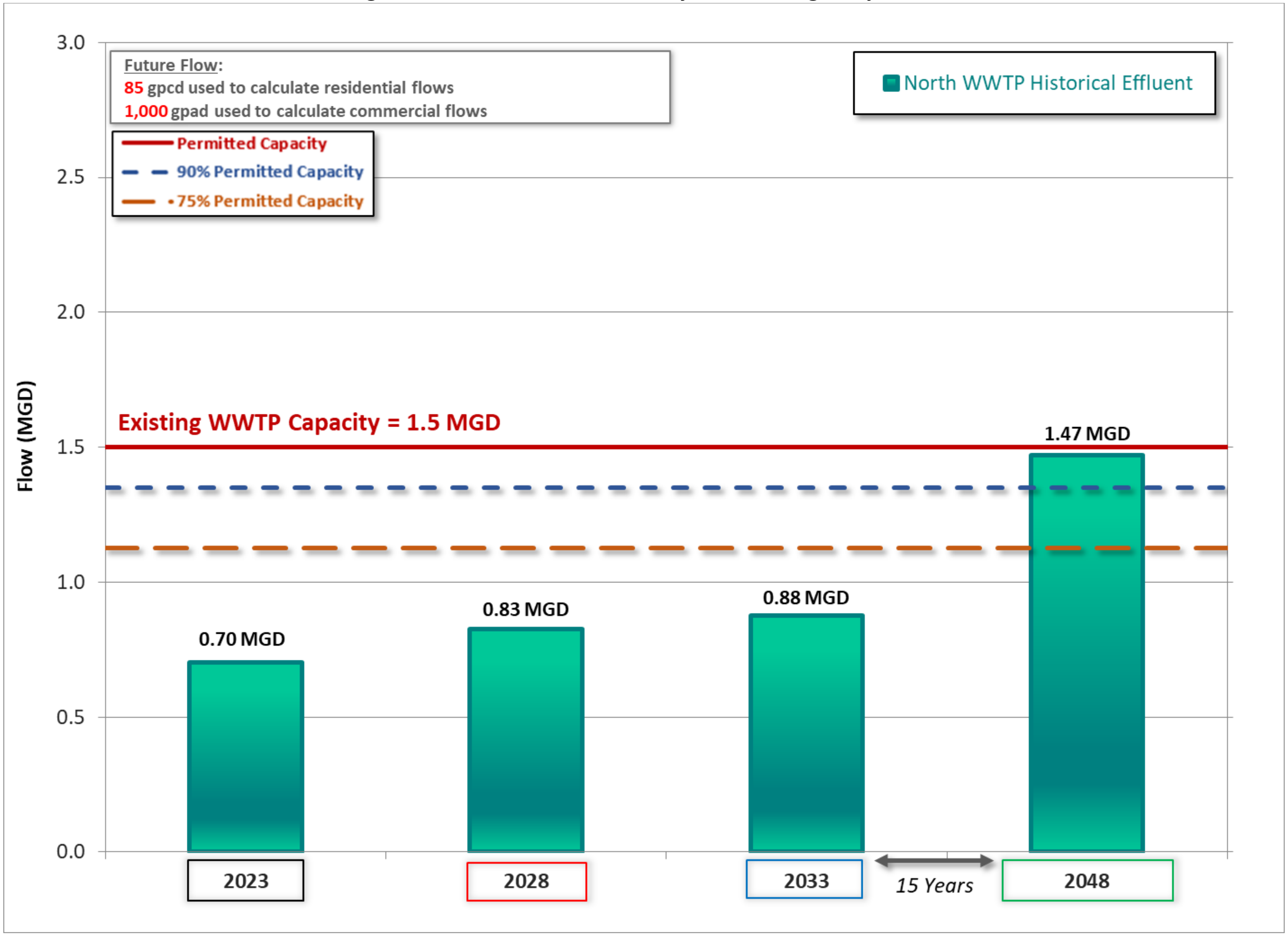
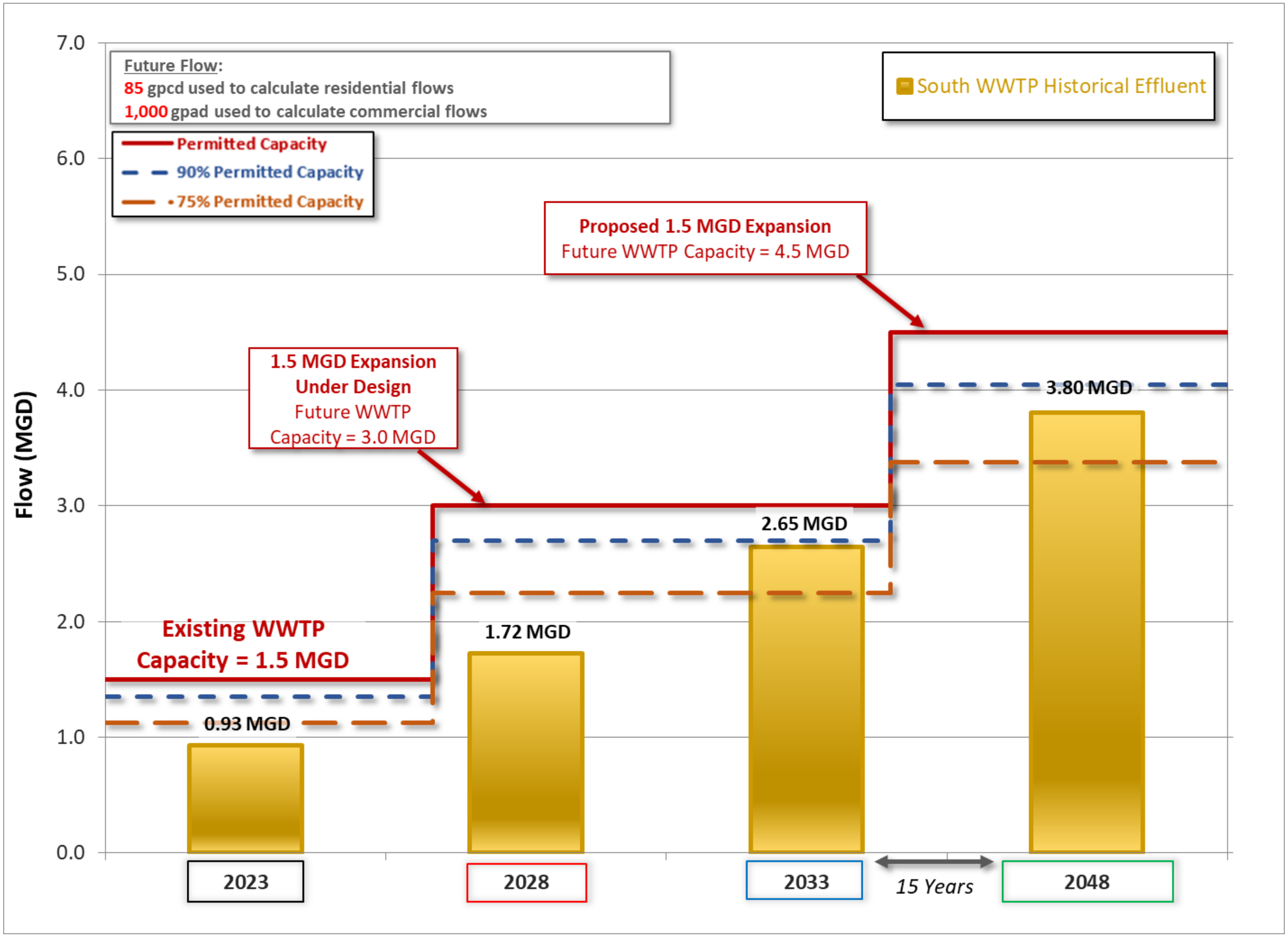


Figure 11-2: South WWTP Projected Average Day Flows



12.0 WASTEWATER SYSTEM CAPITAL IMPROVEMENTS PLAN

A wastewater system capital improvements plan (CIP) was developed for the City of Tomball. The complete wastewater CIP consists of the following components:

- Capacity CIP Projects – *documented in **Section 12.1***
- Sanitary Sewer Evaluation Study (SSES) CIP Projects – *documented in **Section 12.2***

The CIP recommendations are based on the wastewater system flow monitoring, land use assumptions, flow projections, hydraulic modeling, and system analyses discussed in this report. The recommended capacity projects improve the collection system's ability to convey existing wastewater flows and provide the required conveyance and treatment capacity to serve the projected residential and commercial growth through the 25-year planning period. Where applicable, the recommended capacity projects also address existing condition issues in the wastewater system. The SSES CIP was developed based on the 2023 flow monitoring results and recommends field work and rehabilitation activities to address areas of the collection system with high levels of I/I.

12.1 CAPACITY CIP PROJECTS

The recommended wastewater collection and treatment projects are shown in **Table 12-1** and on **Figure 12-1.** The planning level OPCCs for each project are included in **Appendix B**. **Table 12-2** lists the **5-year** capacity and SSES CIP (discussed in **Section 12.2**) and includes projects costs in future dollars. Wastewater projects currently under design or construction by the City are not included in the CIP and are shown in **orange** on **Figure 12-1.** Projects anticipated to be constructed and paid for by developers are shown in **purple** on **Figure 12-1.** The wastewater CIP projects are arranged and prioritized by planning period (**5-year**, **10-year**, and **25-Year**) based on projected timing of development and the priority of the projects. The projects and planning periods are shown as follows:

- **5-Year Projects**: These are shown **in red** and are recommended to be designed, constructed, and placed into service within the next 5 years (by 2028).
- **10-Year Projects**: These are shown **in blue** and are recommended to be designed, constructed, and placed into service within the next 10 years (by 2033).
- **25-Year Projects**: These are shown **in green** and are recommended to be designed, constructed, and placed into service within the next 25-years (by 2048).

It is recommended that these projects be constructed generally in the order presented; however, development patterns may make it necessary to construct some projects sooner than anticipated.

Locations shown for new lines and lift stations are generalized for hydraulic analyses. Specific alignments and sites will be determined as part of the design process. The recommended infrastructure is sized to convey the projected 25-year peak wet weather wastewater flows. The sections below include the project description and driver for each capacity CIP project.

Table 12-1: Wastewater Capital Improvements Plan Summary

Phase	Project Number	Project Name	Capital Cost(1) in 2023 Dollars *(Costs do not include Inflation)*
5-Year	1	Replacement 10/12-inch Gravity Lines along Alma/James Streets	$3,435,900
	2	Hicks Lift Station (LS) Expansion to 1.2 MGD	$1,223,100
	3	18-Inch South Persimmon Gravity Line	$4,081,400
	4	10/18-inch along Lutheran Church Road and FM 2920 Rd Gravity Line	$5,143,300
	5	Replacement 21/24-inch North Willow Street Gravity Line	$1,835,400
	6	21-inch Gravity Line along Humble Road	$4,790,000
	7	Wastewater Master Plan & Impact Fee Update	$250,000
		Total 2023 - 2028	**$20,509,100**
10-Year	8	New 1.1 MGD Telge Lift Station, 8-inch Force Main, and 21-inch Gravity Main	$5,105,300
	9	Snook Lane Lift Station Expansion to 0.5 MGD	$738,200
		Total 2029 - 2033	**$5,843,500**
25-Year	10	South WWTP 1.5 MGD Expansion to 4.5 MGD	$65,520,000
	11	Replacement 18-Inch Gravity Line Along Inwood Street to West Hufsmith Road	$2,284,400
	12	Hunterwood Lift Station Expansion to 0.22 MGD	$424,400
	13	New 315 gpm Lift Station, 6-Inch Force Main, and 10-Inch Gravity Line and Replacement 12/15-Inch Gravity Line	$3,850,100
	14	Replacement 18-Inch Gravity Line Along Highway 249 near Hicks Lift Station	$1,169,100
	15	Replacement 24-Inch Gravity Line Along Hufsmith Road	$1,190,300
	16	New 0.15 MGD Lift Station and 2-Inch Force Main at Boudreaux Estates	$656,400
		Total 2034 - 2048	**$75,094,700**
Timeline Pending	T1	Wastewater SCADA Master Plan	$200,000
	T2	Wastewater SCADA System	$3,057,600
		Total Timeline Pending Project Cost	**$3,257,600**
		Total Capacity Wastewater CIP Cost	**$104,704,900**

(1) **Costs are in 2023 dollars and do not include inflation.** Planning level costs were developed for proposed future projects and include construction costs, contingency, and engineering. Additional expenses related to owner's contingency, construction management/inspection, materials testing, and legal fees are not included.

Table 12-2: 5-Year Capacity and Rehabilitation CIP

Project No.	Project Name	Total 5-Year Cost(1)	Component	FY2024 Cost (2023 Dollars)	FY2025 Cost (2024 Dollars)	FY2026 Cost (2025 Dollars)	FY2027 Cost (2026 Dollars)	FY2028 Cost (2027 Dollars)
					Costs include inflation			
A	South WWTP 1.5 MGD Expansion	**$70,434,457**	Engineering/Survey/ Construction Phase Services	$5,535,195	$4,425,000	-	$422,000	-
			Construction	$11,442,081	$15,714,000	$20,788,081	$11,602,000	-
B	FM 2920 Lift Station Consolidation	**$15,394,100**	Easement Acquisition	$393,000				
			Engineering/Survey	$2,015,500				
			Construction	$12,770,000				
C	Rudolph Road Sewer Extension	**$839,600**	Easement Acquisition					
			Engineering/Survey					
			Construction	$382,000				
1	Replacement 10/12-inch Gravity Lines along Alma/James Streets	**$3,970,000**	Engineering/Survey		$485,000			
			Construction			$3,485,000		
2	Hicks Lift Station Expansion to 1.2 MGD	**$1,410,000**	Engineering/Survey		$221,000			
			Construction			$1,189,000		
3	18-Inch South Persimmon Gravity Line	**$4,341,000**	Engineering/Survey		$530,000			
			Construction			$3,811,000		
4	10/18-inch along Lutheran Church Road and FM 2920 Gravity Line	**$976,000**	Easement Acquisition					$300,000
			Engineering/Survey					$676,000
5	Replacement 21/24-inch North Willow Street Gravity Line	**$2,474,000**	Engineering/Survey				$302,000	
			Construction					$2,172,000
6	21" Telge Gravity Line along Humble Road	**$860,000**	Easement Acquisition					$95,000
			Engineering/Survey					$765,000
SSES 1	SSES Phase 1	**$4,317,000**	Engineering/Survey		$317,000			
			Construction			$4,000,000		
SSES 2	SSES Phase 2	**$8,310,000**	Engineering/Survey				$310,000	
			Construction				$4,000,000	$4,000,000
	5-Year Wastewater Total	**$113,326,157**		**$32,537,776**	**$21,692,000**	**$33,273,081**	**$16,636,000**	**$8,008,000**

(1) Costs include prior year expenditures.

Development of Capital Costs

Planning level opinions of probable construction costs (OPCCs) were developed for all recommended improvements in 2023 dollars based on previous similar engineering experience and include allowances for the following:

- **Contingencies:** A 30% contingency was utilized for all future projects. This is the cost assigned to the unknowns in the definition of the project. The contingency is intended to account for construction costs that have not yet been identified due to the project's maturity and should be expected to be fully utilized during construction.

- **Engineering/Survey:** For this study, engineering and survey was set at 20% for projects including facilities and at 15% for line-only projects. The engineering and survey portion of the OPCC accounts for costs projected to be incurred for design, geotechnical, subsurface utility engineering, environmental engineering, and survey tasks during the design of a project.

Costs in 2023 dollars shown on **Table 12-1** do not include financing, inflation, individual service connections or subdivision lines. Costs for easements and land acquisition are included where specifically noted on the OPCCs. The pipeline and manhole unit costs utilized in the development of the OPCCs are provided in **Table 12-3.**

Table 12-3: Wastewater Capital Improvements Plan Unit Costs

Pipelines		Cost/Diam-in/LF
Force Mains		$18
Gravity Lines < 8-feet deep		$17
Gravity Lines 8 - 16-feet deep		$18
Gravity Lines > 16-feet deep		$20
Manholes		**Cost/Manhole**
4-ft Diameter	<=8-ft	$12,000
	8-ft – 16-ft depth	$16,000
	>16ft – 24-ft depth	$20,000
5-ft Diameter	<=8-ft	$16,000
	8-ft – 16-ft depth	$20,000
	>16ft – 24-ft depth	$24,000
6-ft Diameter	<=8-ft	$18,000
	8-ft – 16-ft depth	$22,000
	>16ft – 24-ft depth	$27,000


FIGURE 12-1
CITY OF TOMBALL
WATER AND WASTEWATER MASTER PLAN
WASTEWATER CAPITAL IMPROVEMENTS PLAN
LEGEND
Under Design/Construction
Lift Station
Wastewater Treatment Plant
Gravity Main
5 Year Proposed Improvements
Lift Station
Gravity Main
10 Year Proposed Improvements
Lift Station
Gravity Main
Force Main
25-Year Proposed Improvements
Lift Station
Gravity Main
Developer Improvements
Lift Station
Force Main
Existing Wastewater System
Lift Station
Private Lift Station
Wastewater Treatment Plant
8" and Smaller Wastewater Line
10" and Larger Wastewater Line
8" and Smaller Force Main
10" and Larger Force Main
Grand Parkway 99
Stream
North Service Area
South Service Area
City Limit
ETJ
County Line
FREESE AND NICHOLS
THE CITY OF TOMBALL TEXAS FOUNDED 1907
The timing of projects shown is subject to change based on development patterns. The utility alignments shown in this figure are for illustration purposes only and do not set the alignments. The alignment of each utility will be determined at the time of the engineering design.
7 Wastewater Master Plan & Impact Fee Update
T1 Wastewater SCADA System
Hunterwood LS
Firm Capacity = 0.16 MGD
Proposed Firm Capacity = 0.22 MGD
Proposed LS
Proposed Firm Capacity = 315 gpm
North Star Estates LS
Firm Capacity = 0.22 MGD
Tomball Hills LS
Firm Capacity = 0.59 MGD
Raleigh Creek LS
Firm Capacity = 0.5 MGD
Broussard Park LS
Firm Capacity = 0.04 MGD
Juergens Park LS
Snook Lane LS
Firm Capacity = 0.17 MGD
Proposed Firm Capacity = 0.50 MGD
Sherwood LS
Firm Capacity = 0.43 MGD
Matheson Park LS
North Wastewater Treatment Plant
Permitted Capacity
Average Daily Flow = 1.5 MGD
Peak Flow = 4.5 MGD
Hicks LS
Firm Capacity = 0.56 MGD
Proposed Firm Capacity to 1.2 MGD
Persimmon LS
To Be Decommissioned
FM 2920 LS
Firm Capacity = 0.58 MGD
Decommission Lift Station and 6-inch Force Main
Private LS
South Wastewater Treatment Plant
Permitted Capacity
Average Daily Flow = 1.5 MGD
Peak Flow = 6.0 MGD
Proposed Average Daily Flow Capacity = 3.0 MGD
Proposed Average Daily Flow Capacity = 4.5 MGD (by Buildout)
Proposed LS
Proposed Firm Capacity = 0.15 MGD
Rocky Road LS
New Telge LS
Proposed Firm Capacity = 1.1 MGD
South Wastewater Treatment Plant
Permitted Capacity
Average Daily Flow = 1.5 MGD
Peak Flow = 6.0 MGD
Proposed Average Daily Flow Capacity = 3.0 MGD
Proposed Average Daily Flow Capacity = 4.5 MGD
0 1,400 2,800
SCALE IN FEET

12.1.1 Ongoing Wastewater Capital Improvement Projects

The following projects are under design or planned to begin design in 2023. A brief description of planned improvements is provided for each project.

Project A – South WWTP Expansion

The City is currently designing and expansion to the South WWTP from 1.5 MGD to 3.0 MGD average day flow capacity.

Project B – FM 2920 Lift Station Consolidation

The City is currently designing a 24-inch and 30-inch line project to consolidate the FM 2920 Lift Station and convey flows to the existing 30-inch gravity line along Holderreith Road to the South WWTP.

Project B – Rudolph Road Sewer Extension

This project includes the construction of a new 8-inch water line along Rudolph Road.

12.1.2 Capacity CIP: Five-Year Projects (2023 - 2028)

Project 1 – Replacement 10/12-inch Gravity Lines along Alma/James Streets

Project Description: This project includes the construction of a new 10-inch gravity line to replace the existing 8-inch line along Alma Street/James Street. This project also includes the construction of a new 12-inch gravity line to replace the existing 8-inch line along Magnolia Street.

Project Driver: The hydraulic model indicates a lack of capacity in these lines to convey existing peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Project 2 – Hicks Lift Station (LS) Expansion to 1.2 MGD

Project Description: This project includes expansion of the Hicks Lift Station firm pumping capacity to 1.2 MGD.

Project Driver: Expansion of the firm pumping capacity at the Hicks Lift Station is needed to serve existing and future peak flows to this lift station. The lift station wet well and force main have capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, piping and valves.

Project 3 – 18-Inch South Persimmon Gravity Line

Project Description: This project includes the construction of a new 18-inch gravity line along South Persimmon Street between the Persimmon Lift Station and Medical Complex Drive.

Project Driver: The recommended gravity line will replace the existing 6-inch line and is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53). This project is also sized to consolidation of the existing Persimmon Lift Station.

Project 4 – 10/18-inch along Lutheran Church Road and FM 2920 Rd Gravity Line

Project Description: This project includes the construction of a new 10-inch gravity line along Lutheran Church Road and an 18-inch gravity line along FM 2920. The eastern part of the 18-inch line segment will replace the existing 12-inch line along FM 2920.

Project Driver: The recommended gravity lines are sized to convey the projected future peak wet weather wastewater flows from anticipated future developments in this area to the new 24-inch line (**Project B**). This line will allow the anticipated developments along the Lutheran Church Road to connect to the City's collection system.

Project 5 – Replacement 21/24-inch North Willow Street Gravity Line

Project Description: This project includes the construction of a new 21/24-inch gravity line to replace the existing 8-inch line along North Willow Street to East Hufsmith Road.

Project Driver: The hydraulic model indicates a lack of capacity in the existing 15-inch lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Project 6 – 21-inch Gravity Line along Humble Road

Project Description: This project includes the construction of a new 21-inch gravity line along Humble Road from the anticipated Telge development to the new 30-inch line.

Project Driver: This project will allow conveyance of projected future wastewater flows from the anticipated developments along Telge Road to the City's South WWTP. The new 21-inch gravity line is proposed to connect to the currently under-design 30-inch FM 2920 consolidation line along Holderrieth Road (**Project B**).

Note: During the development of the project, it is recommended that the City review the necessity for water **Project 10**.

Project 7 – Wastewater Master Plan and Impact Fee Update

Project Description: This project includes an update to the City's Wastewater Master Plan and Impact Fee study.

Project Drivers: Texas Local Government Code (TLGC) Chapter 395 requires 5-year updates to the water and wastewater impact fees.

12.1.3 Capacity CIP: Ten-Year Projects (2029 - 2033)

Project 8 – New 1.1 MGD Telge Lift Station, 8-inch Force Main, and 21-inch Gravity Main

Project Description: This project includes the construction of a new 1.1 MGD lift station west of Telge Road along with an 8-inch force main. The project also includes the construction of a 21-inch gravity line that will connect to the proposed 21-inch line along Humble Road (**Project 4**).

Project Driver: The proposed lift station, force main and gravity main are sized to serve projected future peak wet weather flows from the anticipated developments along Telge Road.

Project 9 – Snook Lane Lift Station Expansion to 0.5 MGD

Project Description: This project includes expansion of the Snook Lane Lift Station firm pumping capacity to 0.5 MGD. This project also includes the construction of a 6-inch force main.

Project Driver: It is understood that the Snook Lane Lift Station currently has firm pumping capacity of approximately 0.17 MGD and a 4-inch force main. To serve projected future peak wet weather wastewater flows, the firm pumping capacity needs to be increased to 0.5 MGD . The lift station wet well has capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, and piping and valves and a replacement 6-inch force main sized to convey future peak wet weather wastewater flows.

Note: It is recommended that the lift station's existing pumping capacity is evaluated during the preliminary design phase of this project.

12.1.4 Capacity CIP: Twenty-Five-Year Projects (Through 2048)

Project 10 – South WWTP 1.5 MGD Expansion to 4.5 MGD

Project Description: This project includes the expansion of the South WWTP from 3.0 MGD to 4.5 MGD permitted ADF capacity.

Project Driver: The wastewater flow projections developed during this master plan show a need for additional average day flow treatment capacity at the South WWTP beyond the ongoing expansion to 3.0 MGD (**Project A**).

Note: It is recommended that the expansion sizing is reevaluated during future master planning efforts.

Project 11 – Replacement 18-Inch Gravity Line Along Inwood Street to West Hufsmith Road

Project Description: This project includes the construction of a new 18-inch gravity line to replace the existing 15-inch line along Inwood Street to Hufsmith Road.

Project Driver: The hydraulic model indicates a lack of capacity in the existing 15-inch lines to convey the projected future peak wet weather flow based on minimum slope assumption of this 15-inch line. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Note: It is recommended that this line is surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Project 12 – Hunterwood Lift Station Expansion to 0.22 MGD

Project Description: This project includes expansion of the Hunterwood Lift Station firm pumping capacity to 0.22 MGD.

Project Driver: Expansion of the firm pumping capacity at the Hunterwood Lift Station is needed to serve existing and future peak flows to the lift station. The lift station wet well and force main have capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, piping and valves.

Note: It is recommended that the lift station's existing pumping capacity is evaluated during the preliminary design phase of this project.

Project 13 – New 315 gpm Lift Station, 6-Inch Force Main, and 10-Inch Gravity Line and Replacement 12/15-Inch Gravity Line

Project Description: This project includes the construction of a new 315 gpm Lift Station at the northern part of the city near Quinn Road, 6-inch force main and 10-inch gravity main to Zion Road. The project also includes construction of replacement 12" and 15" lines along Zion Road.

Project Driver: The recommended lift station, force main, and 10-inch gravity lines are sized to convey projected future flows near Quinn Road to the existing collection system along Zion Road. The 12-inch and 15-inch lines will replaced the existing 10-inch and 12-inch lines along Zion Road. The capacity provided by these gravity lines will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53) with the projected future wastewater flows in the area.

Note: It is recommended that the existing 10-inch and 12-inch lines along Zion Road are surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Project 14 – Replacement 18-Inch Gravity Line Along Highway 249 near Hicks Lift Station

Project Description: This project includes the construction of a new 18-inch gravity line to replace the existing 12-inch line along Highway 249.

Project Driver: The hydraulic model indicates a lack of capacity in these lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Note: It is recommended that this line is surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Project 15 – Replacement 24-Inch Gravity Line Along Hufsmith Road

Project Description: This project includes the construction of a new 24-inch gravity line to replace the existing 20-inch line along Hufsmith Road from North Cherry Street to Peach Street.

Project Driver: The hydraulic model indicates a lack of capacity in the existing 20-inch lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Project 16 – New 0.15 MGD Lift Station and 2-Inch Force Main at Boudreaux Estates

Project Description: This project includes the construction of a new 0.15 MGD Lift Station.

Project Driver: The recommended lift station and force mains are sized to convey the projected future peak wet weather wastewater flows. These lines will allow the septic users in Boudreaux Estates to connect to the City's collection system.

12.1.5 Timeline Pending Water Projects

Project T1: Wastewater SCADA System

Project Description: This project includes the selection and installation of a Supervisory Control and Data Acquisition (SCADA) system at the wastewater treatment plants and city-owned lift stations in the collection system.

Project Driver: A wastewater SCADA system would allow City staff to optimize the operation of the wastewater system.

Project T2: Wastewater SCADA Master Plan

Project Description: This project includes the development of a Wastewater SCADA Master Plan.

Project Driver: A wastewater SCADA Master Plan would allow City staff to optimize the operation of the wastewater system.

12.2 SANITARY SEWER EVALUATION STUDY (SSES) PROJECTS

The flow monitoring data collected during this study were utilized to create a prioritized plan to address the sewer basins contributing the greatest amounts of inflow and infiltration (I/I) throughout the City. The City's 2017 Wastewater Master Plan included recommendation for SSES projects based on flow monitoring data collected during November, 2016 to January, 2017. Since then, the City has conducted SSES work at their highest priority basin from the 2017 recommendations. The SSES CIP projects discussed in **Section 12.2.2** below provide updated recommendations and prioritization for City's SSES program. FNI considered the results of the sewer basin I/I analysis discussed in **Section 8.0** along with other parameters such as peaking factor, depth of flow, surcharging, I/I volume etc**.** Planning level costs were developed for the recommended SSES projects in high and medium I/I basins in 2023 dollars. These costs are based on previous similar SSES studies and include allowances for contingencies and engineering.

12.2.1 SSES Basin Prioritization

The recommended basin prioritization for the SSES CIP Projects is shown in **Table 12-4.** These five basins are being recommended for SSES field investigation and rehabilitation design and construction activities with the goal of reducing I/I in the collection system. Two of the basins measured **high** levels of I/I and three of the basins measured **medium** levels of I/I.

Table 12-4: Wastewater SSES CIP Basin Prioritization

SSES CIP Project Ranking	Flow Meter ID	WWTP Basin	Gravity Lines (LF)	No. of MHs	Average I/I (Gal/LF/in)
1	**N-03**	North	47,403	196	**7.8**
2	**N-01**	North	19,171	69	**5.0**
3	**S-02**	South	65,240	247	**3.6**
4	**S-03**	South	46,711	224	**3.5**
5	**S-05**	South	23,862	100	**3.3**

N-05 Flow Monitoring Basin Evaluation

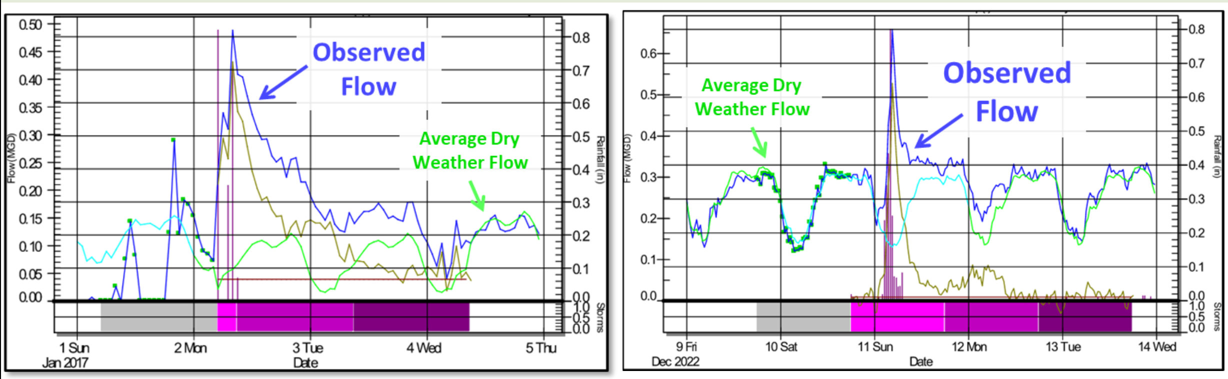
As discussed in **Section 8.0**, the N-05 Basin measured high levels of I/I during the 2023 flow monitoring period. However, the N-05 basin has been excluded from the prioritized list of basins for the SSES CIP.

This is due to the City's recent investment in I/I reduction efforts in this basin and a measured improvement in the basin's response to wet weather, as summarized in the discussion below and shown on **Figure 12-2**.

The N-05 basin was experienced the highest normalized I/I rate (12.6 Gal/LF/in) among all the basins during the City's 2017 Wastewater Master Plan flow monitoring. The 2017 master plan recommended SSES inspection, rehabilitation and repairs in this basin as a near-term improvement project. In response to this, the City conducted I/I reduction effort in this basin prior to the beginning of the 2023 master plan flow monitoring period. FNI reviewed and compared the I/I rates and wet weather response in the N-05 basin between the 2023 and 2017 flow monitoring data. The comparison of wet weather response in this basin during 2017 and 2023 flow monitoring is shown on **Figure 12-2**. The figure shows that the basin's response to a similar wet weather event has improved significantly, with the flow returning to average dry weather rates more quickly than before. It is recommended that the City continue to evaluate this basin's performance during future flow monitoring efforts.

Figure 12-2: N-05 2017 and 2023 Flow Monitoring Wet Weather Response Comparison

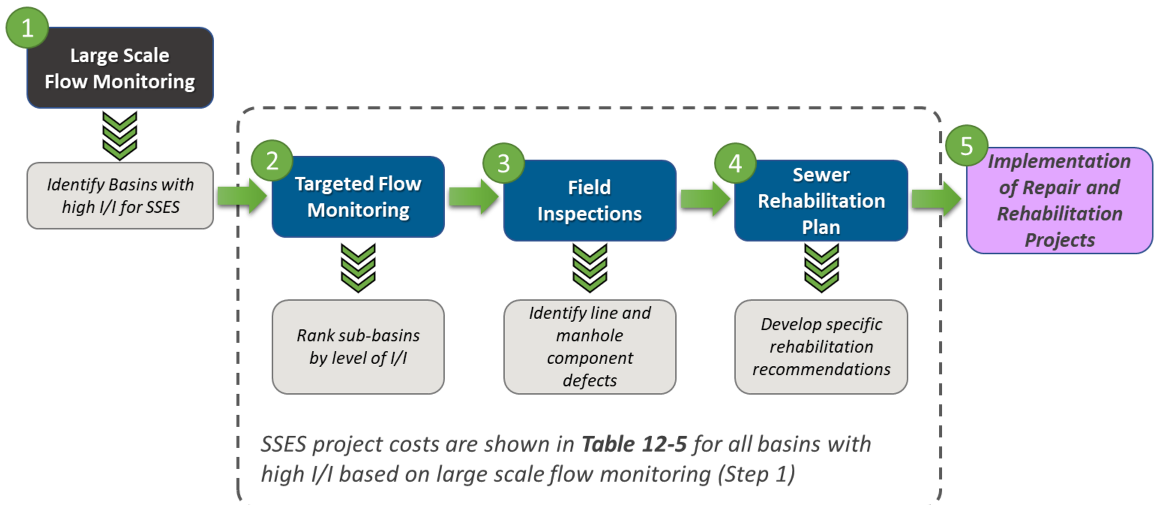
2016/2017 Flow Monitoring	2022/2023 Flow Monitoring
Storm Event: 1/2/2017	Storm Event: 12/10/2022
Rainfall Intensity: 0.5 in/hr	Rainfall Intensity: 0.4 in/hr



12.2.2 SSES Capital Improvements Plan

FNI recommends an SSES project approach for I/I reduction as shown on **Figure 12-3**.

Figure 12-3: SSES Project Approach for I/I Reduction



<u>*SSES Steps*</u>

1. The **Large Scale Flow Monitoring** was completed as part of this wastewater master plan project and is described in **Section 8.0**. Ten flow meters and two rain gauges were installed throughout the collection system.
2. The **Targeted Flow Monitoring** breaks down the five high and medium I/I basins into smaller sub-basins and ranks these sub-basins based on observed I/I.
3. Results from Targeted Flow Monitoring inform decisions for the **Field Inspections**, that may include manhole inspection and CCTV/smoke testing on lines, in the appropriate sub basins.
4. Based on the findings from Field Inspections, a prioritized **Sewer Rehabilitation Plan** will be developed for the SSES areas.
5. The Sewer Rehabilitation Plan is implemented.

Step 1 was completed as part of this *Wastewater Master Plan Update.* The flow monitoring discussed in **Section 8.0** served as the large-scale flow monitoring discussed above.

Budgetary costs for *Steps 2 – 4* were developed for each of the SSES basins in 2023 dollars utilizing the unit costs show in **Table 12-5**. These unit costs are based on previous similar SSES studies. GIS information was utilized to approximate the linear footage of gravity lines and number of manholes for field inspections (Step 3). The inspection costs include smoke testing, line cleaning, and closed-caption television (CCTV) inspections and manhole survey/inspection. The planning level costs also include allowances for 25% contingencies and approximate program management and rehab design costs. It should be noted that the costs in the SSES Potential Plan are only for investigation and design activities, and do not include the capital cost of infrastructure rehabilitation or replacement. The updated SSES Plan with planning level SSES costs in 2023 dollars are presented in **Table 12-6. Figure 12-4** shows the proposed SSES basin prioritization.

Table 12-5: SSES Planning Level Unit Costs

Line Cleaning	Cost/LF
6-10-inch	$1.70
12-15-inch	$2.10
16-18-inch	$5.30
19-24-inch	$7.90
25-30-inch	$9.50
CCTV Inspection	**Cost/LF**
<21-inch	$1.60
>21-inch	$2.10
Smoke Testing	
Cost/LF	$0.50
Manhole Inspection	
Cost/Manhole	$135.00
Contingency	
Percentage	25%
Focused Flow Monitoring	
Cost/Flow Meter	$8,500

The SSES projects identified in **Table 12-6** will result in targeted recommendations for manhole and gravity line rehabilitation based on field inspected data. This results in a more efficient use of rehab dollars to target specific assets based on known condition information.

Annual Rehabilitation Budget

It is recommended for the City to budget at least $4.0M per year for sewer rehabilitation efforts as directed by the SSES projects.

Table 12-6: SSES Project Costs (Steps 2-4)

SSES Basin No.	Master Plan Flow Meter Basins			SSES Cost in 2023 Dollars *(Costs do not include Inflation)*					
	Flow Meter Basin No.	Length of Gravity Lines (LF)	No. of Manholes	Focused Flow Monitoring(1)	Field Inspection(2)	Program Management(3)	Total SSES (w Contingency(4))	Rehab Design(3)	Total SSES Project
SSES - 1	**N-03**	47,403	196	$17,000	$94,200	$75,000	$214,000	$100,000	**$314,000**
SSES - 2	**N-01**	19,171	69		$75,100	$75,000	$168,900	$100,000	**$268,900**
SSES - 3	**S-02**	65,240	247	$25,500	$152,900	$125,000	$348,000	$150,000	**$498,000**
SSES - 4	**S-03**	46,711	224	$17,000	$146,500	$75,000	$279,400	$100,000	**$379,400**
SSES - 5	**S-05**	23,862	100		$94,700	$75,000	$193,400	$100,000	**$293,400**

(1) Approximately $8,500 per flow meter with at least 2 meters per basin. The number of flow meters utilized is based on 25,000 LF per flow meter and is to be revisited during SSES project implementation.

(2) Assumption of field inspection cost for 50% of lines and manholes for basins over 25,000 LF and 100% of lines and manholes for basins within 25,000 LF. Smoke testing for 10% of the gravity lines in the basin.

(3) Approximate program management and development of rehab recommendations based on basin size and are to be revised based on field inspection data.

(4) SSES costs include 25% contingency on flow monitoring and field inspection efforts.

FIGURE 12-4
CITY OF TOMBALL
2023 WATER AND WASTEWATER MASTER PLAN UPDATE
SSES BASIN PRIORITIZATION

APPENDIX A
Water CIP
Planning Level Opinion of Probable Construction Costs (OPCC)

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 1, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 1 **Phase:** 5-Year

Project Name: **16-inch Water Line along Hufsmith Road**

Project Description:

This project includes the construction of a new 16-inch water line along Hufsmith Road from Ulrich Road to Timber Trails Lake Place.

Project Drivers:

The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for maintaining the Ulrich Elevated Storage Tank water level and increasing available fire flow. This project will help alleviate areas of low water system pressure in the northwest area of the City.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	16" WL & Appurtenances	3,700	LF	$ 320	$ 1,184,000
2	30" Boring and Casing	500	LF	$ 660	$ 330,000
3	Pavement Repair	400	LF	$ 150	$ 60,000
				SUBTOTAL:	**$ 1,574,000**
		CONTINGENCY		30%	$ 472,200
				SUBTOTAL:	**$ 2,046,200**
		ENG/SURVEY		15%	$ 307,000
				SUBTOTAL:	**$ 2,353,200**
				Estimated Project Total:	**$ 2,353,200**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 6-2.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* | **September 1, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 2 | **Phase:** 5-Year

Project Name: **6-Inch Water Line along Clayton St and 12-inch Water Line Along Oak Street**

Project Description:

This project includes the construction of new 6-inch Water Lines to replace the existing 2-inch water lines along Clayton Street and a 12-inch water line to replace the existing 6-inch water line along Oak Street.

Project Drivers:

The recommended water lines along Clayton Street will replace the existing small diameter line and improve existing system capacity restrictions. The 12-inch water line along Oak Street is sized to serve existing and future peak hourly demand and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	6" WL & Appurtenances	2,100	LF	$ 120	$ 252,000
2	Pavement Repair	2,100	LF	$ 150	$ 315,000
3	12" WL & Appurtenances	500	LF	$ 240	$ 120,000
4	Pavement Repair	200	LF	$ 150	$ 30,000
				SUBTOTAL:	**$ 717,000**
		CONTINGENCY		30%	$ 215,100
				SUBTOTAL:	**$ 932,100**
		ENG/SURVEY		15%	$ 139,900
				SUBTOTAL:	**$ 1,072,000**
				Estimated Project Total:	**$ 1,072,000**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 6-2.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* | **September 1, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 3 | **Phase:** 5-Year

Project Name: **12-Inch Water Line from Lizzie Lane to FM 2920**

Project Description:

This project includes the construction of a 12-inch water line to replace the existing 6-inch water line along South Persimmon St from Medical Complex Dr to FM 2920. The project also includes construction of a 16-inch water line connection from South Persimmon Street to the East Water Plant.

Project Drivers:

The recommended water lines are sized to convey water from the East Water Plant to the system and future peak hourly demand.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	2,400	LF	$ 240	$ 576,000
2	Pavement Repair	1,200	LF	$ 150	$ 180,000
				SUBTOTAL:	**$ 756,000**
		CONTINGENCY		30%	$ 226,800
				SUBTOTAL:	**$ 982,800**
		ENG/SURVEY		15%	$ 147,500
				SUBTOTAL:	**$ 1,130,300**
				Estimated Project Total:	**$ 1,130,300**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 6-2.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 1, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 4 **Phase:** 5-Year

Project Name: **12/16-inch Water Line along Main Street**

Project Description:

This project includes the construction of a 12-inch water line to replace the existing 6-inch water line along Main Street from near Persimmon Street to Snook Lane. This project also includes the construction of a 16-inch water line to replace the existing 6-inch water line along Main Street from Oak Street to Snook Lane.

Project Drivers:

The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for maintaining the Ulrich Elevated Storage Tank water level and increasing available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	16" WL & Appurtenances	5,600	LF	$ 320	$ 1,792,000
2	12" WL & Appurtenances	900	LF	$ 240	$ 216,000
3	30" Boring and Casing	1,000	LF	$ 660	$ 660,000
4	Pavement Repair	3,000	LF	$ 150	$ 450,000
				SUBTOTAL:	**$ 3,118,000**
		CONTINGENCY		30%	$ 935,400
				SUBTOTAL:	**$ 4,053,400**
		ENG/SURVEY		15%	$ 608,100
				SUBTOTAL:	**$ 4,661,500**
				Estimated Project Total:	**$ 4,661,500**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 6-2.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 1, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 5 **Phase:** 5-Year

Project Name: **12-inch Water Line along Medical Complex Drive**

Project Description:

This project includes the construction of a 12-inch water line along Medical Complex Drive from near South Persimmon St to Mulberry St to coincide with Medical Complex Drive expansion.

Project Drivers:

The recommended water line will connect the existing 12-inch water lines along Agg Road and is sized to meet future peak hourly demands.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	2,700	LF	$ 240	$ 648,000
2	20" Boring and Casing	300	LF	$ 440	$ 132,000
				SUBTOTAL:	**$ 780,000**
		CONTINGENCY		30%	$ 234,000
				SUBTOTAL:	**$ 1,014,000**
		ENG/SURVEY		15%	$ 152,100
				SUBTOTAL:	**$ 1,166,100**
		EASEMENT ACQUISITION			$ 80,000
				SUBTOTAL:	**$ 1,246,100**
				Estimated Project Total:	**$ 1,246,100**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 6-2.

City of Tomball

Water CIP **September 2, 2023**

CIP Project Number: 6 **Phase:** 5-Year

Project Name: **Water Master Plan & Impact Fee Update**

Project Description:

This project includes an update to the City's Water Master Plan and Impact Fee study.

Project Drivers:

Texas Local Government Code (TLGC) Chapter 395 requires 5-year updates to the water and wastewater impact fees.

Study Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Water Master Plan & Impact Fee Update	1	EA	$ 250,000	$ 250,000
				Estimated Project Total:	**$ 250,000**

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 7 **Phase:** 10-Year

Project Name: **12-inch Telge Water Line**

Project Description:

This project includes the construction of a 12-inch water line along Telge Road at the western part of the City.

Project Drivers:

This water line will connect the City's existing water distribution system along FM 2920 with water lines along Boudreaux Road to create a loop and connect the system with the future Telge Water Plan (Project 8). This project will help serve peak hour demand in the City's system and future Telge area customers.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	21,000	LF	$ 240	$ 5,040,000
2	20" Boring and Casing	1,500	LF	$ 440	$ 660,000
3	Pavement Repair	4,500	LF	$ 150	$ 675,000
				SUBTOTAL:	**$ 6,375,000**
		CONTINGENCY		30%	$ 1,912,500
				SUBTOTAL:	**$ 8,287,500**
		ENG/SURVEY		15%	$ 1,243,200
				SUBTOTAL:	**$ 9,530,700**
				Estimated Project Total:	**$ 9,530,700**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* | **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 8 | **Phase:** 10-Year

Project Name: New West Water Plant Phase 1

Project Description:

This project includes the construction of a new water plant in the southwest of the city limits near Telge Road and SH 99 Grand Parkway intersection with 2,000 gpm water supply, a 2,500 firm capacity pump station and a 0.75 MG ground storage tank.

Project Drivers:

This new water plant will help meet the future projected demands in the City's water distribution system.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	2,500 gpm Pump Station	1	EA	$ 5,400,346	$ 5,400,346
2	0.75 MG Ground Storage Tank	1	LS	$ 1,387,500	$ 1,387,500
3	2,000 gpm Groundwater Well	1	EA	$ 2,880,184	$ 2,880,184
				SUBTOTAL:	**$ 9,668,100**
		CONTINGENCY		30%	$ 2,900,500
				SUBTOTAL:	**$ 12,568,600**
		ENG/SURVEY		20%	$ 2,513,800
				SUBTOTAL:	**$ 15,082,400**
		SITING STUDY			$ 75,000
				SUBTOTAL:	**$ 15,157,400**
				Estimated Project Total:	**$ 15,157,400**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 9 — **Phase:** 10-Year

Project Name: **12-inch Water Line along SH 249**

Project Description:

This project includes the construction of a 12-inch water line along SH 249 from Humble Road towards Holderreith Road.

Project Drivers:

The recommended water line will improve connectivity and is sized to serve future peak hourly demand and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	2,000	LF	$ 240	$ 480,000
2	20" Boring and Casing	200	LF	$ 440	$ 88,000
3	Pavement Repair	800	LF	$ 150	$ 120,000
				SUBTOTAL:	**$ 688,000**
		CONTINGENCY		30%	$ 206,400
				SUBTOTAL:	**$ 894,400**
		ENG/SURVEY		15%	$ 134,200
				SUBTOTAL:	**$ 1,028,600**
				Estimated Project Total:	**$ 1,028,600**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 10 **Phase:** 25-Year

Project Name: **12-Inch Telge Road and Holderrieth Road Water Line**

Project Description:

This project includes the construction of a 12-inch water line along Holderreith Road and Humble Road to Telge Road.

Project Drivers:

The recommended water line will connect the existing system water lines to the proposed future Telge water line (Project 7) and is sized to serve future peak hourly demand and increase available fire flow.
Note: The timing of this project should be evaluated based on the timeline for development along Telge Road.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	10,000	LF	$ 240	$ 2,400,000
2	20" Boring and Casing	1,000	LF	$ 440	$ 440,000
3	Pavement Repair	4,000	LF	$ 150	$ 600,000
4	Easement Acquisition	6,600	LF	$ 25	$ 165,000
				SUBTOTAL:	**$ 3,605,000**
		CONTINGENCY		30%	$ 1,081,500
				SUBTOTAL:	**$ 4,686,500**
		ENG/SURVEY		15%	$ 703,000
				SUBTOTAL:	**$ 5,389,500**
				Estimated Project Total:	**$ 5,389,500**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* | **September 2, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 11 | **Phase:** 25-Year

Project Name: FM 2920 Water Plant Pump Station Expansion to add 1,000 gpm Firm Pumping Capacity, 1.5 MG Ground Storage Capacity and 1,600 gpm Supply Capacity

Project Description:

This project includes an expansion of the FM 2920 pump station to 4,000 gpm firm capacity. This project also includes the construction of an additional 1.5 MG ground storage capacity and an additional 1,600 gpm of water supply. This project also includes the construction of a new 16-inch water line parallel to the existing 16-inch.

Project Drivers:

The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	1,000 gpm Pump Station	1	EA	$ 2,160,138	$ 2,160,138
2	0.5 MG Elevated Storage Tank	3	LS	$ 2,250,000	$ 6,750,000
3	1,600 gpm Groundwater Well	1	EA	$ 2,304,147	$ 2,304,147
4	16" WL & Appurtenances	1,000	LF	$ 320	$ 320,000
5	30" Boring and Casing	100	LF	$ 660	$ 66,000
6	Pavement Repair	100	LF	$ 150	$ 15,000
				SUBTOTAL:	**$ 11,615,300**
		CONTINGENCY		30%	$ 3,484,600
				SUBTOTAL:	**$ 15,099,900**
		ENG/SURVEY		20%	$ 3,020,000
				SUBTOTAL:	**$ 18,119,900**
				Estimated Project Total:	**$ 18,119,900**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 12 — **Phase:** 25-Year

Project Name: West Water Plant Expansion to add 1,000 gpm Firm Pumping Capacity, 1.0 MG Ground Storage Capacity, and 500 gpm Water Supply

Project Description:

This project includes the expansion of the West Water Plant pump station to 3,500 gpm firm capacity. This project also includes the construction of additional 1.0 MG ground storage capacity and additional 500 gpm of supply.

Project Drivers:

The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	1,000 gpm Pump Station	1	EA	$ 2,160,138	$ 2,160,138
2	0.5 MG Elevated Storage Tank	2	LS	$ 2,250,000	$ 4,500,000
3	500 gpm Groundwater Well	1	EA	$ 720,046	$ 720,046
				SUBTOTAL:	**$ 7,380,200**
		CONTINGENCY		30%	$ 2,214,100
				SUBTOTAL:	**$ 9,594,300**
		ENG/SURVEY		20%	$ 1,918,900
				SUBTOTAL:	**$ 11,513,200**
				Estimated Project Total:	**$ 11,513,200**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 13 **Phase:** 25-Year

Project Name: 16-Inch Parallel Water Line along Ulrich Road

Project Description:

This project includes the construction of a parallel 16-inch water line from the Ulrich Road elevated storage tank to Zion Road.

Project Drivers:

The recommended water line is sized to serve future peak hourly demand and provide distribution system capacity for increasing available fire flow. This project will help alleviate areas of low water system pressure in the northwest area of the City.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	16" WL & Appurtenances	1,400	LF	$ 320	$ 448,000
2	30" Boring and Casing	200	LF	$ 660	$ 132,000
3	Pavement Repair	600	LF	$ 150	$ 90,000
				SUBTOTAL:	**$ 670,000**
		CONTINGENCY		30%	$ 201,000
				SUBTOTAL:	**$ 871,000**
		ENG/SURVEY		15%	$ 130,700
				SUBTOTAL:	**$ 1,001,700**
				Estimated Project Total:	**$ 1,001,700**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 14 **Phase:** 25-Year

Project Name: **Replacement 1.5 MG Ulrich EST, Decommissioning of Pine Street EST and new 0.4 MG G**

Project Description:

This project includes the construction of a new 1.5 MG EST at Ulrich Road, demolition of the existing Ulrich Road and Pine Street ESTs, and construction of a new 0.4 MG ground storage tank at Pine Street Water Plant.

Project Drivers:

The new larger Ulrich Road EST tank is sized to meet the future elevated storage capacity requirements in the city's water system and improve system hydraulics. The new GST at the Pine Street Water Plant will provide additional ground storage at the Pine Street Water Plant.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Elevated Storage Tank Demolition	2	EA	$ 25,000	$ 50,000
2	1.5 MG Elevated Storage Tank	1	LS	$ 6,750,000	$ 6,750,000
				SUBTOTAL:	**$ 6,800,000**
		CONTINGENCY		30%	$ 2,040,000
				SUBTOTAL:	**$ 8,840,000**
		ENG/SURVEY		20%	$ 1,768,000
				SUBTOTAL:	**$ 10,608,000**
				Estimated Project Total:	**$ 10,608,000**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

FREESE AND NICHOLS

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 15 **Phase:** 25-Year

Project Name: **East Water Plant Expansion to add 3,000 gpm Pumping, 2.0 MG Ground Storage, and 2,500 gpm Supply Capacity**

Project Description:

This project includes the expansion of the East Water Plant pump station from 3,000 gpm firm capacity to 6,000 gpm firm capacity. This project also includes the construction of one 2.0 MG ground storage tanks and two 1,250 gpm off-site groundwater wells.

Project Drivers:

The recommended supply and pumping capacity expansion is sized to meet projected future system demands. The recommended ground storage tanks are sized to provide 8 hours of projected maximum day demand storage.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	3,000 gpm Pump Station	1	EA	$ 6,480,415	$ 6,480,415
2	2.0 MG Ground Storage Tank	1	LS	$ 3,700,000	$ 3,700,000
3	1,250 gpm Groundwater Well	2	EA	$ 1,800,115	$ 3,600,230
4	10" WL & Appurtenances	4,000	LF	$ 200	$ 800,000
				SUBTOTAL:	**$ 14,580,700**
		CONTINGENCY		30%	$ 4,374,300
				SUBTOTAL:	**$ 18,955,000**
		ENG/SURVEY		20%	$ 3,791,000
				SUBTOTAL:	**$ 22,746,000**
				Estimated Project Total:	**$ 22,746,000**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 16 **Phase:** 25-Year

Project Name: **12-Inch Water Line along Snook Lane**

Project Description:

This project includes the construction of a 12-inch water line replacing the existing 6-inch water lines along Snook Lane from Huffsmith Road to Main Street.

Project Drivers:

The recommended water line is sized to serve future peak hourly demand and improve available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" WL & Appurtenances	4,900	LF	$ 240	$ 1,176,000
2	20" Boring and Casing	500	LF	$ 440	$ 220,000
3	Pavement Repair	1,000	LF	$ 150	$ 150,000
				SUBTOTAL:	**$ 1,546,000**
		CONTINGENCY		30%	$ 463,800
				SUBTOTAL:	**$ 2,009,800**
		ENG/SURVEY		15%	$ 301,500
				SUBTOTAL:	**$ 2,311,300**
				Estimated Project Total:	**$ 2,311,300**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: T1 **Phase:** Timeline Pending

Project Name: **8-inch Water Line in Corral RV Park**

Project Description:

This project includes the construction of a new 8-inch water line from the 8-inch Corral RV Park water line to the 12-inch water line along Medical Complex Drive.

Project Drivers:

The recommended water lines are sized to increase available fire flow and serve future peak hourly demand.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	8" WL & Appurtenances	300	LF	$ 160	$ 48,000
2	Pavement Repair	200	LF	$ 150	$ 30,000
				SUBTOTAL:	**$ 78,000**
		CONTINGENCY		30%	$ 23,400
				SUBTOTAL:	**$ 101,400**
		ENG/SURVEY		15%	$ 15,300
				SUBTOTAL:	**$ 116,700**
				Estimated Project Total:	**$ 116,700**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

FREESE AND NICHOLS

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

CIP Project Number: T2 **Phase:** Timeline Pending

Project Name: **8-inch Water Line along Liberty Lane**

Project Description:

This project includes the construction of an 8-inch water line from the 6-inch water line along Liberty Lane to the 12-inch water line along Hufsmith Road.

Project Drivers:

The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	8" WL & Appurtenances	500	LF	$ 160	$ 80,000
2	Pavement Repair	100	LF	$ 150	$ 15,000
				SUBTOTAL:	**$ 95,000**
		CONTINGENCY		30%	$ 28,500
				SUBTOTAL:	**$ 123,500**
		ENG/SURVEY		15%	$ 18,600
				SUBTOTAL:	**$ 142,100**
				Estimated Project Total:	**$ 142,100**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

CIP Project Number: T3 **Phase:** Timeline Pending

Project Name: **8-inch Water Line along Stella Lane**

Project Description:

This project includes the construction of 8-inch water lines along Stella Lane from Camille Drive to Capella Circle.

Project Drivers:

The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	8" WL & Appurtenances	1,700	LF	$ 160	$ 272,000
2	Pavement Repair	200	LF	$ 150	$ 30,000
				SUBTOTAL:	**$ 302,000**
		CONTINGENCY		30%	$ 90,600
				SUBTOTAL:	**$ 392,600**
		ENG/SURVEY		15%	$ 58,900
				SUBTOTAL:	**$ 451,500**
				Estimated Project Total:	**$ 451,500**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

CIP Project Number: T4 **Phase:** Timeline Pending

Project Name: **8-inch Water Line along Julia Lane**

Project Description:

This project includes the construction of 8-inch water lines along Julia Lane from Lost Creek Road to Quinn Road.

Project Drivers:

The water lines are recommended to connect existing dead end water lines and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	8" WL & Appurtenances	1,500	LF	$ 160	$ 240,000
2	Pavement Repair	200	LF	$ 150	$ 30,000
				SUBTOTAL:	**$ 270,000**
		CONTINGENCY		30%	$ 81,000
				SUBTOTAL:	**$ 351,000**
		ENG/SURVEY		15%	$ 52,700
				SUBTOTAL:	**$ 403,700**
				Estimated Project Total:	**$ 403,700**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Water CIP - Opinion of Probable Construction Cost* **September 2, 2023**

CIP Project Number: T5 **Phase:** Timeline Pending

Project Name: **8-inch Water Line along Helen Lane**

Project Description:

This project includes the construction of 8-inch water lines along Helen Lane to Spring Hollow Drive.

Project Drivers:

The water line is recommended to connect existing dead end water lines and increase available fire flow.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	8" WL & Appurtenances	800	LF	$ 160	$ 128,000
2	Pavement Repair	100	LF	$ 150	$ 15,000
				SUBTOTAL:	**$ 143,000**
		CONTINGENCY		30%	$ 42,900
				SUBTOTAL:	**$ 185,900**
		ENG/SURVEY		15%	$ 27,900
				SUBTOTAL:	**$ 213,800**
				Estimated Project Total:	**$ 213,800**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

APPENDIX B
Wastewater CIP
Planning Level Opinion of Probable Construction Costs (OPCC)

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 1 **Phase:** 5-Year

Project Name: **Replacement 10/12-inch Gravity Lines along Alma/James Streets**

Project Description:

This project includes the construction of a new 10-inch gravity line to replace the existing 8-inch line along Alma Street/James Street. This project also includes the construction of a new 12-inch gravity line to replace the existing 8-inch line along Magnolia Street.

Project Drivers:

The hydraulic model indicates a lack of capacity in these lines to convey existing peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	12" Pipe 8- 16 feet deep	2,700	LF	$ 216	$ 583,200
2	10" Pipe 8- 16 feet deep	3,000	LF	$ 180	$ 540,000
3	48" Diameter Manhole (8 - 16 feet deep)	20	EA	$ 16,000	$ 320,000
4	Pavement Repair	5,700	LF	$ 150	$ 855,000
				SUBTOTAL:	**$ 2,298,200**
		CONTINGENCY		30%	$ 689,500
				SUBTOTAL:	**$ 2,987,700**
		ENG/SURVEY		15%	$ 448,200
				SUBTOTAL:	**$ 3,435,900**
				Estimated Project Total:	**$ 3,435,900**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 2 **Phase:** 5-Year

Project Name: **Hicks Lift Station (LS) Expansion to 1.2 MGD**

Project Description:

This project includes expansion of the Hicks Lift Station firm pumping capacity to 1.2 MGD.

Project Drivers:

Expansion of the firm pumping capacity at the Hicks Lift Station is needed to serve existing and future peak flows to this lift station. The lift station wet well and force main have capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, piping and valves.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Hicks Pumps	1	LS	$ 240,000	$ 240,000
2	Hicks Electrical	1	LS	$ 291,000	$ 291,000
3	Hicks Generator	1	LS	$ 132,000	$ 132,000
4	Hicks Piping and Valves	1	LS	$ 121,000	$ 121,000
				SUBTOTAL:	**$ 784,000**
		CONTINGENCY		30%	$ 235,200
				SUBTOTAL:	**$ 1,019,200**
		ENG/SURVEY		20%	$ 203,900
				SUBTOTAL:	**$ 1,223,100**
				Estimated Project Total:	**$ 1,223,100**

<u>*Note:*</u> The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 3 — **Phase:** 5-Year

Project Name: 18-Inch South Persimmon Gravity Line

Project Description:

This project includes the construction of a new 18-inch gravity line along South Persimmon Street between the Persimmon Lift Station and Medical Complex Drive.

Project Drivers:

The recommended gravity line will replace the existing 6-inch line and is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53). This project is also sized to consolidation of the existing Persimmon Lift Station.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Decommission Persimmon Lift Station	1	EA	$ 50,000	$ 50,000
2	18" Gravity Line	5,700	LF	$ 360	$ 2,052,000
3	60" Diameter Manhole (8 - 16 feet deep)	8	EA	$ 20,000	$ 160,000
4	30" Boring and Casing	300	LF	$ 660	$ 198,000
5	Pavement Repair	1,800	LF	$ 150	$ 270,000
				SUBTOTAL:	**$ 2,730,000**
		CONTINGENCY		30%	$ 819,000
				SUBTOTAL:	**$ 3,549,000**
		ENG/SURVEY		15%	$ 532,400
				SUBTOTAL:	**$ 4,081,400**
				Estimated Project Total:	**$ 4,081,400**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 4 — **Phase:** 5-Year

Project Name: **10/18-inch along Lutheran Church Road and FM 2920 Rd Gravity Line**

Project Description:

This project includes the construction of a new 10-inch gravity line along Lutheran Church Road and an 18-inch gravity line along FM 2920. The eastern part of the 18-inch line segment will replace the existing 12-inch line along FM 2920.

Project Drivers:

The recommended gravity lines are sized to convey the projected future peak wet weather wastewater flows from anticipated future developments in this area to the new 24-inch line (Project B). This line will allow the anticipated developments along the Lutheran Church Road to connect to the City's collection system.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	10" Pipe > 16 feet deep	3,400	LF	$ 200	$ 680,000
2	18" Pipe 8- 16 feet deep	5,900	LF	$ 324	$ 1,911,600
3	48" Diameter Manhole (16 - 24 feet deep)	7	EA	$ 20,000	$ 140,000
4	60" Diameter Manhole (8 - 16 feet deep)	8	EA	$ 20,000	$ 160,000
5	30" Boring and Casing	300	LF	$ 660	$ 198,000
6	Pavement Repair	1,000	LF	$ 150	$ 150,000
				SUBTOTAL:	**$ 3,239,600**
		CONTINGENCY		30%	$ 971,900
				SUBTOTAL:	**$ 4,211,500**
		ENG/SURVEY		15%	$ 631,800
				SUBTOTAL:	**$ 4,843,300**
		EASEMENT ACQUISITION			$ 300,000
				SUBTOTAL:	**$ 5,143,300**
				Estimated Project Total:	**$ 5,143,300**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 5 **Phase:** 5-Year

Project Name: **Replacement 21/24-inch North Willow Street Gravity Line**

Project Description:

This project includes the construction of a new 21/24-inch gravity line to replace the existing 8-inch line along North Willow Street to East Hufsmith Road.

Project Drivers:

The hydraulic model indicates a lack of capacity in the existing 15-inch lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" Pipe 8- 16 feet deep	60	LF	$ 432	$ 25,920
2	21" Pipe < 8 feet deep	3,100	LF	$ 357	$ 1,106,700
3	60" Diameter Manhole (8 - 16 feet deep)	4	EA	$ 20,000	$ 80,000
4	Pavement Repair	100	LF	$ 150	$ 15,000
				SUBTOTAL:	**$ 1,227,700**
		CONTINGENCY		30%	$ 368,400
				SUBTOTAL:	**$ 1,596,100**
		ENG/SURVEY		15%	$ 239,500
				SUBTOTAL:	**$ 1,835,600**
				Estimated Project Total:	**$ 1,835,600**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

**Planning Level Cost in 2023 Dollars*

CIP Project Number: 6 — **Phase:** 5-Year

Project Name: **21-inch Gravity Line along Humble Road**

Project Description:

This project will allow conveyance of projected future wastewater flows from the anticipated developments along Telge Road to the City's South WWTP. The new 21-inch gravity line is proposed to connect to the currently under-design 30-inch FM 2920 consolidation line along Holderrieth Road (Project B).

Project Drivers:

This project will allow conveyance of projected future wastewater flows from the anticipated developments along Telge Road to the City's South WWTP. The new 21-inch gravity line is proposed to connect to the currently under-design 30 – inch FM 2920 consolidation line along Holderrieth Road (Project B).
Note: During the development of the project, it is recommended that the City review the necessity for water Project 10.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	21" Pipe 8- 16 feet deep	6,600	LF	$ 378	$ 2,494,800
2	60" Diameter Manhole (8 - 16 feet deep)	9	EA	$ 20,000	$ 180,000
3	36" Boring and Casing	550	LF	$ 792	$ 435,600
4	Pavement Repair	200	LF	$ 150	$ 30,000
				SUBTOTAL:	**$ 3,140,400**
		CONTINGENCY		30%	$ 942,200
				SUBTOTAL:	**$ 4,082,600**
		ENG/SURVEY		15%	$ 612,400
				SUBTOTAL:	**$ 4,695,000**
		EASEMENT ACQUISITION			$ 95,000
				SUBTOTAL:	**$ 4,790,000**
				Estimated Project Total:	**$ 4,790,000**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

Project costs in future dollars are provided in the 2023 Water and Wastewater Master Plan Update Report in Table 12-2.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 1, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 7 **Phase:** 5-Year

Project Name: **Wastwater Master Plan & Impact Fee Update**

Project Description:

This project includes an update to the City's Wastewater Master Plan and Impact Fee study.

Project Drivers:

Texas Local Government Code (TLGC) Chapter 395 requires 5-year updates to the water and wastewater impact fees.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Wastewater Master Plan and Impact Fee Study Update	1	EA	$ 250,000	$ 250,000
				Estimated Project Total:	**$ 250,000**

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

**Planning Level Cost in 2023 Dollars*

CIP Project Number: 8 **Phase:** 10-Year

Project Name: New 1.1 MGD Telge Lift Station, 8-inch Force Main, and 21-inch Gravity Main

Project Description:

This project includes the construction of a new 1.1 MGD lift station west of Telge Road along with an 8-inch force main. The project also includes the construction of a 21-inch gravity line that will connect to the proposed 21-inch line along Humble Road (Project 4).

Project Drivers:

The proposed lift station, force main and gravity main are sized to serve projected future peak wet weather flows from the anticipated developments along Telge Road.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	21" Pipe 8- 16 feet deep	5,100	LF	$ 378	$ 1,927,800
2	60" Diameter Manhole (8 - 16 feet deep)	7	EA	$ 20,000	$ 140,000
3	36" Boring and Casing	100	LF	$ 792	$ 79,200
4	8" Force Main < 8 feet deep	2,400	LF	$ 144	$ 345,600
5	New Telge LS Pumps	1	LS	$ 220,000	$ 220,000
6	New Telge LS Electrical	1	LS	$ 273,000	$ 273,000
7	New Telge LS Generator	1	LS	$ 121,000	$ 121,000
8	New Telge LS Piping and Valves	1	LS	$ 121,000	$ 121,000
9	Pavement Repair	300	LF	$ 150	$ 45,000
				SUBTOTAL:	**$ 3,272,600**
		CONTINGENCY		30%	$ 981,800
				SUBTOTAL:	**$ 4,254,400**
		ENG/SURVEY		20%	$ 850,900
				SUBTOTAL:	**$ 5,105,300**
				Estimated Project Total:	**$ 5,105,300**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 9 — **Phase:** 10-Year

Project Name: **Snook Lane Lift Station Expansion to 0.5 MGD**

Project Description:

This project includes expansion of the Snook Lane Lift Station firm pumping capacity to 0.5 MGD. This project also includes the construction of a 6-inch force main.

Project Drivers:

It is understood that the Snook Lane Lift Station currently has firm pumping capacity of approximately 0.17 MGD and a 4-inch force main. To serve projected future peak wet weather wastewater flows, the firm pumping capacity needs to be increased to 0.5 MGD . The lift station wet well has capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, and piping and valves and a replacement 6-inch force main sized to convey future peak wet weather wastewater flows.
Note: It is recommended that the lift station’s existing pumping capacity is evaluated during the preliminary design phase of this project.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Snook Lane Pumps	1	LS	$ 100,000	$ 100,000
2	Snook Lane Electrical	1	LS	$ 165,000	$ 165,000
3	Snook Lane Generator	1	LS	$ 55,000	$ 55,000
4	Snook Lane Piping and Valves	1	LS	$ 98,000	$ 98,000
5	6" Force Main < 8 feet deep	510	LF	$ 108	$ 55,080
				SUBTOTAL:	**$ 473,100**
		CONTINGENCY		30%	$ 142,000
				SUBTOTAL:	**$ 615,100**
		ENG/SURVEY		20%	$ 123,100
				SUBTOTAL:	**$ 738,200**
				Estimated Project Total:	**$ 738,200**

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It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

FREESE AND NICHOLS

Wastewater CIP - Opinion of Probable Construction Cost* | **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 10 **Phase:** 25-Year

Project Name: **South WWTP 1.5 MGD Expansion to 4.5 MGD**

Project Description:

This project includes the expansion of the South WWTP from 3.0 MGD to 4.5 MGD permitted ADF capacity.

Project Drivers:

The wastewater flow projections developed during this master plan show a need for additional average day flow treatment capacity at the South WWTP beyond the ongoing expansion to 3.0 MGD (Project A).
Note: It is recommended that the expansion sizing is reevaluated during future master planning efforts.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	1.5 MGD WWTP Expansion	1	EA	$ 42,000,000	$ 42,000,000
				SUBTOTAL:	**$ 42,000,000**
		CONTINGENCY		30%	$ 12,600,000
				SUBTOTAL:	**$ 54,600,000**
		ENG/SURVEY		20%	$ 10,920,000
				SUBTOTAL:	**$ 65,520,000**
				Estimated Project Total:	**$ 65,520,000**

Note: The FNI Team has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable construction costs provided are based on the information available at the time of preparation and represent only the FNI Team's judgment based on industry experience. The FNI Team cannot and does not guarantee the proposals, bids, or actual construction costs will not vary from the opinion of probable construction costs It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 11 **Phase:** 25-Year

Project Name: **Replacement 18-Inch Gravity Line Along Inwood Street to West Hufsmith Road**

Project Description:

This project includes the construction of a new 18-inch gravity line to replace the existing 15-inch line along Inwood Street to Hufsmith Road.

Project Drivers:

The hydraulic model indicates a lack of capacity in the existing 15-inch lines to convey the projected future peak wet weather flow based on minimum slope assumption of this 15-inch line. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).
Note: It is recommended that this line is surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	18" Pipe 8- 16 feet deep	3,000	LF	$ 324	$ 972,000
2	60" Diameter Manhole (8 - 16 feet deep)	8	EA	$ 20,000	$ 160,000
3	36" Boring and Casing	500	LF	$ 792	$ 396,000
				SUBTOTAL:	**$ 1,528,000**
		CONTINGENCY		30%	$ 458,400
				SUBTOTAL:	**$ 1,986,400**
		ENG/SURVEY		15%	$ 298,000
				SUBTOTAL:	**$ 2,284,400**
				Estimated Project Total:	**$ 2,284,400**

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City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* September 2, 2023

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 12 **Phase:** 25-Year

Project Name: **Hunterwood Lift Station Expansion to 0.22 MGD**

Project Description:

This project includes expansion of the Hunterwood Lift Station firm pumping capacity to 0.22 MGD.

Project Drivers:

Expansion of the firm pumping capacity at the Hunterwood Lift Station is needed to serve existing and future peak flows to the lift station. The lift station wet well and force main have capacity to serve the projected flows. The expansion includes replacement pumps, electrical, generator, piping and valves.
Note: It is recommended that the lift station’s existing pumping capacity is evaluated during the preliminary design phase of this project.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Hunterwood Pumps	1	LS	$ 44,000	$ 44,000
2	Hunterwood Electrical	1	LS	$ 115,000	$ 115,000
3	Hunterwood Generator	1	LS	$ 25,000	$ 25,000
4	Hunterwood Piping and Valves	1	LS	$ 88,000	$ 88,000
				SUBTOTAL:	**$ 272,000**
		CONTINGENCY		30%	$ 81,600
				SUBTOTAL:	**$ 353,600**
		ENG/SURVEY		20%	$ 70,800
				SUBTOTAL:	**$ 424,400**
				Estimated Project Total:	**$ 424,400**

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City of Tomball

FREESE AND NICHOLS

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

***Planning Level Cost in 2023 Dollars**

CIP Project Number: 13 **Phase:** 25-Year

Project Name: **New 315 gpm Lift Station, 6-Inch Force Main, and 10-Inch Gravity Line and Replacement 12/15-Inch Gravity Line**

Project Description:

This project includes the construction of a new 315 gpm Lift Station at the northern part of the city near Quinn Road, 6-inch force main and 10-inch gravity main to Zion Road. The project also includes construction of replacement 12” and 15” lines along Zion Road.

Project Drivers:

The recommended lift station, force main, and 10-inch gravity lines are sized to convey projected future flows near Quinn Road to the existing collection system along Zion Road. The 12-inch and 15-inch lines will replaced the existing 10-inch and 12-inch lines along Zion Road. The capacity provided by these gravity lines will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53) with the projected future wastewater flows in the area.

Note: It is recommended that the existing 10-inch and 12-inch lines along Zion Road are surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Proposed LS Wet Well	1	LS	$ 116,000	$ 116,000
2	Proposed LS Pumps	1	LS	$ 92,000	$ 92,000
3	Proposed LS Electrical	1	LS	$ 159,000	$ 159,000
4	Proposed LS Piping and Valves	1	LS	$ 95,000	$ 95,000
5	6" Force Main < 8 feet deep	2,700	LF	$ 108	$ 291,600
6	10" Pipe 8- 16 feet deep	1,700	LF	$ 180	$ 306,000
7	12" Pipe 8- 16 feet deep	950	LF	$ 216	$ 205,200
8	15" Pipe 8- 16 feet deep	1,800	LF	$ 270	$ 486,000
9	48" Diameter Manhole (8 - 16 feet deep)	12	EA	$ 16,000	$ 192,000
10	18" Boring and Casing	200	LF	$ 396	$ 79,200
11	20" Boring and Casing	100	LF	$ 440	$ 44,000
12	30" Boring and Casing	200	LF	$ 660	$ 132,000
13	Pavement Repair	1,800	LF	$ 150	$ 270,000
				SUBTOTAL:	**$ 2,468,000**
		CONTINGENCY		30%	$ 740,400
				SUBTOTAL:	**$ 3,208,400**
		ENG/SURVEY		20%	$ 641,700
				SUBTOTAL:	**$ 3,850,100**
				Estimated Project Total:	**$ 3,850,100**

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City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 14 — **Phase:** 25-Year

Project Name: **Replacement 18-Inch Gravity Line Along Highway 249 near Hicks Lift Station**

Project Description:

This project includes the construction of a new 18-inch gravity line to replace the existing 12-inch line along Highway 249.

Project Drivers:

The hydraulic model indicates a lack of capacity in these lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).
Note: It is recommended that this line is surveyed during the preliminary engineering phase of the project in order to identify the line capacity.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	18" Pipe 8- 16 feet deep	1,400	LF	$ 324	$ 453,600
2	60" Diameter Manhole (8 - 16 feet deep)	4	EA	$ 20,000	$ 80,000
3	36" Boring and Casing	200	LF	$ 792	$ 158,400
4	Pavement Repair	600	LF	$ 150	$ 90,000
				SUBTOTAL:	**$ 782,000**
		CONTINGENCY		30%	$ 234,600
				SUBTOTAL:	**$ 1,016,600**
		ENG/SURVEY		15%	$ 152,500
				SUBTOTAL:	**$ 1,169,100**
				Estimated Project Total:	**$ 1,169,100**

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City of Tomball

FREESE AND NICHOLS

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: 15 **Phase:** 25-Year

Project Name: **Replacement 24-Inch Gravity Line Along Hufsmith Road**

Project Description:

This project includes the construction of a new 24-inch gravity line to replace the existing 20-inch line along Hufsmith Road from North Cherry Street to Peach Street.

Project Drivers:

The hydraulic model indicates a lack of capacity in the existing 20-inch lines to convey the projected future peak wet weather flow. The recommended replacement gravity line is sized to convey the existing and projected future peak wet weather wastewater flows. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	24" Pipe 8- 16 feet deep	1,100	LF	$ 432	$ 475,200
2	60" Diameter Manhole (8 - 16 feet deep)	3	EA	$ 20,000	$ 60,000
3	36" Boring and Casing	200	LF	$ 792	$ 158,400
4	Pavement Repair	500	LF	$ 150	$ 75,000
5	Easement Acquisition	1,100	LF	$ 25	$ 27,500
				SUBTOTAL:	**$ 796,100**
		CONTINGENCY		30%	$ 238,900
				SUBTOTAL:	**$ 1,035,000**
		ENG/SURVEY		15%	$ 155,300
				SUBTOTAL:	**$ 1,190,300**
				Estimated Project Total:	**$ 1,190,300**

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City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* — **September 2, 2023**

Planning Level Cost in 2023 Dollars

CIP Project Number: 16 **Phase:** 25-Year

Project Name: **New 0.15 MGD Lift Station and 2-Inch Force Main at Boudreaux Estates**

Project Description:

This project includes the construction of a new 0.15 MGD Lift Station.

Project Drivers:

The recommended lift station and force mains are sized to convey the projected future peak wet weather wastewater flows. The capacity provided by these gravity lines will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53). These lines will allow the septic users in Boudreaux Estates to connect to the City's collection system.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Proposed Boudreaux LS Wet Well	1	LS	$ 109,000	$ 109,000
2	Proposed Boudreaux LS Pumps	1	LS	$ 30,000	$ 30,000
3	Proposed Boudreaux LS Electrical	1	LS	$ 102,000	$ 102,000
4	Proposed Boudreaux LS Piping and Valves	1	LS	$ 76,000	$ 76,000
5	2" Force Main < 8 feet deep	1,700	LF	$ 36	$ 61,200
6	Easement Acquisition	1,700	LF	$ 25	$ 42,500
				SUBTOTAL:	**$ 420,700**
		CONTINGENCY		30%	$ 126,300
				SUBTOTAL:	**$ 547,000**
		ENG/SURVEY		20%	$ 109,400
				SUBTOTAL:	**$ 656,400**
				Estimated Project Total:	**$ 656,400**

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City of Tomball

Wastewater CIP **September 2, 2023**

CIP Project Number: T1 **Phase:** Timeline Pending

Project Name: **Wastewater SCADA Master Plan**

Project Description:

This project includes the development of a Wastewater SCADA Master Plan.

Project Drivers:

A wastewater SCADA Master Plan would allow City staff to optimize the operation of the wastewater system.

Study Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Wastewater SCADA Master Plan	1	EA	$ 200,000	$ 200,000
				Estimated Project Total:	**$ 200,000**

City of Tomball

Wastewater CIP - Opinion of Probable Construction Cost* **September 2, 2023**

****Planning Level Cost in 2023 Dollars***

CIP Project Number: T2 **Phase:** Timeline Pending

Project Name: **Wastewater SCADA System**

Project Description:

This project includes the selection and installation of a Supervisory Control and Data Acquisition (SCADA) system at the wastewater treatment plants and city-owned lift stations in the collection system.

Project Drivers:

A wastewater SCADA system would allow City staff to optimize the operation of the wastewater system.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Wastewater SCADA System	1	EA	$ 1,960,000	$ 1,960,000
				SUBTOTAL:	**$ 1,960,000**
		CONTINGENCY		30%	$ 588,000
				SUBTOTAL:	**$ 2,548,000**
		ENG/SURVEY		20%	$ 509,600
				SUBTOTAL:	**$ 3,057,600**
				Estimated Project Total:	**$ 3,057,600**

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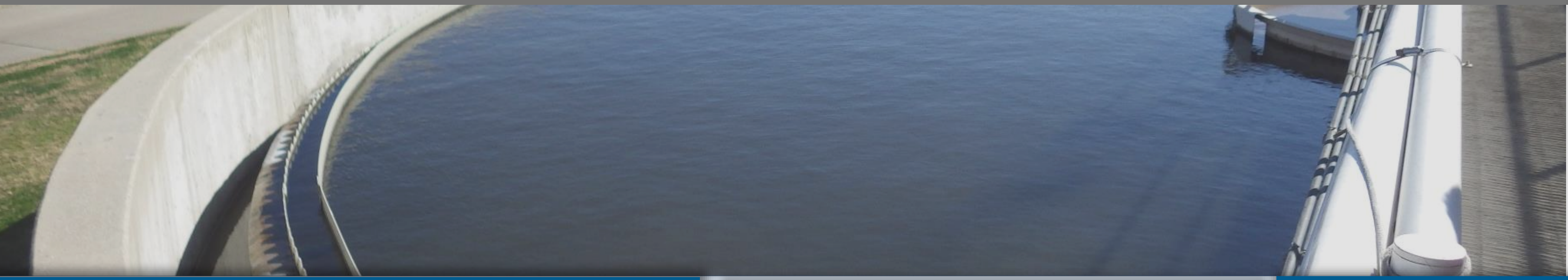
It is recommended the City survey the existing line inverts during the preliminary engineering phase of this project to confirm the existing capacity.

CITY OF TOMBALL

2023 WATER AND WASTEWATER MASTER PLAN UPDATE

APPENDICES C-K



PREPARED FOR:

City of Tomball

PREPARED BY:

Freese and Nichols, Inc.
11200 Broadway St., Suite 2320
Pearland, Texas 77584
832-456-4700

FREESE AND NICHOLS

APPENDIX C
Known Future Development Information

City of Tomball
Water and Wastewater Master Plan
Known Future Residential Developments

Development ID	Name[1]	Planning Year[1]	Developable Area[2] 80% of Area	Units/Acre[3]	No. of Units[4]	Population[5]
R-03	Hicks and Quinn Residential Neighborhood	10	1.2	4.5	6	16
R-06	Bethel Heights Subdivision	10	5.3	4.5	25	65
R-07	Residential	5	12.6	1.0	5	13
R-08	Cherry Pines	5	25.6	7.0	126	328
R-39	New 130 homes	5			130	338
R-13	Telge Tract	5	800	4.0	350	910
		10			950	2,470
		25			1,900	
R-15	Hines Rayburn Development	5	83.2		291	757
R-19	SF Residential (6,000 sf lots)	5	1.5	7.0	6	16
R-22	SF Residential (43,560) sf lots)	5	5.6	1.0	3	8
R-23	Townhomes	5	27.8		113	390
R-25	Multi Family	5	0.9	13.0	11	29
R-26	Residential	5	30.5	4.5	137	357
R-27	Residential	5	22.9		65	169
R-28	Residential	5	15.8		145	377
R-29	Residential	5	39.5	4.5	90	234
R-30	Residential	5	75.4		350	910
R-31	Multi Family	5	14.3		360	936
R-32	Residential	5	0.0		50	130
R-33	Tomball Senior Village	5	2.8	13.0	37	37
R-34	Senior Living	5	3.7		48	48
R-35	Church Adjacent	10	148.9	4.5	670	1,743
R-37	Additional Septic	25			100	260
R-38	Residential	5			177	460
R-36	Telge Well/ Septic	10	434.8		290	754
R-37	Additional Septic	25			100	
R-12	East Side of Telge Road (Northeast part of City)	25	44.5	4.5	600	
	Total		**1,797**		**7,136**	**11,753**

(1) Developments and projected planning years identified by the City's Planning Department.

(2) Developments follow Parcel boundaries and Development area calculated in GIS with assumption of 80% of the acreage being developable.

(3) Units per acres from City's 2009 Comprehensive Plan or from lot size/density per city input.

(4) Impact fee eligible number of units calcualted using input from City or units/acre information.

(5) Population projections using 2.6 persons per dwelling unit assumption from City's 2009 Comprehensive Plan.

City of Tomball
Water and Wastewater Master Plan
Known Future Commercial Developments

Development ID	Name[1]	Planning Year[1]	Developable Area[2] 80% of Area
C-06	Tennis Ventures	5	3.1
C-09b	Commercial	5	4.1
C-11e	General Electric/Office	5	2.0
C-11f	General Electric/Office	5	2.2
C-12	Commercial	10	5.0
C-14	Future Commercial	5	15.1
C-16	Gas Station	10	11.6
C-17	Commercial	10	6.7
C-19a	Commercial (No Concept Yet)	5	14.8
C-19c	Commercial	5	1.5
C-22	Commercial	5	6.5
C-25a	Commercial	5	6.4
C-26	Commercial	5	4.8
C-29[4][5]	Grand Parkway Town Center[3][4]	5	65.0
C-30[5]	HCID17 Commercial	5	16.1
C-32	Retail/Office/Warehouse	5	2.4
C-33	Zoned Industrial expecting office warehouse	5	5.5
C-35	Church	5	25.4
C-36	Office/Warehouse	10	0.8
C-37	Office/Warehouse	10	30.1
C-38a	Costco	5	14.1
C-38b	Commercial	5	6.7
C-41	Retail	5	2.9
C-42	Retail	5	1.6
C-43	Commercial	5	4.7
C-45a	Commercial (No Concept Yet)	5	11.8
C-45c	Commercial (No Concept Yet)	10	20.5
C-46	Commercial (No Concept Yet)	5	3.9
C-48	Commercial (No Concept Yet)	10	9.1
C-49	Commercial (No Concept Yet)	10	5.7
C-50	Commercial	10	9.7
C-51	Commercial (No Concept Yet)	10	19.7
C-54	Commercial (No Concept Yet)	10	5.4
C-57	Winfrey Lane	5	52.2
C-58	Commercial	10	57.7
C-60	Commercial	5	7.8
C-61	Commercial	5	4.2
C-62	Commercial	5	3.5
C-63	Commercial	5	2.2
C-64	Commercial	5	9.4
C-65	Commercial	10	10.2
C-66	Commercial	10	44.1
C-67	Commercial	5	5.9
C-68	Commercial	5	2.6
C-70	Commercial	5	1.8
C-71	Commercial	5	9.7
C-72	Commercial	5	10.3
C-73	Commercial	5	1.7
C-74	Commercial	5	5.6
C-75	Commercial	5	72.8
C-76	Commercial	10	5.9
C-77	Commercial	10	54.0
C-79	Crawfish Restaurant	5	4.2
C-78	Salem Lutheran Church & School	5	22.7
C-02	Speculative Lease Building	25	12.0
C-03	Coastal Power Systems	25	3.3
C-07	Scottish Inn	25	13.0
C-15	Commercial	25	30.5
Total			**791.8**

(1) Developments and projected planning years identified by the City's Planning Department.

(2) Developments follow Parcel boundaries and Development area calculated in GIS with assumption of 80% of the acreage being developable.

(3) Grand Parkway Acreage from Brochure

(4) Nabor acreage per City input

APPENDIX D
2022 Water Model Update and Calibration TM

TECHNICAL MEMORANDUM
Water Model Update and Calibration

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

11200 Broadway Street, Suite 2320 • Pearland, Texas 77584 • 832-456-4700 • FAX 832-456-4701 www.freese.com

TO: David Esquivel, PE, City of Tomball

CC: Jessica Rogers, City of Tomball
Meagan Mageo, City of Tomball

FROM: Richard Weatherly, PE, Freese and Nichols, Inc.
Ishita Rahman, PE, Freese and Nichols, Inc.

SUBJECT: Water Model Update and Calibration

DATE: March 2, 2022

PROJECT: Water and Wastewater Impact Fee Study Update – Phase I

STATE OF TEXAS
RICHARD WEATHERLY
100211
LICENSED
PROFESSIONAL ENGINEER
3/2/2022
Richard Weatherly
FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

1.0 INTRODUCTION AND BACKGROUND

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1.0 Introduction and Background 1
2.0 Existing Water Distribution System 2
3.0 Water Production 7
4.0 Pressure Testing 9
5.0 Hydraulic Model Development and Calibration 11
6.0 Next Steps 18

Freese and Nichols, Inc. (FNI) was retained in 2021 by the City of Tomball (City) to update the City's water distribution system hydraulic model. This project is considered to be Phase I of Tomball's *Water and Wastewater Impact Fee Update* project, which is anticipated to continue in 2022. The goals of this Phase I study were to update the City's existing water distribution system model that was developed during the *2018 Water Master Plan* with recently constructed infrastructure and calibrate the model to observed field conditions. The water model update was performed in parallel with the *2021 Utility GIS Update* project and the applicable GIS database infrastructure updates were incorporated into the hydraulic model. The major elements of the scope of this project included:

- Water production and demand data collection and review
- Field pressure testing
- Update of the distribution system hydraulic model
- Extended Period Simulation (EPS) hydraulic model calibration

2.0 EXISTING WATER DISTRIBUTION SYSTEM

The City of Tomball's water system consists of a network of water lines, two water plants and two elevated storage tanks. **Figure 2-1** shows the City's existing water distribution system (TCEQ Water System No. TX1010026) which is discussed further in the following sections.

2.1 PRESSURE PLANE

The City's water distribution system currently has one pressure plane, with ground elevations ranging between 149 feet and 230 feet above mean sea level (MSL). The pressure plane operates at a static hydraulic gradient of 338 feet MSL established by the Pine Street and Ulrich Road elevated storage tanks.

2.2 WATER SUPPLY

2.2.1 Groundwater

Tomball's water demands are served by five groundwater wells. The groundwater well information is provided in **Table 2-1**. The existing wells are associated with either the Pine Street or FM 2920 water plants.

Table 2-1: Existing Groundwater Wells

Plant Name	Well Name	Tested Capacity(1) gpm	Tested Capacity(1) MGD
Pine Street Water Plant	Well #1	537	0.77
	Well #2	1,889	2.72
	School Well #2	707	1.02
FM 2920 Water Plant	Well #5	763	1.09
	Well #6	546	0.78
	TOTAL	**4,442**	**6.39**

(1) From Well Performance Test Reports completed in October 2020 and May 2021, included in **Appendix A**

2.2.2 Surface Water

The City of Tomball falls under the North Harris County Regional Water Authority (NHCRWA), which was established to help water providers comply with groundwater reduction plans set forth by the Harris-Galveston Subsidence District. NHCRWA maintains infrastructure to convey treated surface water from the City of Houston Northeast Water Purification Plant to customers in North Harris County. NHCRWA is currently developing infrastructure to provide surface water to the City of Tomball after 2025. The City is actively discussing future surface water requirements with NHCRWA.

FIGURE 2-1
CITY OF TOMBALL
EXISTING WATER SYSTEM
PRESSURE RECORDER LOCATIONS

2.3 PUMPING AND STORAGE FACILITIES

Tomball has two pump stations: Pine Street and FM 2920. The City has a total system pumping capacity of 8.64 MGD and a firm system pumping capacity of 7.20 MGD, which is the capacity with the largest pump out of service. **Table 2-2** provides a summary of pumping facilities. In addition to booster pumping, the City also utilizes elevated storage tanks (ESTs) to maintain system pressures. Each of the water plants includes one ground storage tank (GST), and three booster pumps. **Table 2-3** provides a summary of storage capacities.

Table 2-2: Distribution (Booster) Pumping Facilities

Facility Name	Pump Number	Rated Capacity(1) (gpm)	Rated Capacity(1) (MGD)
Pine Street Water Plant	1	1,000	1.44
	2	1,000	1.44
	3	1,000	1.44
FM 2920 Water Plant	1	1,000	1.44
	2	1,000	1.44
	3	1,000	1.44
	TOTAL	**6,000**	**8.64**
	FIRM	***5,000***	***7.20***

(1) From City Staff

Table 2-3: Storage Facilities

Storage Type	Facility Name	Address	Capacity(1) (MG)
Ground	Pine Street Water Plant	802 S Pine Drive	0.40
	FM 2920 Water Plant	15902 FM 2920	0.50
	TOTAL GROUND STORAGE		**0.90**
Elevated	Pine Street Water Plant	802 S Pine Drive	0.75
	Ulrich Road	1331 Ulrich St	0.50
	TOTAL ELEVATED STORAGE		**1.25**

(1) From City Staff

Hydropneumatic Tank

Tomball currently has a 5,000 gallon hydropneumatic tank at the FM 2920 Water Plant. It should be noted that for TCEQ system analyses, total storage does not include hydropneumatic tank capacity (290.45(a)(4)).

2.4 WATER LINES

According to the City's water system Geographic Information System (GIS) updated as part of the *2021 Utility GIS Update* project, the City of Tomball's water system consists of 125 miles of active City-owned water distribution lines, ranging in size from 1-inch to 18-inches. **Figure 2-2** illustrates the percentage of water line length by diameter, and **Figure 2-3** provides a summary of water line materials. **Figure 2-4** illustrates the portion of total water line length by age of the water line.

Figure 2-2: Water Line Diameter by Length

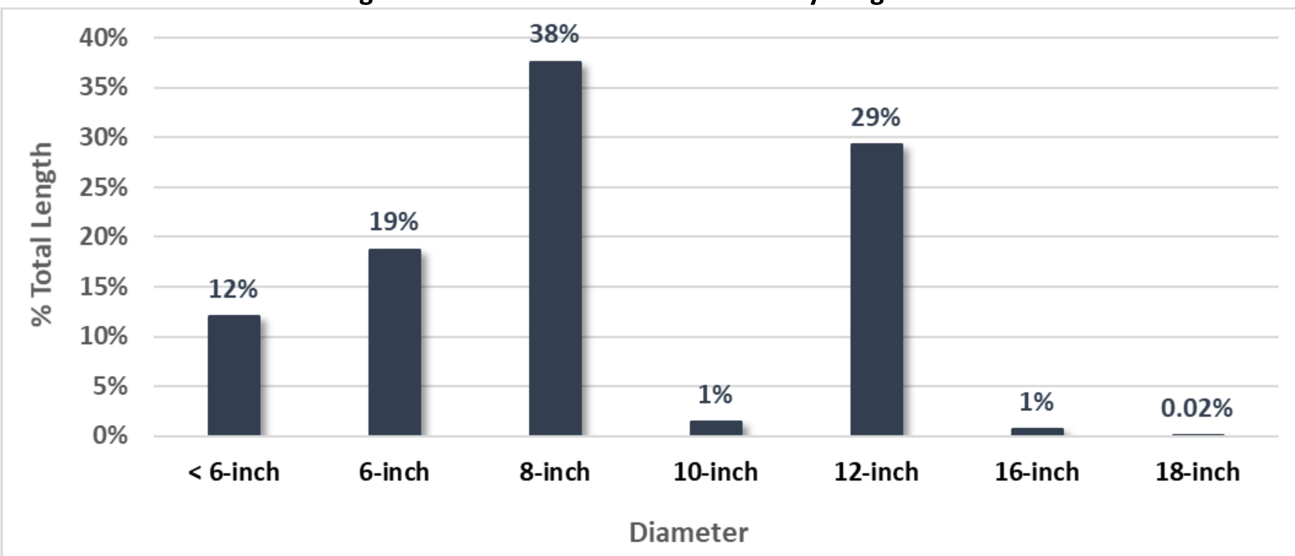
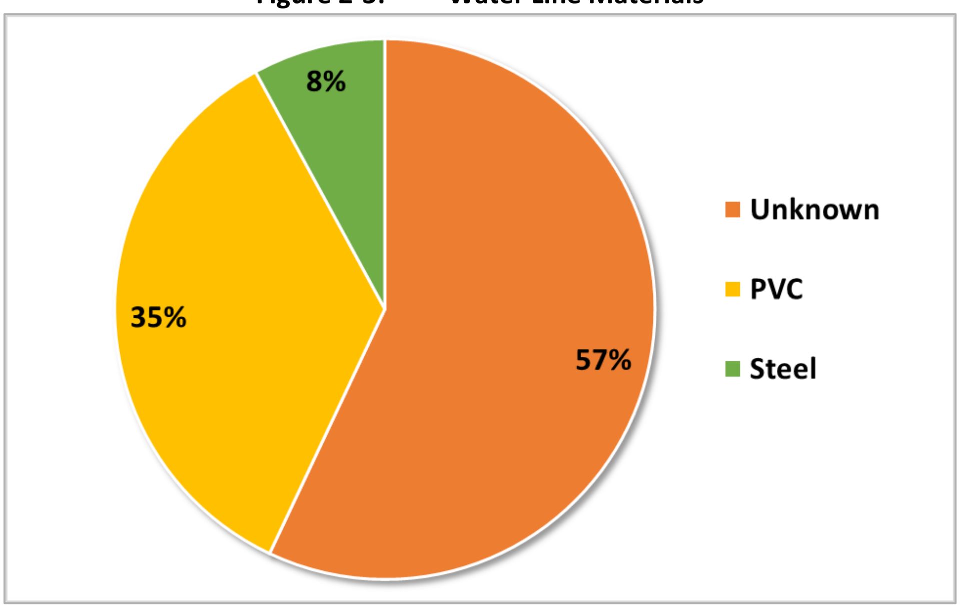
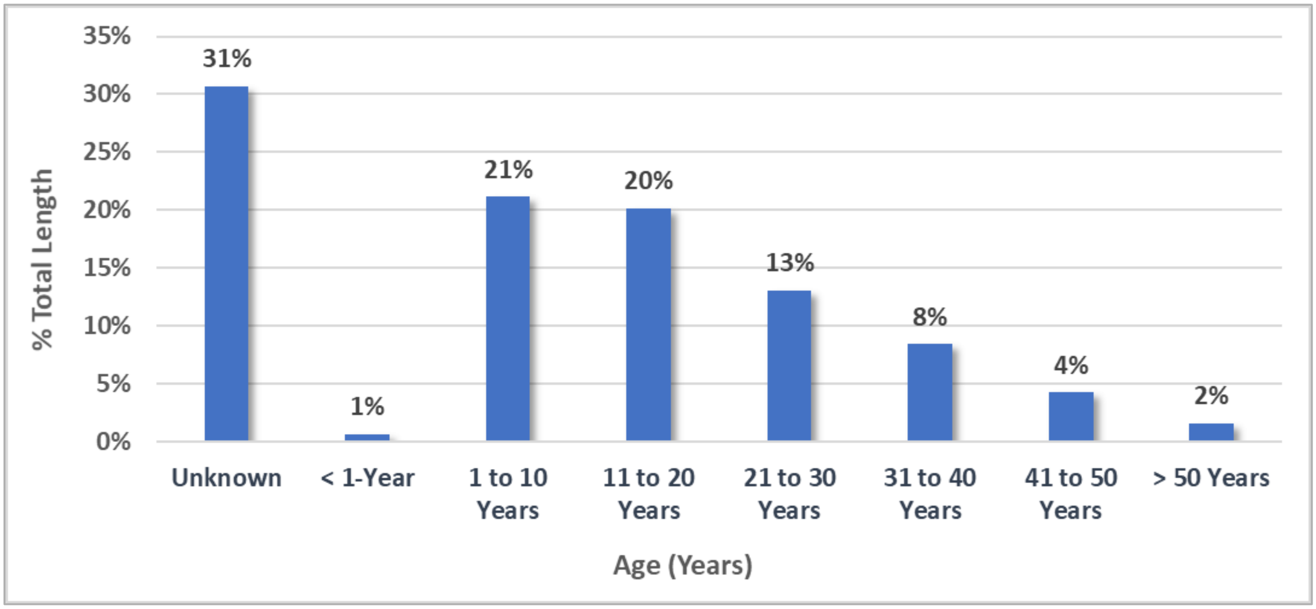


Figure 2-3: Water Line Materials



PVC = Polyvinyl Chloride

Figure 2-4: Water Line Age as of Year 2021



3.0 WATER PRODUCTION

3.1 HISTORICAL WATER PRODUCTION

The City provided historical daily water production records for each water plant in the system from January 2017 to August 2021. This data is tabulated and documented in **Appendix B**. A summary of historical water production is provided in **Table 3-1.**

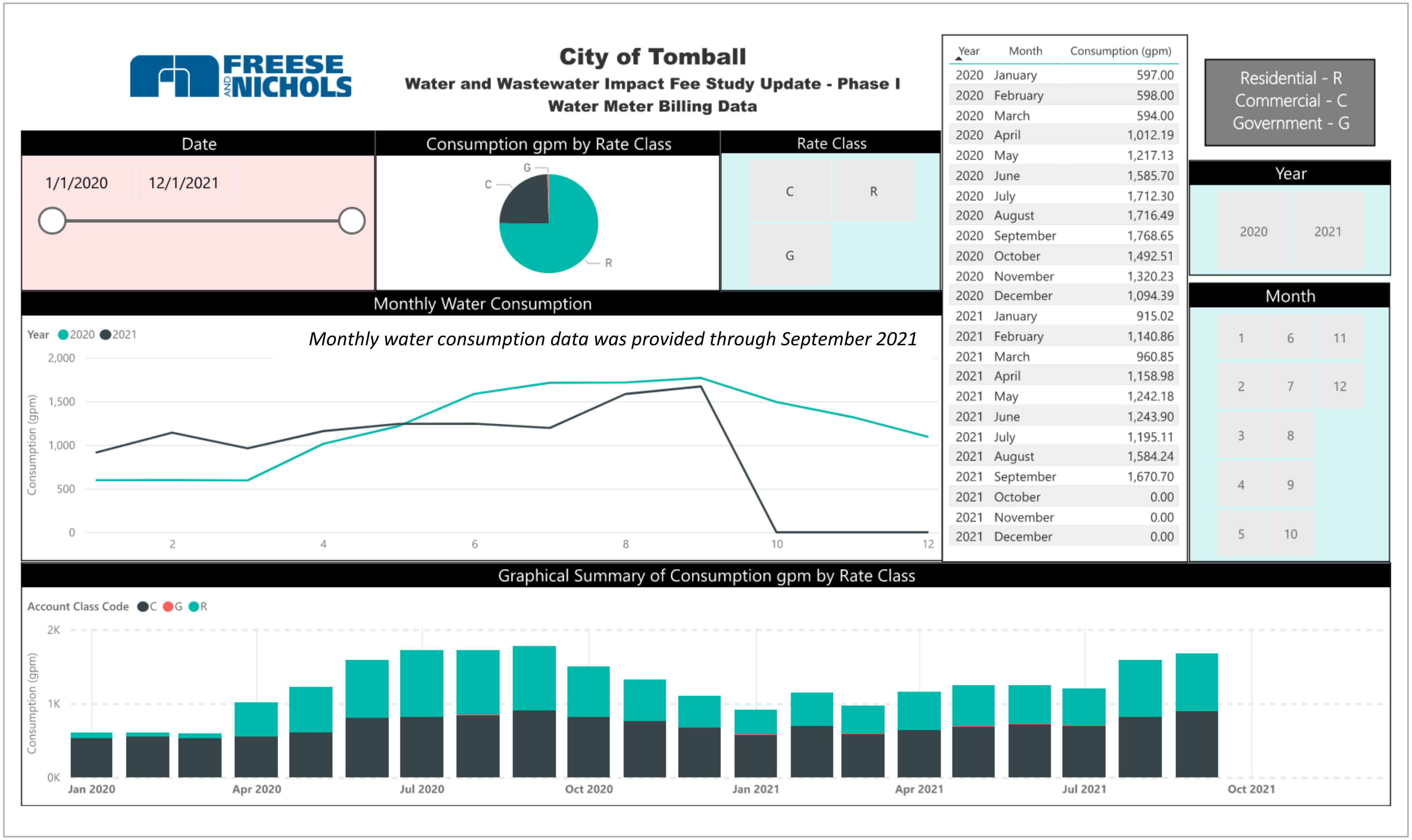
Table 3-1: Historical Water Production (2017 to 2021)

Year	Average Day Demand(1) (MGD)	MD:AD Peaking Factor	Maximum Day Demand(1) (MGD)
2017	2.09	2.28	4.76
2018	2.04	1.81	3.69
2019	2.11	2.41	5.08
2020	2.13	1.94	4.14
2021(2)	1.90	1.59	3.03
Average	**2.05**	**2.01**	**4.14**
Maximum	**2.13**	**2.41**	**5.08**
Minimum	**1.90**	**1.59**	**3.03**

(1) Average and maximum day demand calculated from daily well production data provided by the City.
(2) Includes daily data until August 12, 2021. Maximum day demand excludes data from Winter Storm Uri.

The City also provided water meter billing information from January 2020 to September 2021. FNI developed a Microsoft PowerBI dashboard to analyze this data by month and by rate class (commercial, residential, and governmental), as shown on **Figure 3-1.** The consumption and production data for August 2021 was utilized during hydraulic model calibration, discussed further in **Section 5.0**.

Figure 3-1: Water Meter Billing Data Microsoft PowerBI Dashboard



4.0 PRESSURE TESTING

Pressure testing was conducted between August 8th and 18th, 2021 in Tomball's distribution system. Eight pressure recorders were placed throughout the distribution system to capture system pressures and operational conditions during summer demand conditions. Minimum, maximum, and average pressures were recorded every five (5) minutes at each location. Individual graphs for each pressure recorder are included in **Appendix C**. **Figure 2-1** shows the pressure recorder locations and pressure recorder location details with a summary of observed pressure ranges are provided in **Table 4-1.** Overall pressure results for the testing period are displayed on **Figure 4-1.**

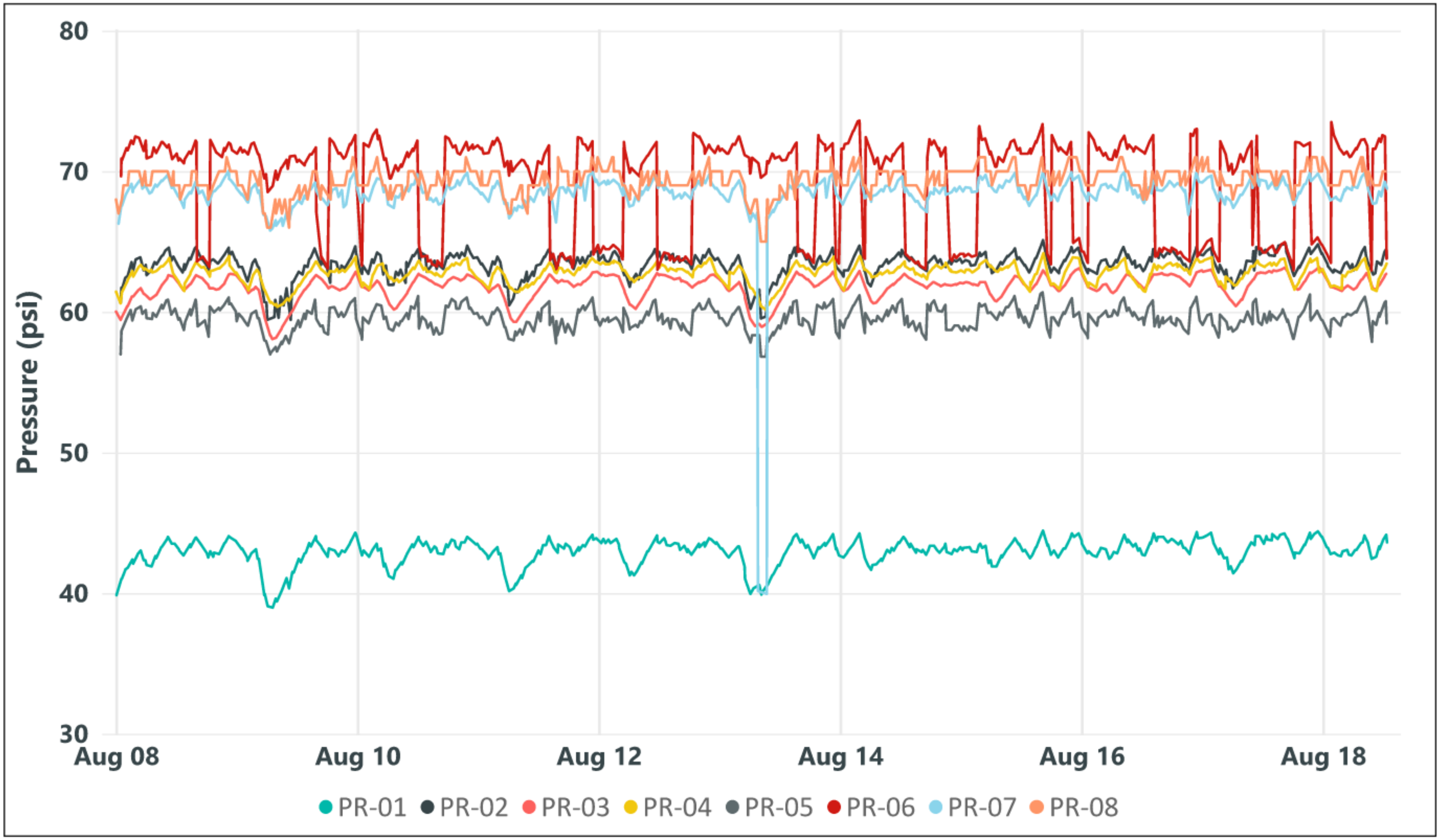
It should be noted that the City conducted hydrant flow testing at the intersection of Boudreaux Road and Hoffman Estates Boulevard during the pressure testing period on August 13, 2021, that resulted in a significant pressure drop in PR-07, and smaller pressure drops in PR-02, PR-05, and PR-08. The PR-06 recorder also observed fluctuations in pressure during the pressure testing period. The observations indicate that the pressure at the PR-06 location was being influenced by the FM 2920 Pump Station when the pumps were on. When the pumps turn off, the pressure seemed to be influenced by the Ulrich and Pine Street elevated tanks. Additionally, pressure testing was conducted during the COVID-19 pandemic, during which quarantine and work from home policies likely affected water consumption quantities and daily usage patterns.

Table 4-1: Pressure Recorder Locations and Observed Pressure Ranges

Pressure Recorder ID	Location	Observed Pressure Range (psi)
PR-01	Next to Economy Inn and Suites	39-44
PR-02	Off of FM 2920, in front of long grey office building	59-65
PR-03	Off Ulrich Road by Juergens Park and Ulrich EST	58-63
PR-04	Next to New Haven sign, Intersection of S Pine Street and James	60-64
PR-05	Chase Bank parking lot, off of FM 2920	57-61
PR-06	Off FM 2920, by FM 2920 Water Plant	63-74
PR-07	At corner of Hoffman Estates Boulevard and Boudreaux Road	40*-70
PR-08	Next to gas station, off of Hufsmith-Kohrville Road	65-71

*Hydrant flow testing resulted in the pressure drop to 40 psi. Minimum pressure observed otherwise was 65 psi.

Figure 4-1: Pressure Testing Results (August 8 – 18, 2021)



5.0 HYDRAULIC MODEL UPDATE AND CALIBRATION

Tomball developed a hydraulic water model of the City's distribution system during the *2018 Water Master Plan*. This model is in the InfoWater® software by Innovyze®. FNI started with this InfoWater model and updated it with the City's latest geographic information system (GIS) database, facility inventory, and field collected information as part of this study. The model was then calibrated to 2021 field pressure testing data and operational information provided by the City. The resulting water model is a tool that can be utilized for future system analyses.

5.1 GIS UPDATE

FNI updated the City's GIS with recently constructed utility lines as part of a separate *2021 Utility GIS Update* project. Recent as-built drawings provided by the City were utilized to update Tomball's water, wastewater, gas, and stormwater shapefiles. The City identified 23 developments to be included in the utility update along with an additional miscellaneous category. Of the 23 developments, 17 included water infrastructure and were incorporated in the water system GIS update. **Table 5-1** summarizes the updates made to the water system GIS by development. The updated water system shapefiles were utilized in the hydraulic model update process, as described in **Section 5.2**.

Table 5-1: Summary of 2021 Water System GIS Update

Development	Water Lines (LF)	Service Lines(1) (LF)	No. of Hydrants	No. of Valves
Raleigh Creek Section 7 & 8	3,144	975	8	9
Cherry Pines Section 2	1,598	0	4	4
Cherry Pines Section 1	4,469	0	12	10
Gatewood Office Condos	266	590	0	0
Boxwood	1,235	0	1	1
Redeemer Church	639	0	1	7
Snook Lane Business Park	549	0	1	1
Bimbo Bakery	0	118	0	2
TISD Ag Barn	2,265	0	4	7
Tomball Heights	1,700	0	3	3
Vulcan Finned Tubes	442	0	1	2
Century Hydraulics	449	0	0	1
Regions Bank	227	0	0	0
Medical Complex 4B	6,508	0	19	6
Persimmon/Lizzie Storm	142	0	0	2
Raburn Reserve	7,326	0	0	0
Cherry Pines Section 3	4,481	0	11	39
Miscellaneous	856	223	3	5
Total	**36,294**	**1,906**	**68**	**99**

(1) After discussions with City staff, service line updates were not included for all developments.

5.2 MODEL UPDATE

5.2.1 Physical Network

Modeled Lines and Junctions

As part of this project, FNI updated the City's existing water distribution system model utilizing the updated water system GIS discussed in **Section 5.1**. All water lines with diameters of 6-inches or greater that were not already in the hydraulic model were added to the model. In addition to that, water line material, installation year, and alignment information was updated where applicable based on the latest GIS and as-built plans from the City. The water lines shown in **purple** on **Figure 5-1** have been added to the model or include updated information. Approximately 500 links were added during the model update, resulting in a total of 1,809 links.

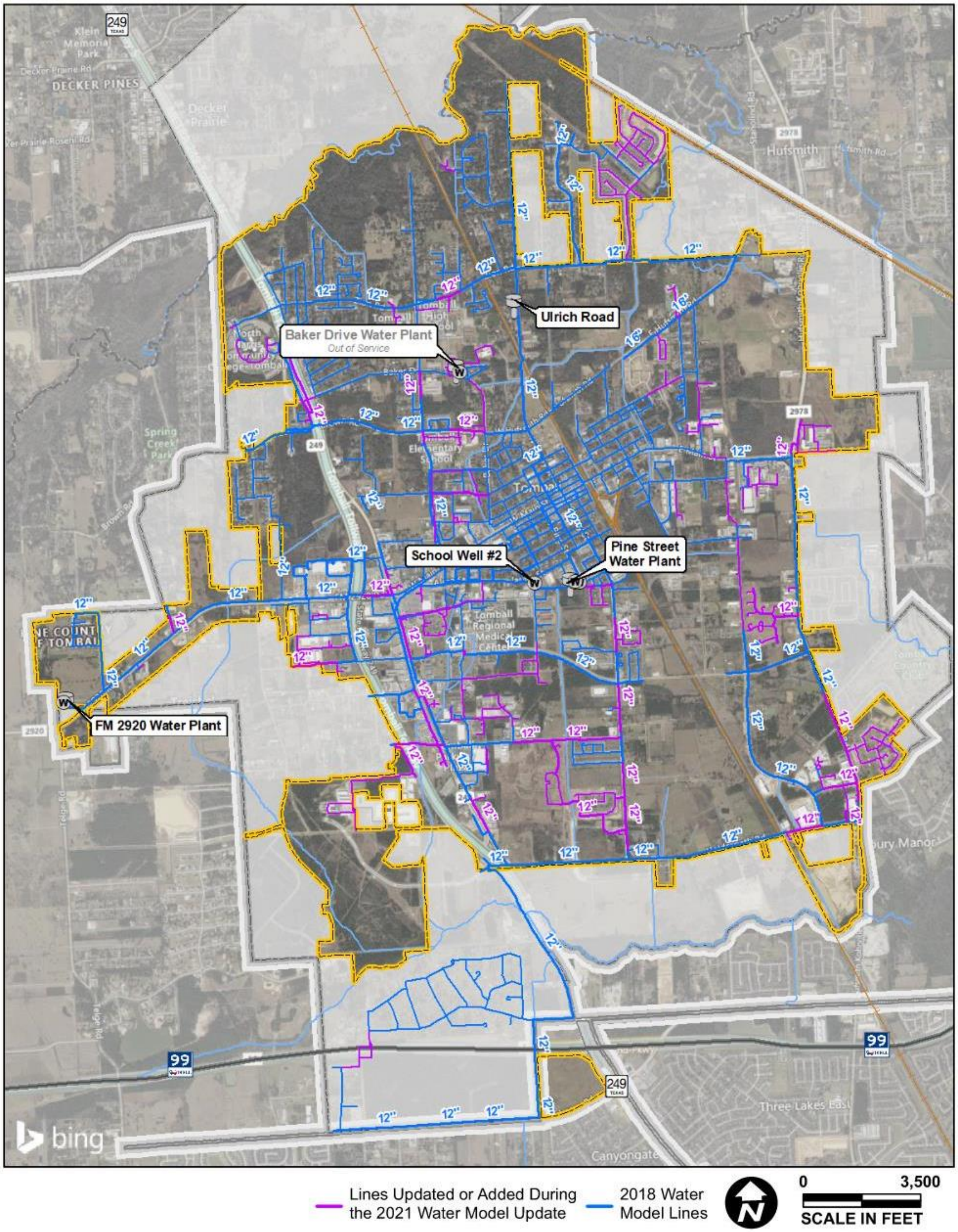
Hazen-Williams roughness coefficients were also updated for all new lines within the hydraulic model based on the age of the water lines, as shown in **Table 5-2.**

Table 5-2: Water Line Roughness Coefficients

Installation Year	C-Value
1991 – Present	130
1980 – 1990	120
Before 1980	100

The model also includes 1,543 junctions. Junctions are placed where modeled pipes connect and are utilized to store demand and elevation data. During the 2021 water model update, elevation information was updated for all new junctions throughout the distribution system based on two-foot ground contour data provided by the City during the *2018 Water Master Plan*.

Figure 5-1: 2021 Water Model Update



Modeled Facilities

During the *2018 Water Master Plan*, pumping and storage facilities, including pump curves, were manually added to the model based on data from TCEQ and information provided by the City. The model includes six (6) distribution pumps, two (2) ground storage tanks, two (2) elevated storage tanks, and two (2) reservoirs representing groundwater wells. Since the development of the 2018 hydraulic water model, the City has not constructed any new pumping or storage facilities, and the capacities of the existing facilities have not changed. For this model update, the City operations staff provided updated booster pump controls, shown in **Table 5-3.**

Table 5-3: Booster Pump Controls

Facility Name	Pump No.	Pump Controls(1)	
		On (psi)	Off (psi)
Pine Street Water Plant	1	61.9	63.6
	2	60.6	63.6
	3	58.4	63.6
FM 2920 Water Plant	1	62.5	64.4
	2	48	50
	3	45	49

(1) From City Staff, based on Ulrich EST

5.2.2 Demand Allocation

The monthly water consumption information for each active water account in the system (discussed in **Section 3.1**) was spatially located via a process called geocoding. Geocoding utilizes street and parcel information in the GIS shapefiles to match locations of the service meter addresses. Consumption information associated with each active meter was then assigned to the nearest model junction.

5.3 MODEL CALIBRATION

A 24-hour extended period simulation (EPS) model calibration was performed to verify that the hydraulic model accurately represents actual distribution system operations. The calibration process involved adjusting system operational parameters, roughness values, demand allocation, and diurnal patterns to match known or observed system conditions. The following sections provide a description of the model calibration and EPS calibration results.

5.3.1 Calibration Day System Operations

August 10, 2021 was selected as the calibration day as there was no rainfall on this day and system operations were typical with no major changes in pressure due to line breaks or other incidents visible in the pressure recorder data. The geocoded meter billing demand in the model was scaled to 3.1 MGD based on the well production data from August 10th. The City provided historical water plant production information with daily pumped flow at each distribution pump station, as well as typical booster pump on/off set points for reference during calibration. The booster pump set points for the Pine Street Water Plant

The model utilized the booster pump set points provided by the City for the Pine Street Water Plant. The set points for the FM 2920 Water Plant were adjusted during calibration to better match the recorded pressure data. **Table 5-4** lists the adjusted controls utilized for the FM 2920 model calibration. These controls will be reviewed in the next phase of this study as more information regarding set points and SCADA becomes available.

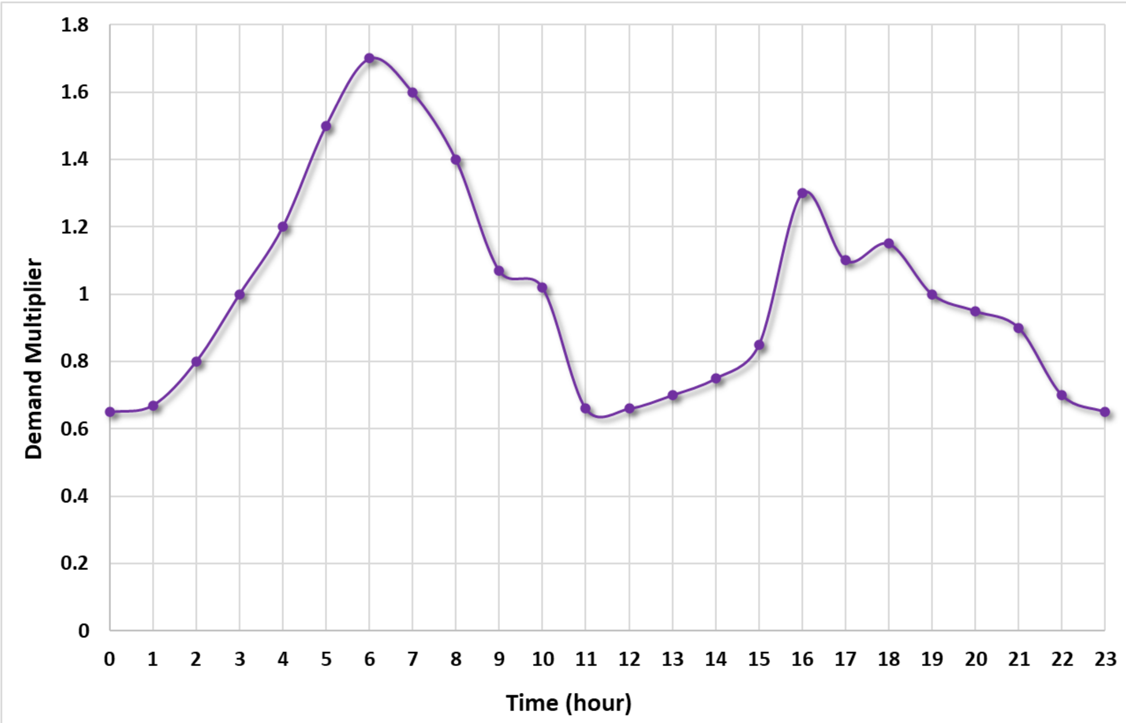
Table 5-4: FM 2920 Water Plant Booster Pump Calibrated Controls

Facility	Pump No.	Calibration Day Clock Time	Operation
FM 2920 Water Plant	Pump 1	0	On
		13:00	Off
		18:00	On

5.3.2 Diurnal Pattern

The diurnal pattern was adjusted during the calibration process utilizing the previous 2018 hydraulic model diurnal pattern as the starting point. **Figure 5-2** shows the system diurnal pattern for August 10, 2021.

Figure 5-2: Calibrated Water System Diurnal Pattern for August 10, 2021



5.3.3 EPS Calibration Results

The calibration scenario representing the day of August 10, 2021 was run for a 24-hour period with outputs in 1-hour increments. The modeled pressures at each time step were compared to the field recorded pressures at each location. The results of the EPS calibration are summarized on the graphs included in **Appendix D.** The graphs show modeled versus recorded pressures at each pressure recorder location.

This same calibration information is computed within given tolerances and shown in **Table 5-5**. The percentages shown represent the number of occurrences where the modeled pressures and observed data were within given tolerances of 10 psi, 5 psi, and 3 psi. The calibration graphs demonstrate a good correlation between recorded data and the calibrated model. A well-calibrated model adds confidence in the validity of the model as a tool for system hydraulic analyses.

Table 5-5: Summary of Calibration Pressures for August 10, 2021

Pressure Recorder	Within 10 psi	Within 5 psi	Within 3 psi
PR-01	100%	100%	100%
PR-02	100%	100%	100%
PR-03	100%	100%	100%
PR-04	100%	100%	100%
PR-05	100%	100%	100%
PR-06	100%	100%	95.8%
PR-07	100%	100%	100%
PR-08	100%	100%	100%
Average	**100%**	**100%**	**99.5%**

6.0 NEXT STEPS

The updated hydraulic water model will be utilized during Phase II of the *Water and Wastewater Impact Fee Update* project to conduct system analyses and evaluate future demand conditions. Phase II is anticipated to be conducted in 2022. During Phase II, the operational controls utilized during calibration should be reviewed. The City is currently in the process of incorporating SCADA into their water system. As additional SCADA information becomes available for the FM 2920 pump station, the model controls should be reviewed and updated as necessary.

APPENDIX D:

APPENDIX A

WELL PERFORMANCE TESTS

October 29, 2020

City of Tomball
401 West Market Street, Suite C
Tomball, Texas 77375

Attention: Operations Manager

Reference: Water Well #5 - Performance Testing

Collection and evaluation of field data pertaining to the operation of the well and well pumping equipment was recently completed at the above referenced facility. Included in this report please find the test results and pump curve generated by the testing.

PERFORMANCE TEST REVIEW				
Hydraulic Performance of pump is 763 GPM @ 598' field head	Excellent __X__	Good ___	Marginal____	Poor____
Overall efficiency is 65 percent	Excellent _____	Good__X_	Satisfactory ____	Poor____
Pump Submergence 159 feet	Excellent __X__	Good ____	Marginal____	Poor____
Vibration Analysis (N/A)	Excellent ______	Good ___	Marginal____	Poor____
Suspended Solids Testing	Excellent __X__	Good ____	Marginal____	Poor___
Brass Observed in SST	None _____X__	Trace____	Substantial___	Excessive__
Flowmeter Accuracy is 98.3 percent				

The test indicated the pump appears to be operating in satisfactory condition.

A HCSD meter affidavit was completed during the test and is attached.

We appreciate this opportunity to be of service. If you have any questions or comments, please call.

Sincerely,

Gary McMurrey
G-M Services

Performance Test Report

SPECIALIZED INSPECTION SERVICES FOR THE WATER INDUSTRY

website: www.g-mservices.com phone: 281-894-8971

Facility	City of Tomball - well #5	**Test Date**	10/23/2020
U.S.G.S. #	LJ-60-60-T5	**Subsidence Well ID#:**	11049

PUMP DATA

Manufacturer :	American
Bowl Type :	12-L-55
Stages :	9
Setting :	720
Column Size :	8" x 3" x 1 15/16"
Design Point :	700 GPM @ 723' TDH

MOTOR DATA

Manufacturer :	U.S. Motors
Size (HP) :	200
Amps/Volts :	219/460
Serial # :	R05 20085501
Frame :	449TP
Speed (RPM) :	1785

PERFORMANCE TEST DATA

Static Lvl (ft) -428

Discharge Pressure	16	42
Capacity (GPM)	763	693
Pumping Lvl (ft)	-561	-554
Drawdown (ft)	133	126
Specific Capacity	5.74	5.50
Field Head (ft)	597.96	651.02
Water Horsepower	115.2	114.04
Overall Efficiency	65%	65%
Horsepower Input	177.68	175.00
Kilowatt Input	132.6	130.6
Amp Draw	168-174-171	167-173-169
Voltage	490-488	489-489
Sand (PPM)	1	1
Time (min)	45	15

Meter Data

Manufacturer:	Water Spec	Size:	8
Serial #:	20092359		
Meter Read:	843156.000		

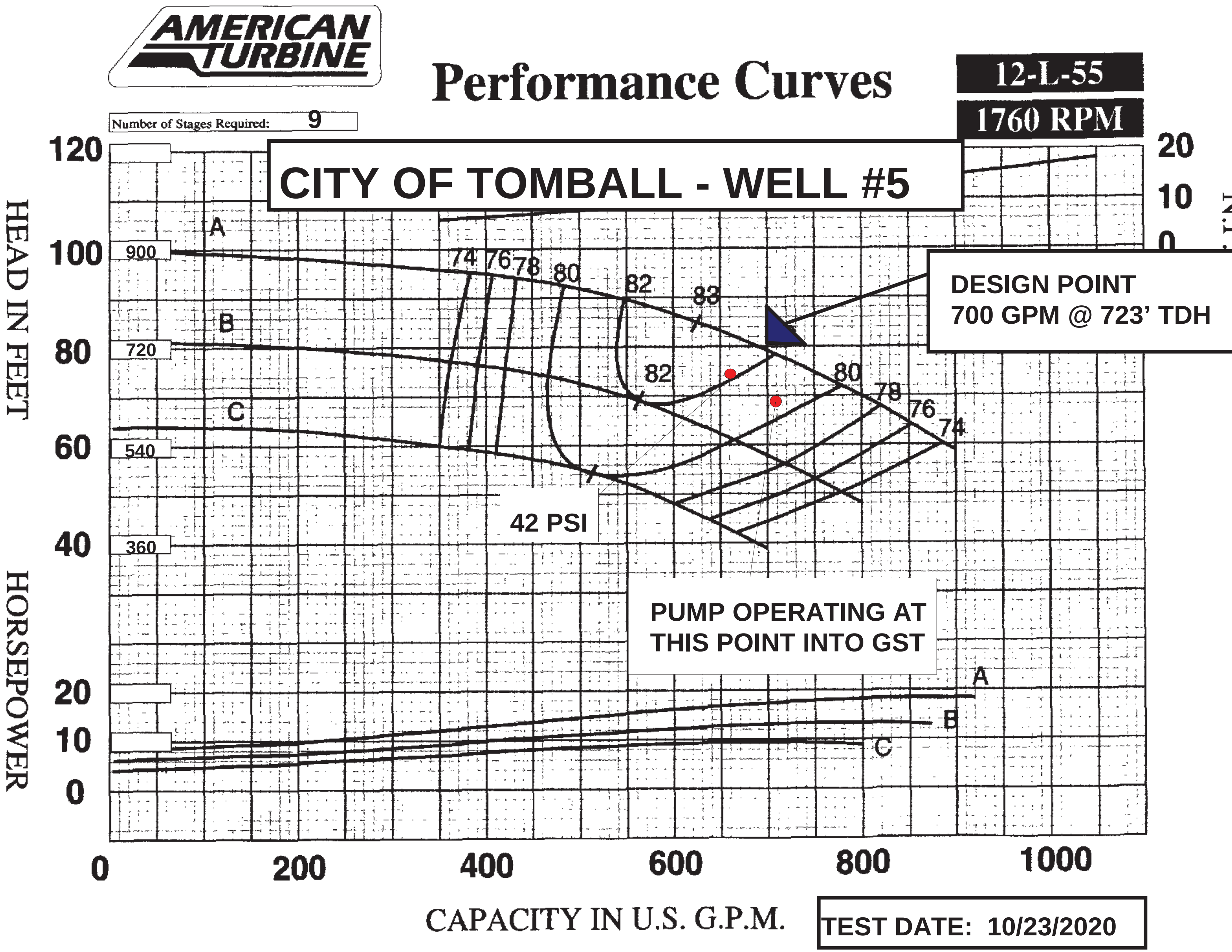
Meter accuracy is 98.3 % at 750 GPM

Additional Data

Start-up Sand (PPM)	2
Brass Detect:	No
Pump Submergence (ft)	159
ETM Read:	40489

Remarks
Meter affidavit completed.

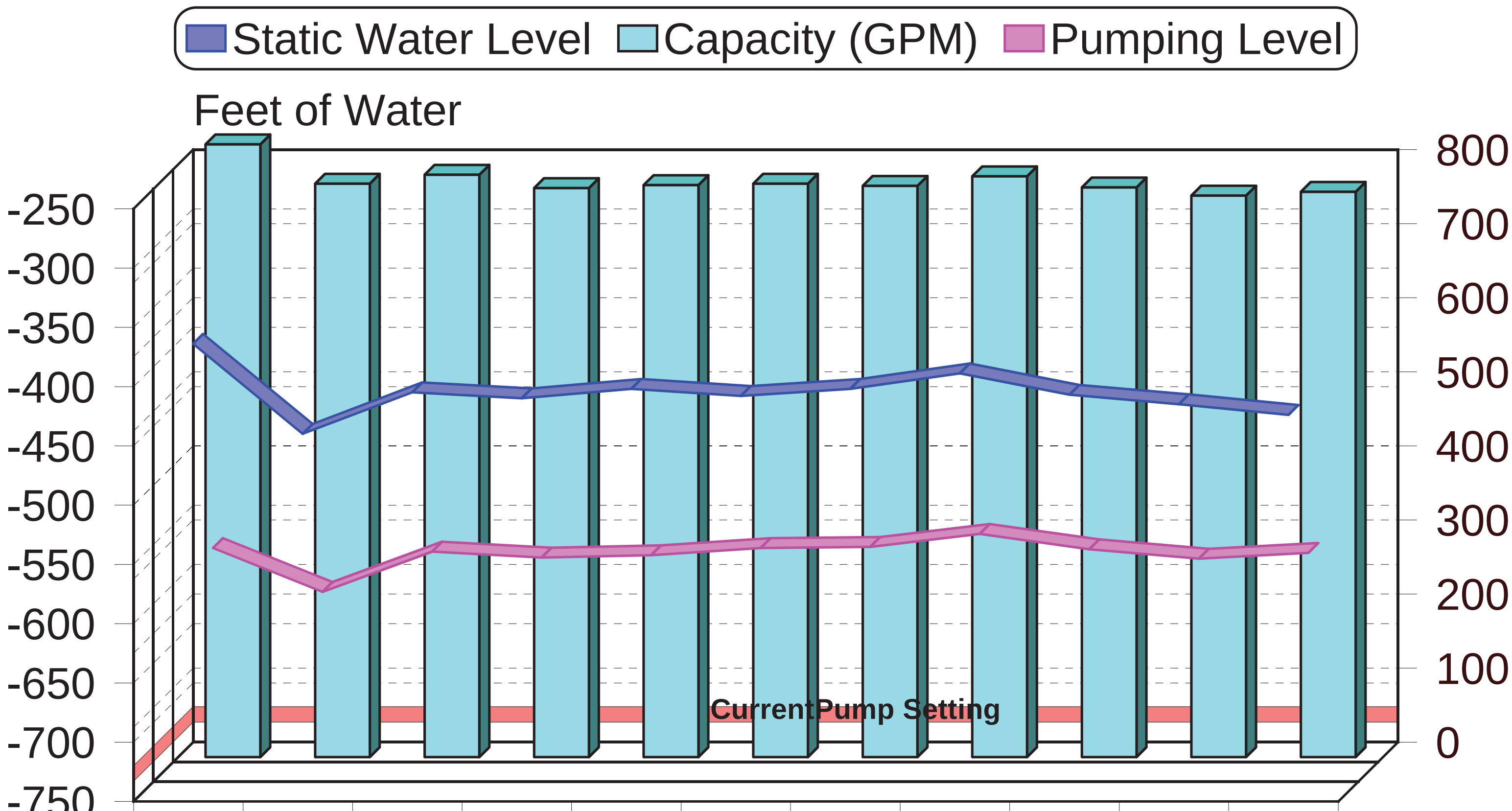
TECHNICIAN P. White



Performance Curves
12-L-55
1760 RPM
Number of Stages Required: 9
CITY OF TOMBALL - WELL #5
DESIGN POINT
700 GPM @ 723' TDH
42 PSI
PUMP OPERATING AT
THIS POINT INTO GST
HEAD IN FEET
HORSEPOWER
N.P.S.H
CAPACITY IN U.S. G.P.M.
TEST DATE: 10/23/2020
120
100
80
60
40
20
10
0
900
720
540
360
A
B
C
74 76 78 80 82 83
82
80 78 76 74
200
400
600
800
1000

City of Tomball

Well #5



	12/10	9/11	11/12	9/13	9/14	9/15	10/16	10/17	10/18	10/19	10/20
Static Water Level	-368	-444	-409	-414	-406	-412	-406	-393	-411	-419	-428
Capacity (GPM)	827	774	786	768	772	774	771	784	769	758	763
Pumping Level	-557	-594	-560	-565	-563	-557	-556	-545	-558	-566	-561

Prepared by G-M Services

Harris-Galveston Subsidence District

Serving the Gulf Coast Community Since 1975

Affidavit of Meter Calibration Test

Instructions:
Items marked with an * are required.

*Permittee Name:	City of Tomball
*Well No.:	11049
*Description of site at location:	well #5
*Meter Manufacturer:	Water Specialties
*Serial No.:	20092359
*Type:	(●) Propeller ( ) Turbine ( ) Positive Displacement ( ) Compound ( ) Other
*Testing Firm:	G-M Services
*Mailing Address:	P.O. Box 690309
*City:	Houston
*State:	Texas
*Zip:	77269
*Phone Number:	281-894-8971 (###-###-####) Ext.:
*Test Supervisor:	P. White
*Title:	tech
*Details of Test:	( ) Pitot Tube (●) Transmit Time ( ) In-Line Calibrated Meter
*Date of Test:	10/23/2020 (mm/dd/yyyy)
*Description of Test:	set up downstream of meter
*Unit Serial No.:	Q2F0185TO

Please fax or mail a diagram of installation tested, including the test equipment used. A schematic diagram is acceptable if pipe dimensions are given. Include a copy of test tape if transit time method is used.

Test Results:

*Meter reading at start of test:	843156000	Gallons
*Meter reading at end of test:	843163500	Gallons
*Metered quantity (item 2 - item 1):	7500	Gallons
*Known standard quantity in test:	7630	Gallons
*Percent accuracy (item 3 ÷ item 4 x 100)	98.3	%
*Flow Rate:	763	Gallons/Min
*Pipe Diameter:	8	in.
*Recalibration:	○ Yes ◉ No	
Percent Accuracy after Recalibration:		%
Remarks:		
*Applicant/Agent Name:	GM	
*Please enter your e-mail address:	gary@g-mservices.com	
*Please re-enter your e-mail address:	gary@g-mservices.com	

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G-M SERVICES
Operation Support Specialists

October 29. 2020

City of Tomball
401 West Market Street, Suite C
Tomball, Texas 77375

Attention: Operations Manager

Reference: Water Well #6 - Performance Testing

Collection and evaluation of field data pertaining to the operation of the well and well pumping equipment was recently completed at the above referenced facility. Included in this report please find the test results and pump curve generated by the testing.

PERFORMANCE TEST REVIEW

Hydraulic Performance of pump is 546 GPM @ 331' field head	Excellent ______	Good __X__	Marginal____	Poor____
Overall efficiency is 56 percent	Excellent ______	Good____	Satisfactory __X__	Poor____
Pump Submergence 124 feet	Excellent __X___	Good ____	Marginal____	Poor____
Vibration Analysis (N/A)	Excellent _______	Good ___	Marginal____	Poor____
Suspended Solids Testing	Excellent __X__	Good ____	Marginal____	Poor___
Brass Observed in SST	None _____X__	Trace____	Substantial___	Excessive__
Flowmeter Accuracy is 98.0 percent				

The test indicated the pump appears to be operating in satisfactory condition.

A HCSD meter affidavit was completed during the test and is attached.

We appreciate this opportunity to be of service. If you have any questions or comments, please call.

Sincerely,

Gary McMurrey
G-M Services

Performance Test Report

G-M SERVICES
SPECIALIZED INSPECTION SERVICES FOR THE WATER INDUSTRY

website: www.g-mservices.com phone: 281-894-8971

Facility City of Tomball - well #6
U.S.G.S. # LJ-60-60-T6

Test Date 10/23/2020
Subsidence Well ID#: 11290

PUMP DATA

Manufacturer :	American
Bowl Type :	10-M-55
Stages :	9
Setting :	420
Column Size :	8" x 2 1/2" x 1 11/16"
Design Point :	550 GPM @ 420' TDH

MOTOR DATA

Manufacturer :	U.S. Motors
Size (HP) :	100
Amps/Volts :	115/460
Serial # :	R 06 200885877
Frame :	405TP
Speed (RPM) :	1780

PERFORMANCE TEST DATA

Static Lvl (ft) -159

Discharge Pressure	15	15
Capacity (GPM)	546	546
Pumping Lvl (ft)	-296	-296
Drawdown (ft)	137	137
Specific Capacity	3.99	3.99
Field Head (ft)	330.65	330.65
Water Horsepower	45.58	45.64
Overall Efficiency	56%	56%
Horsepower Input	81.61	81.61
Kilowatt Input	60.9	60.9
Amp Draw	86-89-86	86-89-86
Voltage	489-489	489-489
Sand (PPM)	1	1
Time (min)	45	45

Meter Data

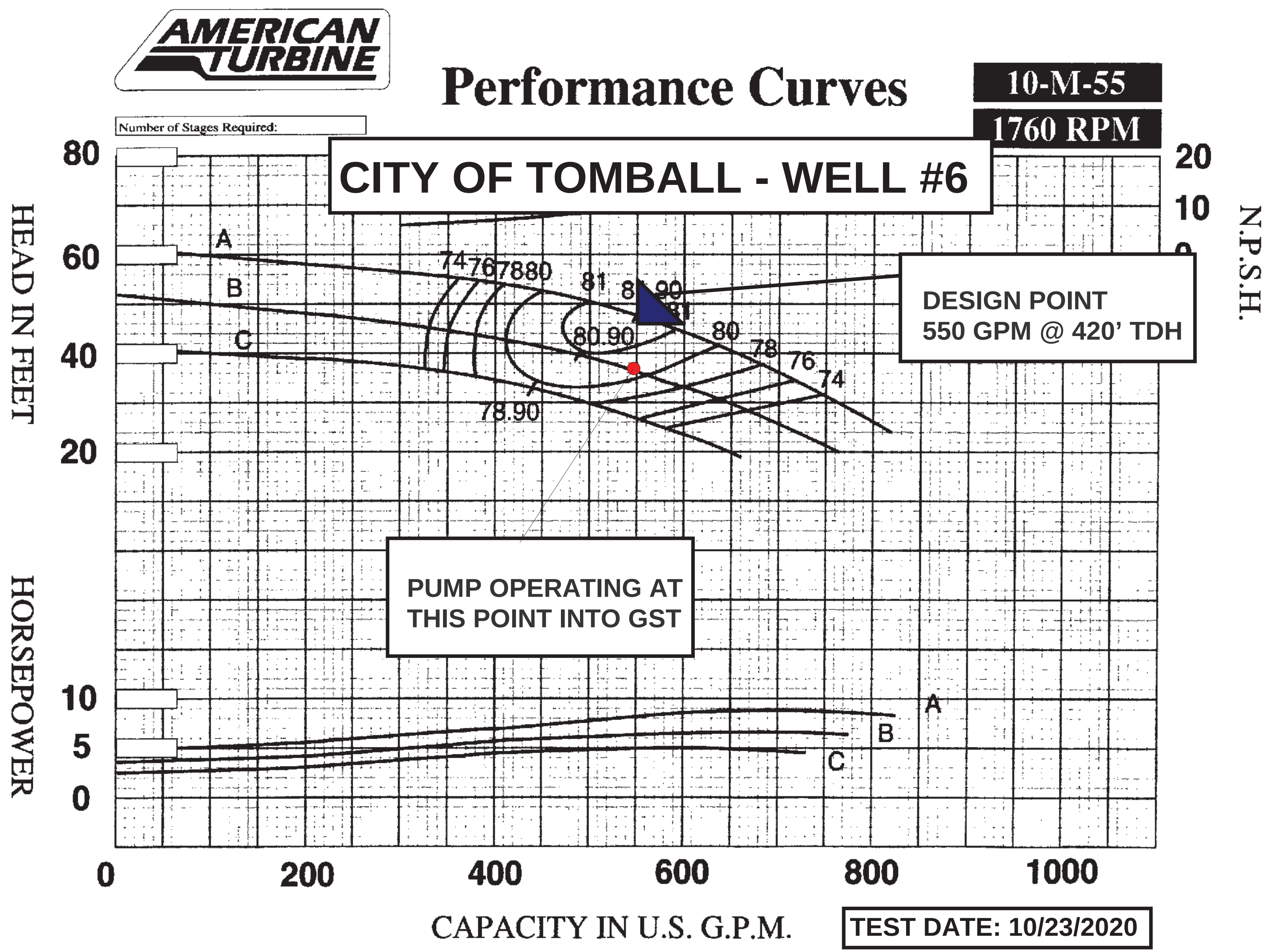
Manufacturer: Water Specialtie Size: 8
Serial #: 20092360
Meter Read: 336322.000
Meter accuracy is 98.0 % at 535 GPM

Additional Data

Start-up Sand (PPM)	2
Brass Detect:	No
Pump Submergence (ft)	124
ETM Read:	8270

Remarks
Meter affidavit completed.

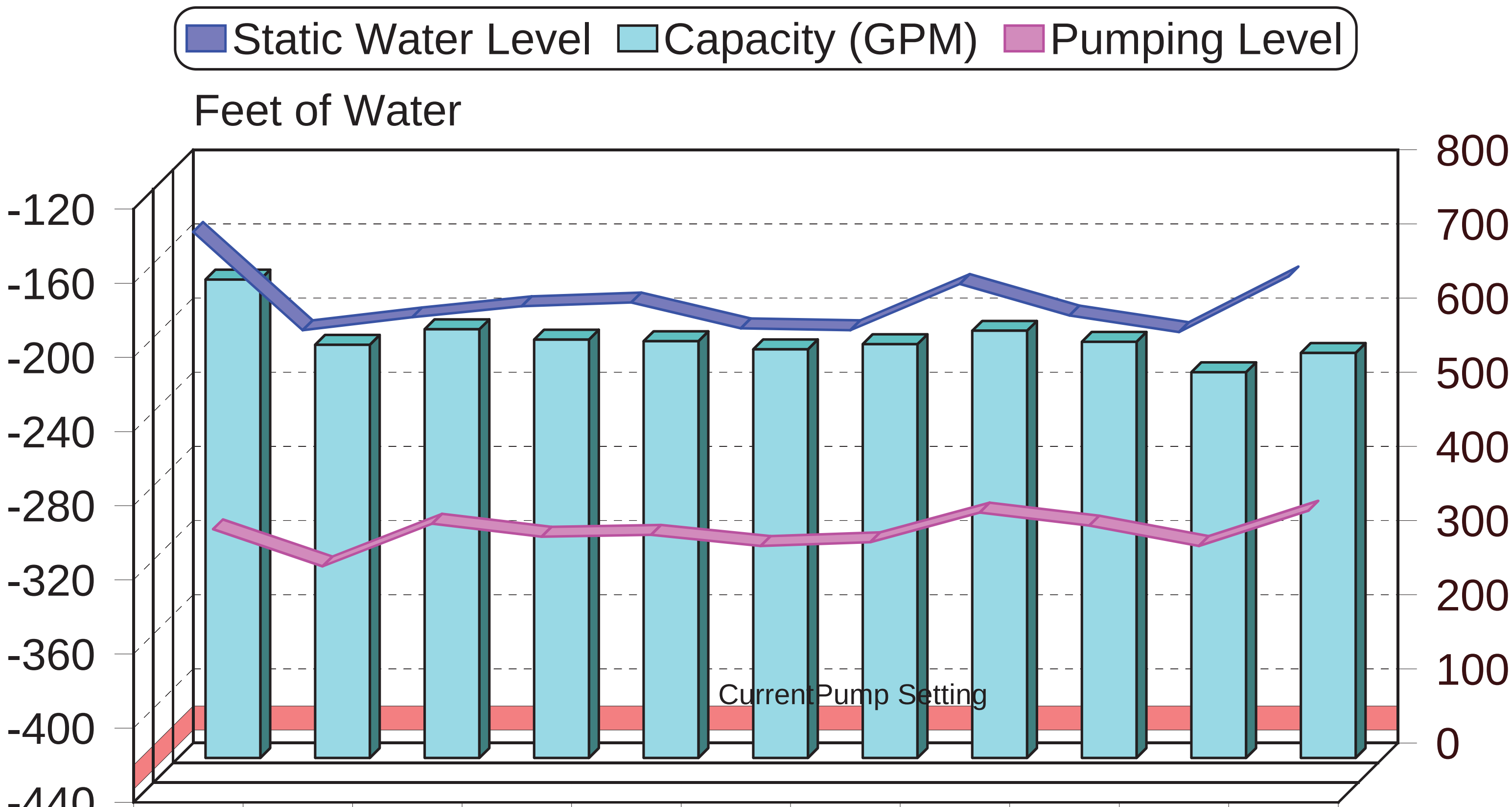
TECHNICIAN P. White



AMERICAN TURBINE
Performance Curves
10-M-55
1760 RPM
Number of Stages Required:
CITY OF TOMBALL - WELL #6
DESIGN POINT
550 GPM @ 420' TDH
PUMP OPERATING AT
THIS POINT INTO GST
HEAD IN FEET
HORSEPOWER
N.P.S.H.
CAPACITY IN U.S. G.P.M.
TEST DATE: 10/23/2020

City of Tomball

Well #6



	12/10	9/11	11/12	9/13	9/14	9/15	10/16	10/17	10/18	10/19	10/20
Static Water Level	-135	-188	-181	-175	-173	-187	-188	-163	-180	-189	-159
Capacity (GPM)	645	557	578	564	562	551	558	576	561	520	546
Pumping Level	-306	-326	-303	-310	-309	-315	-313	-297	-304	-315	-296

Prepared by G-M Services

Harris-Galveston Subsidence District

Serving the Gulf Coast Community Since 1975

Affidavit of Meter Calibration Test

Instructions:
Items marked with an * are required.

*Permittee Name:	City of Tomball
*Well No.:	11290
*Description of site at location:	well #6
*Meter Manufacturer:	Water Specialties
*Serial No.:	20092360
*Type:	(•) Propeller ( ) Turbine ( ) Positive Displacement ( ) Compound ( ) Other
*Testing Firm:	G-M Services
*Mailing Address:	P.O. Box 690309
*City:	Houston
*State:	Texas
*Zip:	77269
*Phone Number:	281-894-8971 (###-###-####) Ext.:
*Test Supervisor:	P. White
*Title:	tech
*Details of Test:	( ) Pitot Tube (•) Transmit Time ( ) In-Line Calibrated Meter
*Date of Test:	10/23/2020 (mm/dd/yyyy)
*Description of Test:	set up downstream of meter
*Unit Serial No.:	Q2F0185TO

Please fax or mail a diagram of installation tested, including the test equipment used. A schematic diagram is acceptable if pipe dimensions are given. Include a copy of test tape if transit time method is used.

Test Results:

*Meter reading at start of test:	336322000	Gallons
*Meter reading at end of test:	336327350	Gallons
*Metered quantity (item 2 - item 1):	5350	Gallons
*Known standard quantity in test:	5460	Gallons
*Percent accuracy (item 3 ÷ item 4 x 100)	98.0	%
*Flow Rate:	546	Gallons/Min
*Pipe Diameter:	8	in.
*Recalibration:	○ Yes ◉ No	
Percent Accuracy after Recalibration:		%
Remarks:		
*Applicant/Agent Name:	GM	
*Please enter your e-mail address:	gary@g-mservices.com	
*Please re-enter your e-mail address:	gary@g-mservices.com	

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May 13, 2021

City of Tomball
401 West Market Street, Suite C
Tomball, Texas 77375

Attention: Operations Manager

Reference: Pine Street Water Well #1 - Performance Testing

Dear Sir,

Collection and evaluation of field data pertaining to the operation of the well and well pumping equipment was recently completed at the above referenced facility. Included in this report please find the test results and pump curve generated by the testing.

PERFORMANCE TEST REVIEW

Hydraulic Performance of pump is 537 GPM @ 188' field head	Excellent ______	Good _X__	Marginal_____	Poor____
Overall efficiency is 49 percent	Excellent _____	Good______	Satisfactory _X__	Poor____
Pump Submergence 117 feet	Excellent _X__	Good ____	Marginal_____	Poor____
Physical Condition of unit	Excellent _X__	Good ___	Marginal____	Poor____
Suspended Solids Testing	Excellent _X__	Good ______	Marginal____	Poor___
Brass Observed in SST	None _____X__	Trace____	Substantial___	Excessive__
Flowmeter Accuracy is 98.3 percent				

The test indicated that the pump is operating in good condition.

A HCSD meter affidavit was completed during the test and is attached.

We appreciate this opportunity to be of service. If you have any questions or comments, please call.

Sincerely,

Gary McMurrey
G-M Services

G-M SERVICES

SPECIALIZED INSPECTION SERVICES FOR THE WATER INDUSTRY

Performance Test Report

website: www.g-mservices.com phone: 281-894-8971

Facility City of Tomball - Pine St. Well

Test Date 05/06/2021

U.S.G.S. # LJ-60-60-10G

Subsidence Well ID#: 1934

PUMP DATA

Manufacturer :	Shakti
Bowl Type :	6 SME-50-4C
Stages :	4
Setting :	275
Column Size :	6"
Design Point :	500 GPM @ 254' TDH

MOTOR DATA

Manufacturer :	SME
Size (HP) :	50
Amps/Volts :	67.5/460
Serial # :	
Frame :	
Speed (RPM) :	3480

PERFORMANCE TEST DATA

Static Lvl (ft) -130

Discharge Pressure	13	42
Capacity (GPM)	537	443
Pumping Lvl (ft)	-158	-154
Drawdown (ft)	28	24
Specific Capacity	19.18	18.46
Field Head (ft)	188.03	251.02
Water Horsepower	25.49	28.11
Overall Efficiency	49%	54%
Horsepower Input	52.39	51.59
Kilowatt Input	39.1	38.5
Amp Draw	60-60-58	59-59-58
Voltage	484-484-482	482-484-481
Sand (PPM)	1	1
Time (min)	45	15

Meter Data

Manufacturer:	Water Special	Size:	6
Serial #:	20200453		
Meter Read:	42330.000		

Meter accuracy is 98.3 % at 528 GPM

Additional Data

Start-up Sand (PPM)	2
Brass Detect:	No
Pump Submergence (ft)	117
ETM Read:	47087

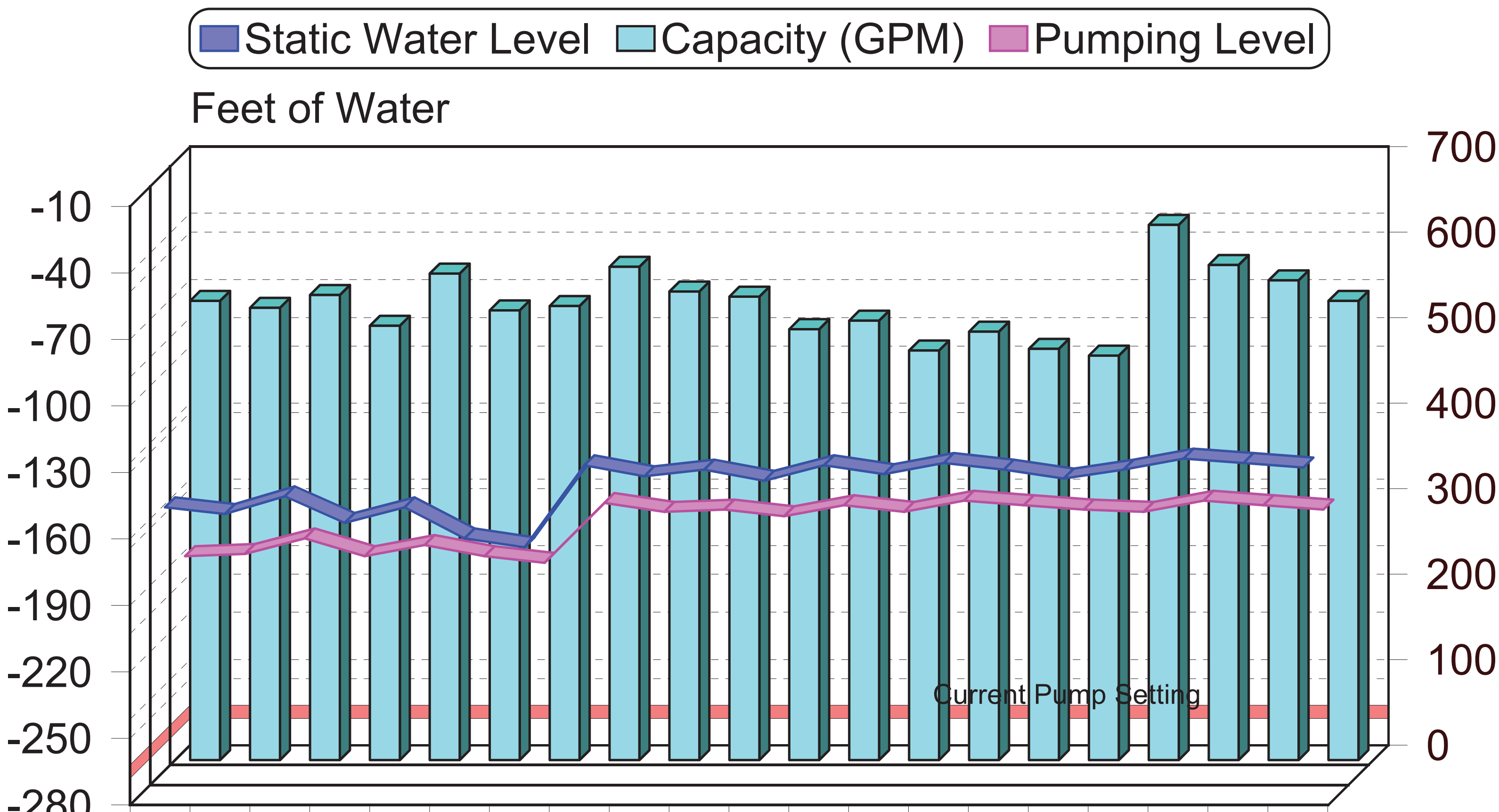
Remarks

Meter affidavit completed.

TECHNICIAN P. White

City of Tomball

Pine Street Well - Screened 260' thru 400'



	9/05	8/06	10/07	7/09	9/10	3/11	9/11	4/12	11/12	3/13	9/13	3/14	9/14	4/15	5/16	5/17	5/18	5/19	5/20	5/21
Static Water Level	-148	-151	-143	-155	-148	-162	-166	-129	-134	-131	-136	-129	-133	-128	-131	-135	-131	-126	-128	-130
Capacity (GPM)	537	529	544	508	569	526	531	577	548	542	504	514	479	501	481	473	626	579	561	537
Pumping Level	-179	-178	-171	-179	-174	-179	-182	-155	-159	-158	-161	-156	-159	-154	-156	-158	-159	-154	-156	-158

Prepared by G-M Services

Harris-Galveston Subsidence District

Serving the Gulf Coast Community Since 1975

Affidavit of Meter Calibration Test

Instructions:
Items marked with an * are required.

*Permittee Name: CIty of Tomball

*Well No.: 1934

*Description of site at location: Pine St. Well

*Meter Manufacturer: Water Specialties

*Serial No.: 20200453

*Type: (●) Propeller ( ) Turbine ( ) Positive Displacement ( ) Compound ( ) Other

*Testing Firm: G-M Services

*Mailing Address: P.O. Box 690309

*City: Houston

*State: Texas *Zip: 77269

*Phone Number: 281-894-8971 (###-###-####) Ext.:

*Test Supervisor: P. White

*Title: tech

*Details of Test: ( ) Pitot Tube (●) Transmit Time ( ) In-Line Calibrated Meter

*Date of Test: 05/06/2021 (mm/dd/yyyy)

*Description of Test: set up downstream of meter

*Unit Serial No.: Q2FO185TO

Please fax or mail a diagram of installation tested, including the test equipment used. A schematic diagram is acceptable if pipe dimensions are given. Include a copy of test tape if transit time method is used.

Test Results:

*Meter reading at start of test:	42330000	Gallons
*Meter reading at end of test:	423353280	Gallons
*Metered quantity (item 2 - item 1):	5280	Gallons
*Known standard quantity in test:	5370	Gallons
*Percent accuracy (item 3 ÷ item 4 x 100)	98.3	%
*Flow Rate:	528	Gallons/Min
*Pipe Diameter:	6	in.
*Recalibration:	○ Yes ◉ No	
Percent Accuracy after Recalibration:		%
Remarks:		
*Applicant/Agent Name:	GM	
*Please enter your e-mail address:	gary@g-mservices.com	
*Please re-enter your e-mail address:	gary@g-mservices.com	

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May 13, 2021

City of Tomball
401 West Market Street, Suite C
Tomball, Texas 77375

Attention: Operations Manager

Reference: Pine Street Water Well #2 - Performance Testing

Dear Sir,

Collection and evaluation of field data pertaining to the operation of the well and well pumping equipment was recently completed at the above referenced facility. Included in this report please find the test results and pump curve generated by the testing.

PERFORMANCE TEST REVIEW

Hydraulic Performance of pump is 1889 GPM @ 562' field head	Excellent __X__	Good ___	Marginal_____	Poor____
Overall efficiency is 74 percent	Excellent __X__	Good_____	Satisfactory ____	Poor
Pump Submergence 76 feet	Excellent __X__	Good ___	Marginal____	Poor____
Physical Condition of unit	Excellent __X__	Good ___	Marginal____	Poor____
Suspended Solids Testing	Excellent __X__	Good___	Marginal____	Poor___
Brass Observed in SST	None _____X__	Trace______	Substantial ___	Excessive__
Flowmeter Accuracy is 98.6 percent				

The test indicated that the pump appears to be operating in good condition.

A HCSD meter affidavit was completed during the test and attached.

We appreciate this opportunity to be of service. If you have any questions or comments, please call.

Sincerely,

Gary McMurrey
G-M Services

G-M SERVICES

SPECIALIZED INSPECTION SERVICES FOR THE WATER INDUSTRY

Performance Test Report

website: www.g-mservices.com phone: 281-894-8971

Facility City of Tomball - Pine Street #2

U.S.G.S. # LJ-60-60-11G

Test Date 05/06/2021

Subsidence Well ID#: 6927

PUMP DATA

Manufacturer :	Goulds
Bowl Type :	14" RJMC
Stages :	8
Setting :	610
Column Size :	10" x 3" x 1 15/16"
Design Point :	2000 GPM @ 550' TDH

MOTOR DATA

Manufacturer :	U.S. Motors
Size (HP) :	400
Amps/Volts :	387/460
Serial # :	R117459794-0001
Frame :	447TPA
Speed (RPM) :	1780

PERFORMANCE TEST DATA

Static Lvl (ft) -440

Discharge Pressure	12	40
Capacity (GPM)	1889	1688
Pumping Lvl (ft)	-534	-528
Drawdown (ft)	94	88
Specific Capacity	20.10	19.18
Field Head (ft)	561.72	620.4
Water Horsepower	267.9	264.72
Overall Efficiency	74%	74%
Horsepower Input	360.33	359.12
Kilowatt Input	268.9	268
Amp Draw	357-368-367	356-368-365
Voltage	484-486-486	483-486-485
Sand (PPM)	9	4
Time (min)	45	15

Meter Data

Manufacturer: Water Spec Size: 10

Serial #: 20170351

Meter Read: 805877.000

Meter accuracy is 98.6 % at 1862 GPM

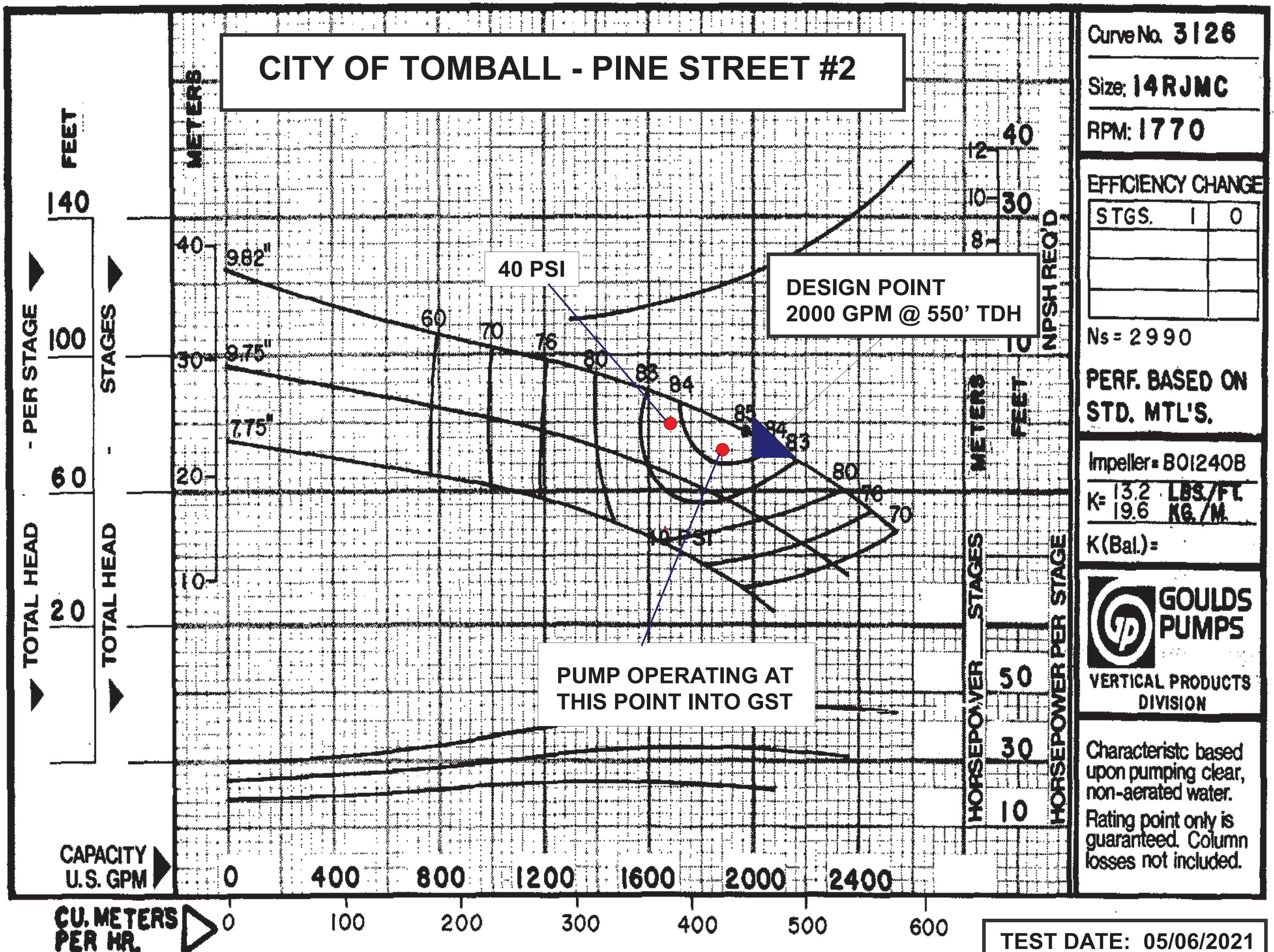
Additional Data

Start-up Sand (PPM)	2
Brass Detect:	No
Pump Submergence (ft)	76
ETM Read:	7264

Remarks

Meter affidavit completed.

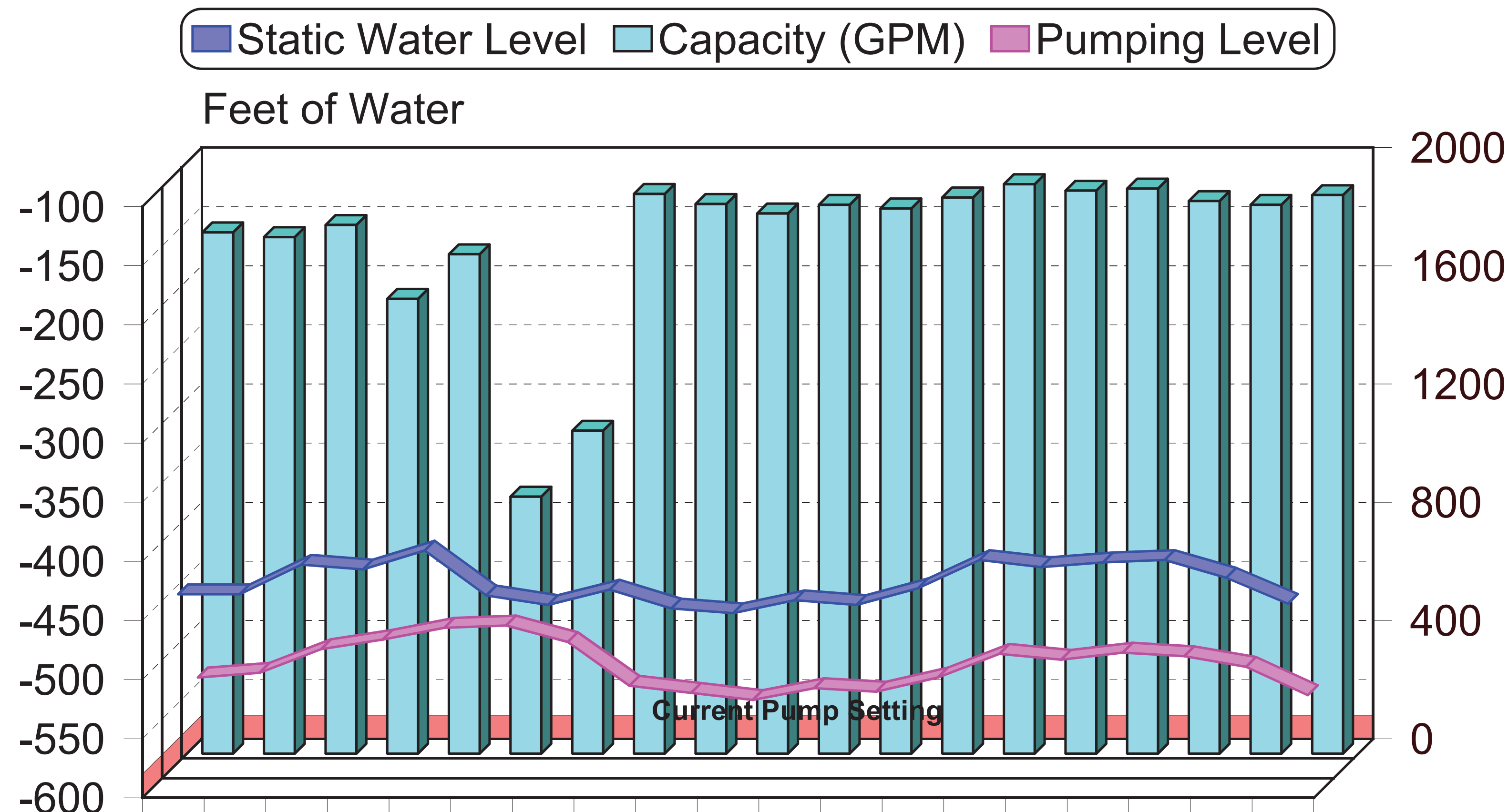
TECHNICIAN P. White



TEST DATE: 05/06/2021

City of Tomball

Pine Street #2



	8/03	11/04	9/05	8/06	10/07	7/09	7/09	11/09	9/10	9/11	11/12	9/13	9/14	4/15	5/16	5/17	5/18	5/19	5/21
Static Water Level	-432	-432	-407	-411	-395	-433	-441	-428	-444	-448	-437	-441	-427	-403	-409	-405	-403	-418	-440
Capacity (GPM)	1763	1747	1788	1538	1689	869	1092	1893	1859	1827	1856	1844	1881	1926	1904	1911	1869	1856	1889
Pumping Level	-519	-515	-495	-487	-477	-475	-489	-526	-532	-538	-528	-531	-519	-499	-504	-498	-501	-510	-534

Prepared by G-M Services

Harris-Galveston Subsidence District

Serving the Gulf Coast Community Since 1975

Affidavit of Meter Calibration Test

Instructions:
Items marked with an * are required.

*Permittee Name: City of Tomball

*Well No.: 6927

*Description of site at location: Pine Street #2

*Meter Manufacturer: Water Specialties

*Serial No.: 20170351

*Type: (●) Propeller ( ) Turbine ( ) Positive Displacement ( ) Compound ( ) Other

*Testing Firm: G-M Services

*Mailing Address: P.O. Box 690309

*City: Houston

*State: Texas *Zip: 77269

*Phone Number: 281-894-8971 (###-###-####) Ext.:

*Test Supervisor: P. White

*Title: tech

*Details of Test: ( ) Pitot Tube (●) Transmit Time ( ) In-Line Calibrated Meter

*Date of Test: 05/06/2021 (mm/dd/yyyy)

*Description of Test: set up downstream of meter

*Unit Serial No.: Q2FO185TO

Please fax or mail a diagram of installation tested, including the test equipment used. A schematic diagram is acceptable if pipe dimensions are given. Include a copy of test tape if transit time method is used.

Test Results:

*Meter reading at start of test:	805877000	Gallons
*Meter reading at end of test:	805895620	Gallons
*Metered quantity (item 2 - item 1):	18620	Gallons
*Known standard quantity in test:	18890	Gallons
*Percent accuracy (item 3 ÷ item 4 x 100)	98.6	%
*Flow Rate:	1862	Gallons/Min
*Pipe Diameter:	10	in.
*Recalibration:	○ Yes ◉ No	
Percent Accuracy after Recalibration:		%
Remarks:		
*Applicant/Agent Name:	GM	
*Please enter your e-mail address:	gary@g-mservices.com	
*Please re-enter your e-mail address:	gary@g-mservices.com	

Submit Print

May 13, 2021

City of Tomball
401 West Market Street, Suite C
Tomball, Texas 77375

Attention: Operations Manager

Reference: School Street Water Well - Performance Testing

Dear Sir,

Collection and evaluation of field data pertaining to the operation of the well and well pumping equipment was recently completed at the above referenced facility. Included in this report please find the test results and pump curve generated by the testing.

PERFORMANCE TEST REVIEW

Hydraulic Performance of pump is 707 GPM @ 232' field head	Excellent ______	Good _X_	Marginal____	Poor____
Overall efficiency is 68 percent	Excellent ______	Good _X_	Satisfactory ____	Poor____
Pump Submergence 55 feet	Excellent _____	Good _X_	Marginal_____	Poor____
Physical Condition of unit	Excellent ______	Good _X_	Marginal _____	Poor____
Suspended Solids Testing	Excellent _X_	Good____	Marginal____	Poor___
Brass Observed in SST	None _X_	Trace____	Substantial___	Excessive__
Flowmeter Accuracy is 97.5 percent				

The test indicated the pump is operating in satisfactory condition.

A HCSD meter affidavit was completed during the test and attached.

We appreciate this opportunity to be of service. If you have any questions or comments, please call.

Sincerely,

Gary McMurrey
G-M Services

G-M SERVICES
SPECIALIZED INSPECTION SERVICES FOR THE WATER INDUSTRY

Performance Test Report

website: www.g-mservices.com phone: 281-894-8971

Facility City of Tomball - School St. Well
Test Date 05/06/2021
U.S.G.S. # LJ-60-60-111
Subsidence Well ID#: 4023

PUMP DATA

Manufacturer :	Christensen
Bowl Type :	11-CMC
Stages :	4
Setting :	220
Column Size :	8" X 2" X 1 3/16"
Design Point :	800 GPM @ 260' TDH

MOTOR DATA

Manufacturer :	U.S. Motors
Size (HP) :	75
Amps/Volts :	91.3/460
Serial # :	GT-1008268-138
Frame :	365TP
Speed (RPM) :	1765

PERFORMANCE TEST DATA

Static Lvl (ft) -137

Discharge Pressure	29	52
Capacity (GPM)	707	518
Pumping Lvl (ft)	-165	-158
Drawdown (ft)	28	21
Specific Capacity	25.25	24.67
Field Head (ft)	231.99	278.12
Water Horsepower	41.41	36.42
Overall Efficiency	68%	68%
Horsepower Input	60.84	53.47
Kilowatt Input	45.4	39.9
Amp Draw	63-67-67	57-61-60
Voltage	486-488-484	488-489-486
Sand (PPM)	1	1
Time (min)	45	15

Meter Data

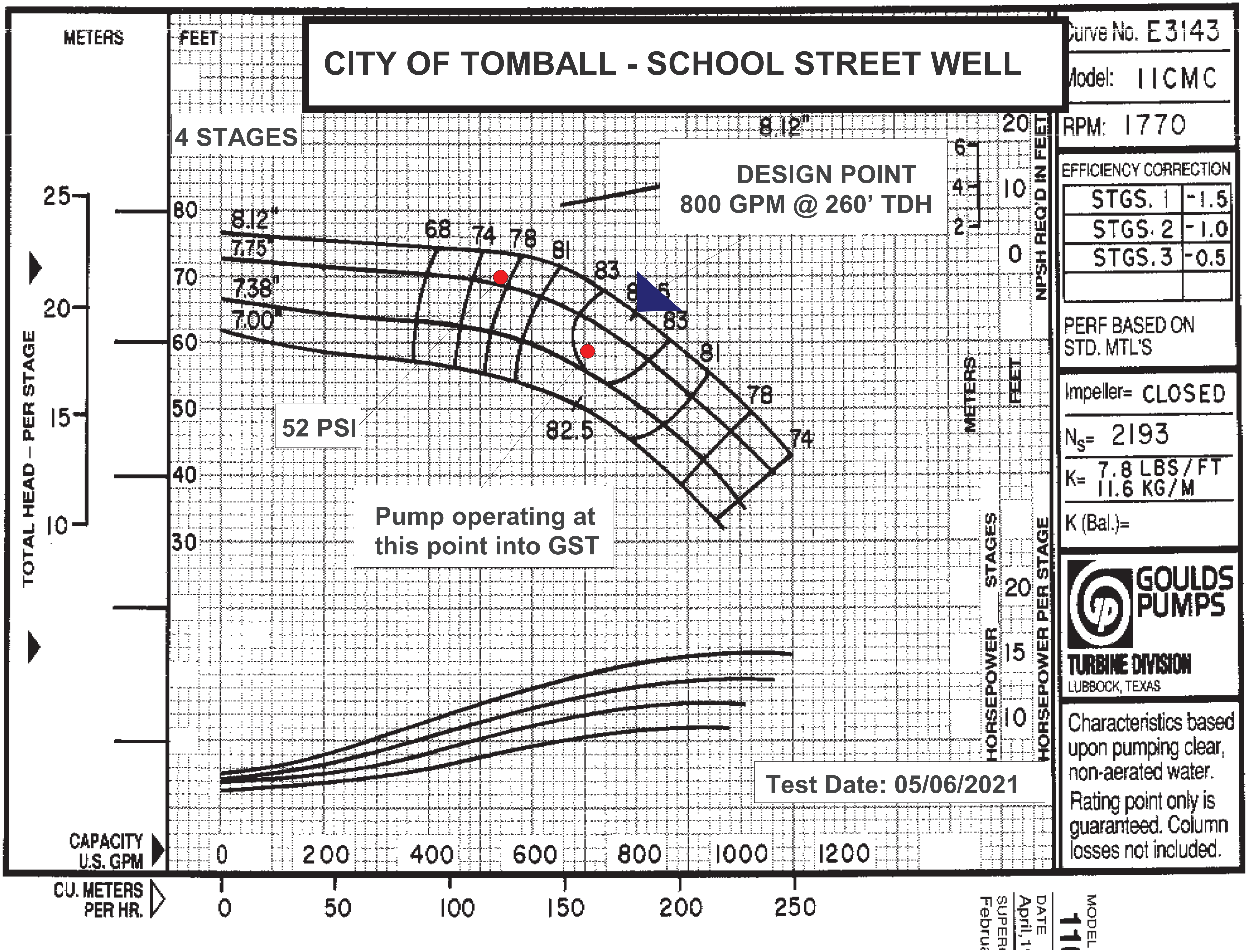
Manufacturer: Water Spec Size: 8
Serial #: 20190821
Meter Read: 220910.000
Meter accuracy is 97.5 % at 689 GPM

Additional Data

Start-up Sand (PPM)	2
Brass Detect:	No
Pump Submergence (ft)	55
ETM Read:	

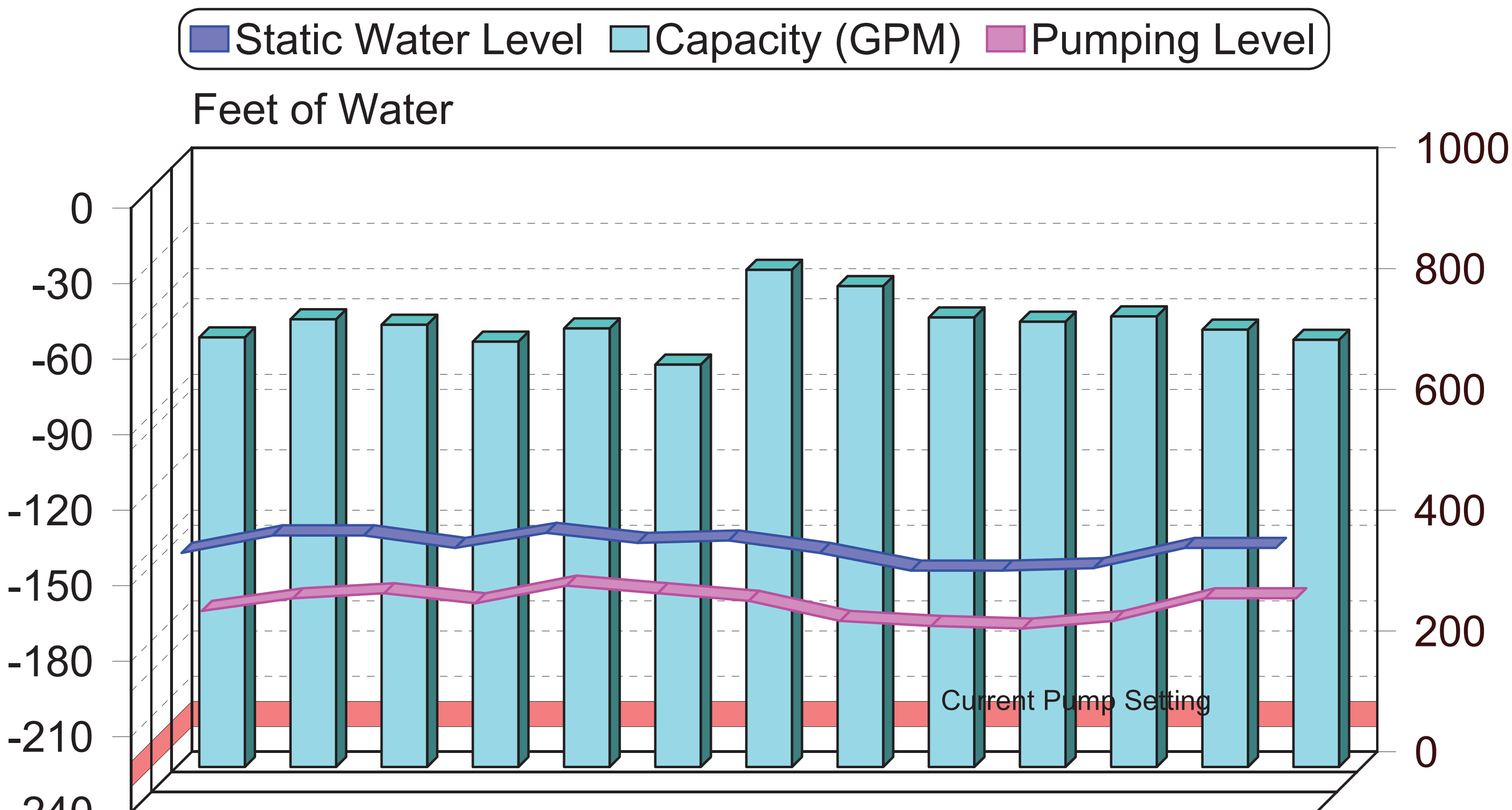
Remarks
Meter affidavit completed.

TECHNICIAN P. White


CITY OF TOMBALL - SCHOOL STREET WELL
4 STAGES
DESIGN POINT
800 GPM @ 260' TDH
52 PSI
Pump operating at
this point into GST
Test Date: 05/06/2021
METERS
FEET
TOTAL HEAD – PER STAGE
CAPACITY U.S. GPM
CU. METERS PER HR.
8.12"
7.75"
7.38"
7.00"
68
74
78
81
83
83
81
78
74
82.5
NPSH REQ'D IN FEET
HORSEPOWER PER STAGE
HORSEPOWER
STAGES
Curve No. E3143
Model: 11CMC
RPM: 1770
EFFICIENCY CORRECTION
STGS. 1 -1.5
STGS. 2 -1.0
STGS. 3 -0.5
PERF BASED ON STD. MTL'S
Impeller= CLOSED
Ns= 2193
K= 7.8 LBS/FT
11.6 KG/M
K (Bal.)=
GOULDS PUMPS
TURBINE DIVISION
LUBBOCK, TEXAS
Characteristics based upon pumping clear, non-aerated water.
Rating point only is guaranteed. Column losses not included.

City of Tomball

School Street Well



	9/11	11/12	3/13	9/13	3/14	4/15	2/16	5/16	5/17	5/18	5/19	5/20	5/21
Static Water Level	-139	-132	-132	-137	-131	-135	-134	-139	-146	-146	-145	-137	-137
Capacity (GPM)	711	741	732	704	726	666	823	796	744	737	746	724	707
Pumping Level	-170	-165	-163	-167	-160	-163	-166	-174	-176	-177	-174	-165	-165

Prepared by G-M Services

Harris-Galveston Subsidence District

Serving the Gulf Coast Community Since 1975

Affidavit of Meter Calibration Test

Instructions:
Items marked with an * are required.

*Permittee Name: CIty of Tomball

*Well No.: 4023

*Description of site at location: School St. Well

*Meter Manufacturer: Water Specialties

*Serial No.: 20190821

*Type: (•) Propeller ( ) Turbine ( ) Positive Displacement ( ) Compound ( ) Other

*Testing Firm: G-M Services

*Mailing Address: P.O. Box 690309

*City: Houston

*State: Texas *Zip: 77269

*Phone Number: 281-894-8971 (###-###-####) Ext.:

*Test Supervisor: P. White

*Title: tech

*Details of Test: ( ) Pitot Tube (•) Transmit Time ( ) In-Line Calibrated Meter

*Date of Test: 05/06/2021 (mm/dd/yyyy)

*Description of Test: set up downstream of meter

*Unit Serial No.: Q2FO185TO

Please fax or mail a diagram of installation tested, including the test equipment used. A schematic diagram is acceptable if pipe dimensions are given. Include a copy of test tape if transit time method is used.

Test Results:

*Meter reading at start of test:	220910000	Gallons
*Meter reading at end of test:	220916890	Gallons
*Metered quantity (item 2 - item 1):	6890	Gallons
*Known standard quantity in test:	7070	Gallons
*Percent accuracy (item 3 ÷ item 4 x 100)	97.5	%
*Flow Rate:	689	Gallons/Min
*Pipe Diameter:	8	in.
*Recalibration:	○ Yes ◉ No	
Percent Accuracy after Recalibration:		%
Remarks:		
*Applicant/Agent Name:	GM	
*Please enter your e-mail address:	gary@g-mservices.com	
*Please re-enter your e-mail address:	gary@g-mservices.com	

Submit Print

APPENDIX D:

APPENDIX B

HISTORICAL WATER PRODUCTION

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
2017 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUNE 2017	JULY 2017	AUG 2017	SEPT 2017	OCT 2017	NOV 2017	DEC 2017	Total
1	1.73	1.62	2.07	1.72	2.03	2.34	2.86	3.23	1.89	2.11	1.61	1.97	
2	1.32	1.57	1.71	1.98	2.97	1.82	2.39	3.05	1.57	2.02	1.60	1.88	
3	1.45	1.67	1.68	1.88	4.76	2.07	2.89	2.65	1.90	2.37	2.10	2.24	
4	1.68	1.38	1.72	1.63	4.54	1.95	3.49	2.23	1.79	1.68	1.90	1.57	
5	1.31	1.62	1.49	2.05	3.27	1.89	2.76	2.53	2.27	2.13	1.82	1.83	
6	1.64	1.69	1.46	2.22	2.46	1.90	3.21	2.21	2.01	2.23	2.01	1.74	
7	1.35	1.45	1.63	2.01	2.28	1.96	2.44	1.99	1.92	2.47	2.10	1.56	
8	2.47	1.95	1.60	2.01	2.49	2.56	3.02	1.92	2.15	1.87	1.93	1.56	
9	2.14	1.81	1.43	2.03	2.82	2.59	2.47	1.81	2.42	2.52	1.63	1.40	
10	1.79	1.71	1.59	2.24	2.29	2.41	1.72	2.23	2.17	2.49	2.05	1.65	
11	1.55	1.60	1.76	1.84	2.57	2.38	2.17	2.20	2.24	2.01	1.59	1.78	
12	1.87	1.65	1.23	1.49	2.48	2.55	2.28	2.24	2.51	2.43	1.91	1.88	
13	1.61	1.80	1.91	1.84	2.73	2.85	2.35	2.31	2.26	2.40	2.08	1.48	
14	1.35	1.82	1.63	1.75	2.68	2.37	2.39	2.44	2.83	2.62	2.01	1.65	
15	1.82	1.19	1.61	1.54	2.58	2.88	2.38	2.77	2.35	2.28	2.09	2.05	
16	1.46	1.78	1.40	2.05	2.93	2.71	2.44	2.76	2.52	1.94	1.84	1.69	
17	1.57	1.43	2.00	1.75	2.87	2.96	2.30	2.72	2.50	2.50	2.06	1.34	
18	1.47	1.46	1.61	1.47	2.71	2.77	2.32	2.97	3.38	2.25	1.91	1.50	
19	1.63	1.57	1.96	1.70	2.86	2.86	2.25	3.45	2.01	2.31	1.92	1.72	
20	1.61	1.37	1.75	1.65	2.93	2.97	2.42	2.66	2.08	2.12	1.94	2.01	
21	1.44	1.66	2.11	2.04	2.61	2.81	2.71	2.84	2.33	2.10	2.05	1.60	
22	1.36	1.47	2.05	2.10	2.34	2.62	3.10	2.92	1.88	1.74	2.05	1.86	
23	1.60	1.48	2.03	1.50	2.05	2.30	2.18	2.95	2.20	1.63	2.08	1.49	
24	1.72	1.68	2.48	2.05	1.94	2.75	2.64	2.85	1.91	2.25	1.57	1.39	
25	1.65	1.45	1.85	2.28	2.44	1.75	2.83	2.38	2.08	1.98	1.81	1.54	
26	1.70	1.68	2.09	2.04	2.28	2.11	2.86	1.76	2.22	1.80	1.80	1.25	
27	1.81	1.76	2.06	2.34	2.76	2.18	2.96	1.23	2.39	2.19	2.01	1.37	
28	1.23	1.74	2.24	2.36	2.42	2.14	3.04	1.93	2.72	1.96	2.21	1.44	
29	1.66		2.05	2.35	1.96	2.54	3.58	1.20	2.31	1.96	2.26	1.47	
30	1.58		1.79	2.09	1.95	2.76	3.38	1.53	2.54	1.96	1.91	1.72	
31	1.74		2.18		2.43		2.54	1.77		2.20		1.19	
Total Monthly Flow	**50.27**	**45.04**	**56.17**			**72.73**	**82.36**						**306.57**
Average Daily Flow per Month	**1.62**	**1.61**	**1.81**	**1.93**	**2.66**	**2.42**	**2.66**	**2.38**	**2.24**	**2.15**	**1.93**	**1.64**	**2.09**
Maximum Daily Flow per Month	**2.47**	**1.95**	**2.48**	**2.36**	**4.76**	**2.97**	**3.58**	**3.45**	**3.38**	**2.62**	**2.26**	**2.24**	**4.76**
Minimum Daily Flow per Month	**1.23**	**1.19**	**1.23**	**1.47**	**1.94**	**1.75**	**1.72**	**1.20**	**1.57**	**1.63**	**1.57**	**1.19**	**1.19**
Trend													

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
2018 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2018	FEB 2018	MAR 2018	APR 2018	MAY 2018	JUNE 2018	JULY 2018	AUG 2018	SEPT 2018	OCT 2018	NOV 2018	DEC 2018	Total
1	1.44	1.66	1.45	1.91	2.31	2.64	2.48	2.35	2.78	1.91	1.60	1.92	
2	1.28	1.55	1.78	1.98	2.27	2.69	2.63	2.52	2.51	1.90	1.79	1.61	
3	1.62	1.53	1.60	2.25	2.27	2.77	2.65	2.84	2.07	1.90	1.66	1.59	
4	1.63	1.43	1.41	1.83	2.21	2.56	2.82	2.77	2.01	1.94	1.79	1.75	
5	1.58	1.34	1.68	1.89	2.10	3.20	1.68	2.40	2.06	1.82	1.49	1.83	
6	1.46	1.77	1.75	2.32	1.90	2.72	1.91	2.85	2.15	2.01	1.82	1.79	
7	1.69	1.36	1.71	2.41	1.98	3.05	2.76	2.32	2.35	1.80	1.63	1.66	
8	1.17	1.43	1.93	1.21	2.21	3.20	1.66	2.44	2.17	1.94	1.63	1.37	
9	1.51	1.53	1.68	2.15	2.45	2.81	1.98	2.52	2.22	1.99	1.69	1.54	
10	1.63	1.58	1.84	1.64	2.57	2.48	2.14	2.47	1.72	1.89	1.94	1.66	
11	1.32	1.35	1.66	1.92	2.45	2.89	2.13	2.61	2.30	1.88	1.45	1.43	
12	1.38	1.13	1.52	1.98	2.51	3.43	2.47	2.30	1.75	1.77	1.51	1.49	
13	1.60	1.42	1.85	2.24	2.55	2.95	2.15	2.34	2.11	2.09	1.52	1.65	
14	1.20	1.46	2.23	1.80	2.39	3.24	2.34	2.03	2.11	2.01	1.78	0.98	
15	1.48	1.66	2.21	1.83	2.93	2.24	2.25	3.01	1.75	1.93	1.46	1.29	
16	1.52	1.47	1.89	1.74	2.79	2.70	2.32	3.06	1.70	2.92	1.70	1.34	
17	2.33	1.37	1.59	1.95	2.91	2.39	2.44	2.79	2.01	3.65	1.53	1.19	
18	2.74	1.70	2.15	2.15	3.14	1.90	2.66	2.78	2.44	3.69	1.58	1.15	
19	3.08	1.40	1.86	1.87	3.08	1.86	2.58	2.77	2.17	2.02	1.23	1.27	
20	1.53	1.76	2.27	2.07	3.04	1.76	2.78	2.66	2.66	1.80	1.73	1.43	
21	1.62	1.64	2.09	2.19	2.33	1.74	3.02	2.90	2.02	1.30	1.53	1.89	
22	1.57	1.34	2.07	1.70	1.80	2.12	2.79	3.02	1.86	1.39	1.66	1.50	
23	1.73	1.48	2.12	1.67	2.11	2.01	2.74	2.98	1.76	1.81	1.21	1.54	
24	1.58	1.48	2.12	1.88	2.05	2.32	2.95	3.31	1.75	1.47	1.61	1.45	
25	1.59	1.38	2.07	1.93	2.17	1.99	2.80	3.24	1.92	1.83	1.47	1.53	
26	1.41	1.58	2.18	1.96	1.86	2.42	3.43	3.12	2.17	1.89	1.55	1.39	
27	1.59	1.43	2.25	2.13	2.16	2.37	3.04	3.09	1.77	1.69	1.64	1.33	
28	1.45	1.60	1.79	2.04	2.02	2.55	3.35	3.36	1.95	1.74	1.75	1.59	
29	1.51		1.74	2.24	2.53	2.73	3.28	2.47	2.04	1.97	1.64	1.56	
30	1.50		2.13	2.18	2.40	3.13	2.73	2.57	1.75	1.98	1.63	1.52	
31	1.62		1.93		2.82		3.46	2.69		1.78		1.42	
Total Monthly Flow	50.35	41.81	58.54			76.84	80.41						307.95
Average Daily Flow per Month	1.62	1.49	1.89	1.97	2.40	2.56	2.59	2.73	2.07	1.99	1.61	1.51	2.04
Maximum Daily Flow per Month	3.08	1.77	2.27	2.41	3.14	3.43	3.46	3.36	2.78	3.69	1.94	1.92	3.69
Minimum Daily Flow per Month	1.17	1.13	1.41	1.21	1.80	1.74	1.66	2.03	1.70	1.30	1.21	0.98	0.98
Trend													

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
2019 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2019	FEB 2019	MAR 2019	APR 2019	MAY 2019	JUNE 2019	JULY 2019	AUG 2019	SEPT 2019	OCT 2019	NOV 2019	DEC 2019	Total
1	1.32	1.46	1.47	1.84	2.26	2.48	1.82	2.50	2.94	2.93	1.84	1.65	
2	1.37	1.67	1.63	2.02	1.98	2.28	1.87	2.73	3.23	2.48	2.05	1.95	
3	1.35	1.18	1.46	2.03	1.85	2.40	1.66	2.92	2.85	2.90	1.99	1.66	
4	1.57	1.30	1.30	1.89	1.89	2.55	1.88	2.19	3.17	2.77	1.65	1.91	
5	1.55	1.55	1.56	1.86	1.63	2.36	1.98	2.69	3.51	2.80	2.07	1.60	
6	1.46	1.44	1.61	1.79	1.87	1.84	2.16	2.95	3.73	2.59	2.18	1.93	
7	1.49	1.65	1.41	1.79	1.70	2.28	2.13	2.65	3.61	2.79	1.83	1.79	
8	1.44	1.39	1.60	1.65	1.63	2.37	2.33	3.21	3.54	2.53	1.91	1.72	
9	1.66	1.65	1.59	1.51	1.60	3.06	2.28	3.23	3.29	2.55	1.86	1.94	
10	1.60	1.35	1.47	1.97	1.65	2.65	2.33	3.29	3.43	2.78	1.67	1.65	
11	1.63	1.34	1.43	1.79	1.72	2.58	2.69	3.44	2.77	2.70	1.94	1.52	
12	1.49	1.62	1.56	1.98	1.51	2.44	2.57	2.85	3.19	2.55	1.76	1.81	
13	1.54	1.38	1.42	1.76	1.67	2.63	2.46	3.49	3.13	2.07	1.87	1.69	
14	1.39	1.57	1.60	1.58	1.72	2.78	2.36	3.26	3.42	2.16	1.67	1.52	
15	1.48	1.38	1.41	1.73	1.91	3.10	2.19	3.09	3.57	2.40	1.72	2.02	
16	1.76	1.74	1.74	2.08	2.16	2.66	1.97	2.72	3.10	2.22	1.81	1.63	
17	1.45	1.34	1.50	1.90	1.90	1.94	2.25	3.14	3.10	1.90	1.78	1.69	
18	1.62	1.56	1.52	1.86	1.85	2.20	2.45	2.77	2.42	2.04	1.62	1.80	
19	1.31	1.33	1.76	1.69	1.93	2.26	2.03	2.76	2.18	2.31	1.71	1.62	
20	1.50	1.62	1.68	1.86	2.18	2.35	2.58	3.02	1.98	2.27	1.99	2.02	
21	1.57	1.35	1.99	1.67	2.37	2.56	2.59	2.85	2.33	2.25	1.73	2.07	
22	1.35	1.68	1.78	1.81	2.15	2.90	2.17	2.99	1.92	3.41	2.01	1.98	
23	1.47	1.49	2.43	2.02	2.44	2.21	2.40	3.14	2.19	5.08	1.56	1.85	
24	1.57	1.55	1.70	2.01	2.50	1.89	2.68	3.02	2.44	4.98	1.51	1.81	
25	1.53	1.74	1.68	1.95	2.37	1.99	2.66	2.79	2.47	3.21	1.92	1.64	
26	1.43	2.80	2.07	2.19	2.48	2.12	2.58	2.42	2.66	2.07	1.74	1.42	
27	1.41	2.65	1.59	2.20	2.20	1.93	3.00	3.31	2.83	1.90	2.00	1.61	
28	1.58	1.27	3.24	2.24	2.77	1.89	2.81	2.97	2.56	2.18	1.63	1.60	
29	1.15		2.01	1.90	2.53	1.97	2.12	3.38	2.61	2.03	1.52	1.60	
30	1.43		2.05	2.23	2.48	1.76	2.51	3.10	2.45	1.94	1.73	1.49	
31	1.44		1.60		2.17		2.21	3.33		1.76		1.38	
Total Monthly Flow	45.90	44.03	52.85			70.43	71.69						284.90
Average Daily Flow per Month	1.48	1.57	1.70	1.89	2.03	2.35	2.31	2.97	2.89	2.60	1.81	1.73	2.11
Maximum Daily Flow per Month	1.76	2.80	3.24	2.24	2.77	3.10	3.00	3.49	3.73	5.08	2.18	2.07	5.08
Minimum Daily Flow per Month	1.15	1.18	1.30	1.51	1.51	1.76	1.66	2.19	1.92	1.76	1.51	1.38	1.15
Trend													

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
2020 Daily Total Production

Water Production in MGD													
DAY OF	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Total
MONTH	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	
1	1.59	1.70	1.68	1.66	1.82	1.63	3.34	2.51	3.35	2.75	1.92	1.69	
2	1.24	1.30	1.66	1.83	1.79	2.03	2.86	2.22	3.40	2.01	2.09	1.75	
3	1.75	1.72	1.49	1.75	2.16	2.23	2.70	2.17	3.58	2.60	1.94	1.73	
4	1.40	1.42	1.89	1.70	2.00	1.80	3.12	2.62	3.11	2.30	2.16	1.61	
5	1.61	1.76	1.55	1.26	2.10	2.17	2.48	2.49	2.79	2.65	2.11	2.00	
6	1.43	1.61	1.85	1.49	2.16	2.19	2.24	3.10	2.31	2.48	2.22	1.45	
7	1.80	1.56	1.76	1.40	2.14	2.43	2.60	2.88	2.34	2.68	2.74	1.62	
8	1.65	1.56	1.69	1.71	2.16	2.32	2.52	3.32	2.07	2.48	1.75	1.62	
9	1.59	1.64	1.53	1.55	2.20	2.42	3.27	2.77	2.42	2.36	2.04	1.73	
10	1.64	1.47	1.78	1.43	2.36	2.75	2.77	2.96	2.62	2.83	2.22	1.79	
11	1.72	1.58	1.71	1.69	1.92	2.63	3.20	2.93	2.41	2.14	2.16	1.55	
12	1.46	1.49	2.13	1.49	2.86	2.94	3.06	3.11	2.91	2.43	2.21	1.81	
13	1.57	1.32	1.83	1.57	2.08	2.04	3.00	3.39	2.42	2.62	2.15	1.45	
14	1.51	1.70	2.16	1.71	2.36	3.67	3.39	3.28	2.18	2.57	2.25	1.54	
15	1.66	1.59	1.81	1.63	1.98	2.76	3.28	3.61	2.55	3.09	2.12	1.53	
16	1.58	1.50	1.91	1.87	1.94	3.13	3.46	3.43	2.63	2.24	2.10	1.67	
17	1.50	1.67	1.79	2.10	1.70	2.77	3.50	3.11	2.81	2.18	1.98	1.43	
18	1.66	1.61	2.05	1.86	1.66	3.45	3.54	2.65	2.36	1.85	2.28	1.75	
19	1.41	1.47	1.65	1.53	2.13	3.12	3.31	2.70	3.01	2.34	2.18	1.78	
20	1.63	1.48	1.88	1.40	2.34	3.08	2.85	3.37	2.61	1.99	2.22	1.79	
21	1.47	1.14	1.64	1.52	2.60	3.12	3.00	3.06	1.90	2.46	2.29	1.59	
22	1.64	1.56	1.23	1.62	2.42	2.27	2.64	3.50	1.77	2.15	1.90	1.74	
23	1.65	1.56	1.41	1.80	1.88	2.05	2.91	2.85	1.73	2.32	2.12	1.49	
24	1.68	1.59	1.50	1.94	2.73	2.00	2.51	2.77	1.66	2.15	2.06	1.76	
25	1.50	1.94	1.61	1.80	2.01	1.97	3.04	3.22	2.07	2.10	2.10	1.48	
26	1.49	1.32	1.58	1.64	1.70	1.73	1.94	2.74	2.29	1.76	1.72	1.35	
27	1.67	1.49	1.95	2.05	1.91	2.26	1.99	2.63	2.20	3.08	1.89	1.28	
28	1.47	1.81	1.69	2.14	1.79	2.03	2.23	3.36	2.14	4.14	1.41	1.85	
29	1.63		1.64	1.78	1.55	2.03	2.29	3.32	2.17	3.88	1.72	1.54	
30	1.32		1.83	1.61	2.21	3.04	2.03	3.14	2.15	2.53	1.59	1.54	
31			1.66		1.75		2.45	3.13		2.01		1.70	
Total Monthly Flow	**46.89**	**43.55**	**53.52**			**74.05**	**87.50**						**305.51**
Average Daily Flow per Month	**1.56**	**1.56**	**1.73**	**1.68**	**2.08**	**2.47**	**2.82**	**2.98**	**2.46**	**2.49**	**2.05**	**1.63**	**2.13**
Maximum Daily Flow per Month	**1.80**	**1.94**	**2.16**	**2.14**	**2.86**	**3.67**	**3.54**	**3.61**	**3.58**	**4.14**	**2.74**	**2.00**	**4.14**
Minimum Daily Flow per Month	**1.24**	**1.14**	**1.23**	**1.26**	**1.55**	**1.63**	**1.94**	**2.17**	**1.66**	**1.76**	**1.41**	**1.28**	**1.14**
Trend													

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
2021 Daily Total Production

Water Production in MGD													
DAY OF	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Total
MONTH	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	
1	1.48	1.78	1.67	1.82	1.62	1.90	2.23	3.28					
2	1.41	1.70	1.49	2.11	1.67	1.96	2.31	2.27					
3	1.53	1.75	1.66	2.06	1.79	1.83	2.42	2.65					
4	1.81	1.70	1.57	1.70	2.08	1.77	1.68	2.84					
5	1.50	1.65	1.60	2.00	1.92	1.83	2.04	2.87					
6	2.11	1.58	1.69	2.18	2.19	2.09	1.45	2.76					
7	1.59	1.51	1.56	2.21	2.19	1.80	2.04	2.65					
8	1.55	1.50	1.61	2.06	2.67	1.88	2.12	3.43					
9	1.63	1.74	1.86	2.19	2.23	2.12	1.81	2.91					
10	1.54	1.74	1.58	2.66	1.88	2.24	1.62	3.09					
11	1.33	1.64	1.81	2.07	2.60	2.21	1.96	3.10					
12	1.70	1.31	1.99	2.09	2.30	2.46	2.11	2.99					
13	1.47	1.34	1.78	2.55	2.22	2.44	1.87	3.08					
14	1.60	0.75	1.75	2.03	1.98	2.76	1.76	3.32					
15	1.31	1.16	1.32	1.88	2.28	2.80	1.85	2.93					
16	1.80	2.12	1.57	1.66	2.24	2.40	1.72	2.45					
17	1.47	4.98	1.48	1.81	1.86	2.27	2.10	2.30					
18	1.57	5.45	1.80	1.59	1.68	2.48	1.80	2.36					
19	1.60	5.73	1.67	1.95	1.74	2.96	1.98	2.17					
20	1.63	3.81	1.78	2.02	1.52	2.54	2.07	2.39					
21	1.58	2.18	1.78	2.17	1.73	2.16	2.23	2.87					
22	1.65	1.88	1.83	2.05	1.65	2.23	2.16	2.93					
23	1.35	2.26	1.76	2.06	1.68	2.25	2.08	2.85					
24	1.44	1.98	1.81	2.00	1.50	2.64	2.51	3.14					
25	1.31	1.73	1.57	1.90	1.63	2.55	2.47	3.08					
26	1.82	1.62	1.92	2.09	1.88	2.83	2.34	3.05					
27	1.50	1.76	2.02	2.30	1.75	2.43	2.65	2.67					
28	1.72	1.60	2.06	2.27	1.94	2.14	2.60	2.96					
29	1.50		1.23	2.23	1.95	1.73	3.03	2.85					
30	1.92		1.96	2.17	1.83	1.97	2.50	2.52					
31			1.96		1.71		2.90	2.98					
Total Monthly Flow	47.40	59.93	53.11			67.64	66.40						294.48
Average Daily Flow per Month	1.58	2.14	1.71	2.06	1.93	2.25	2.14						1.97
Maximum Daily Flow per Month	2.11	5.73	2.06	2.66	2.67	2.96	3.03						5.73
Minimum Daily Flow per Month	1.31	0.75	1.23			1.73	1.45						0.75
Trend													

APPENDIX D:

APPENDIX C

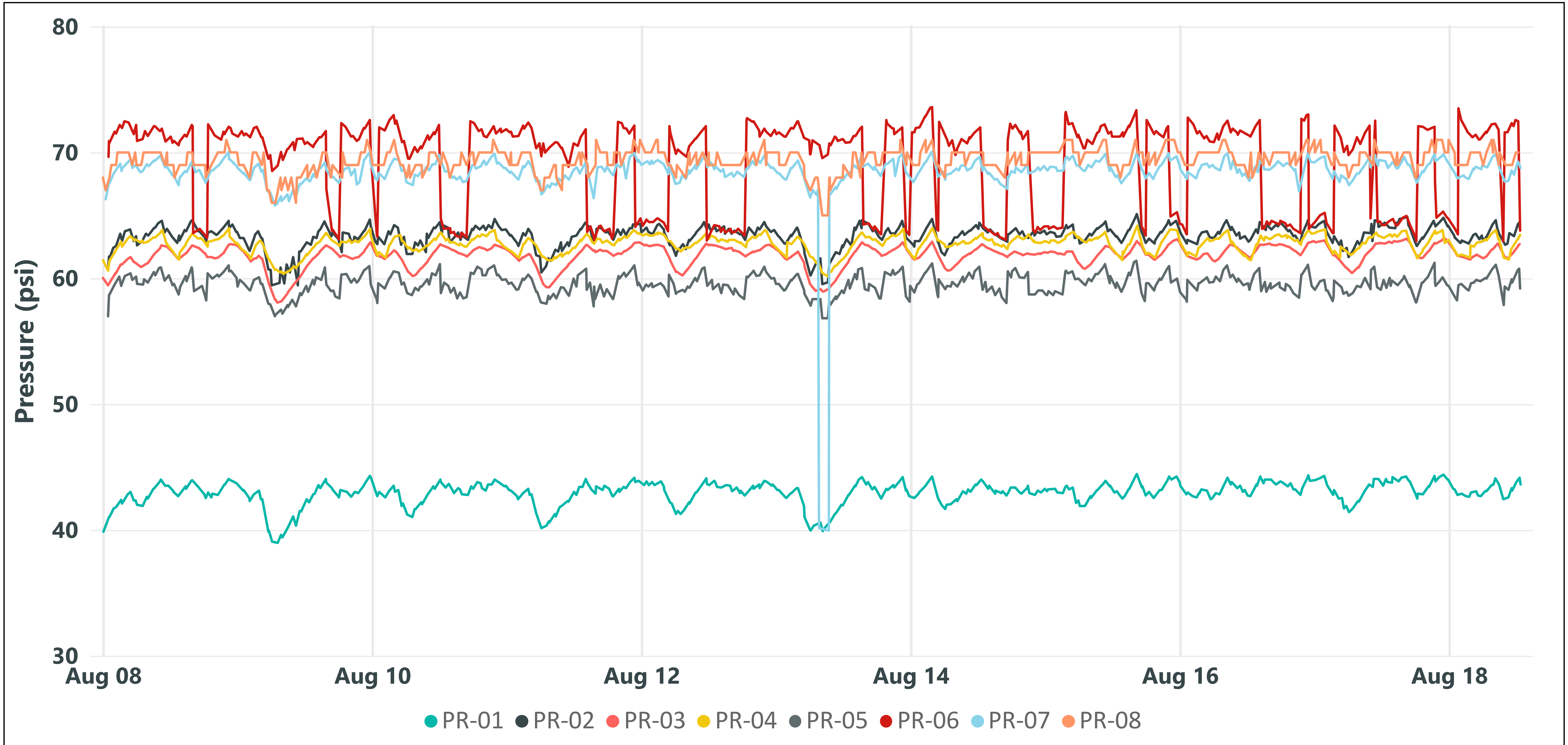
PRESSURE TESTING

City of Tomball

Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

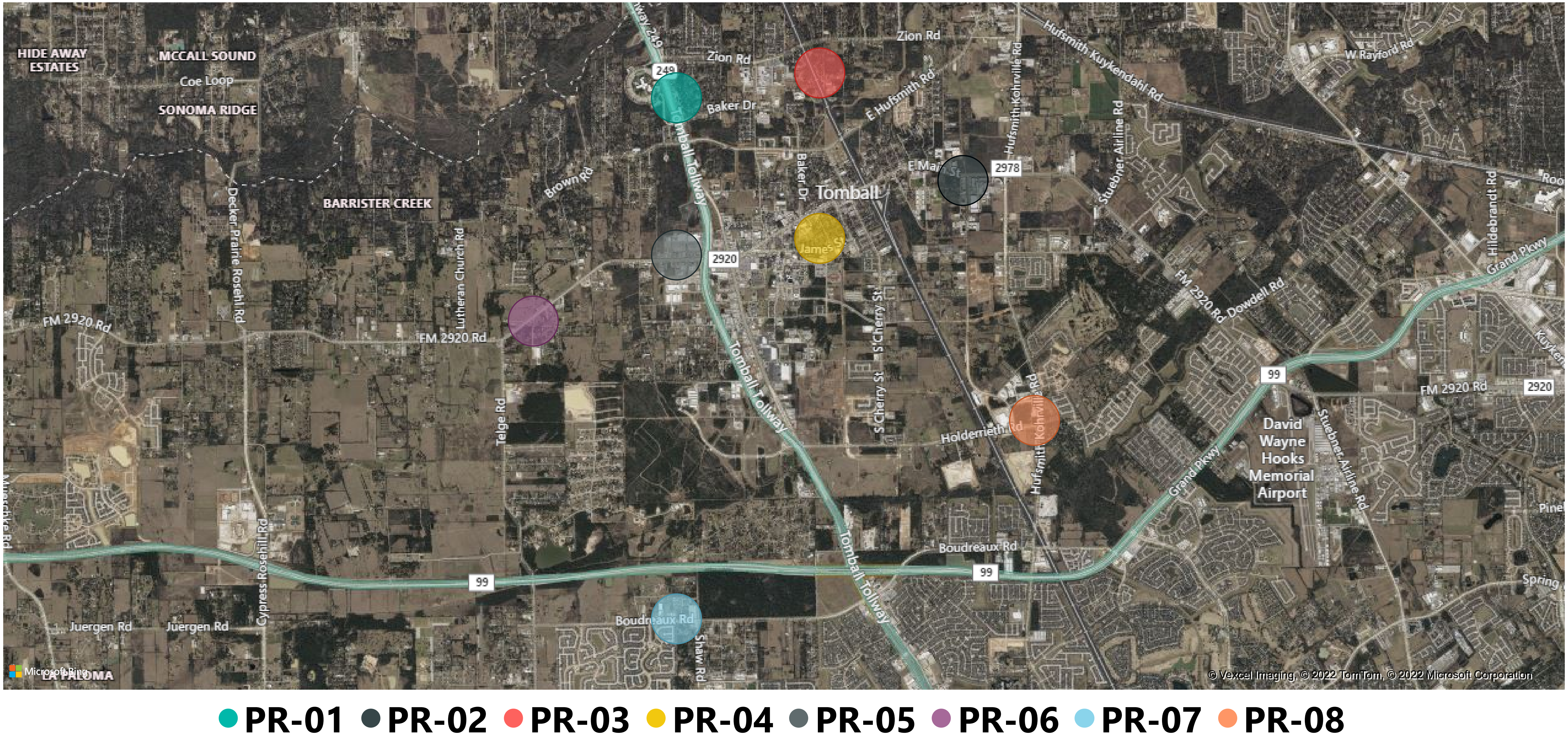


City of Tomball

Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

PR, Lat and Long



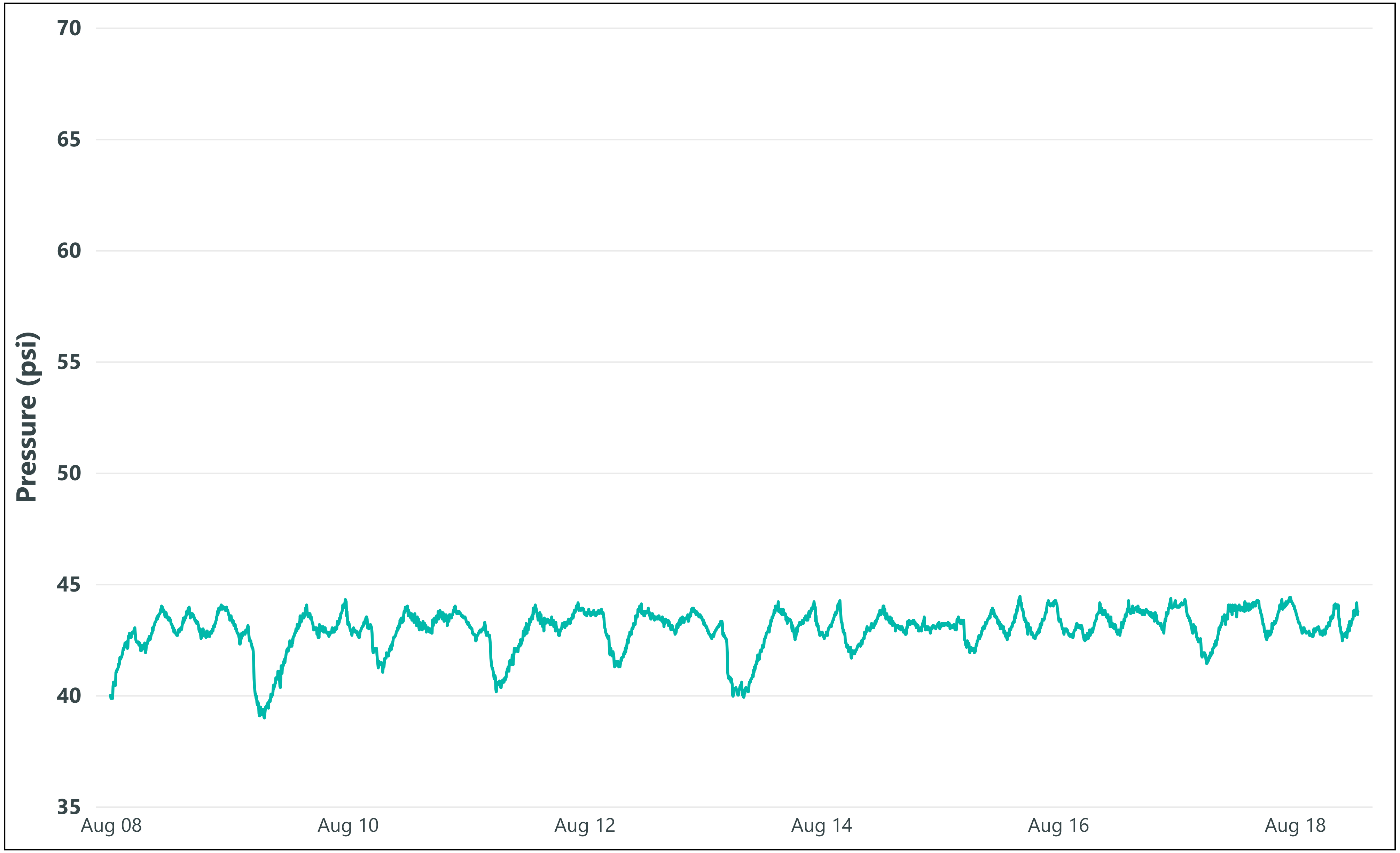
City of Tomball

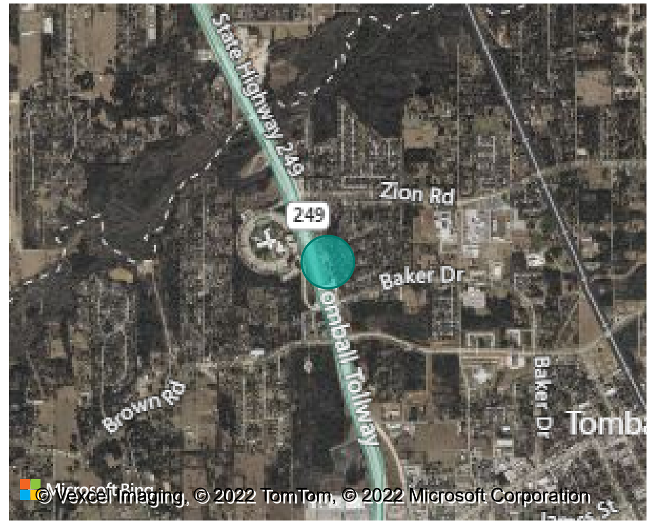
Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-01





Location
Next to Economy Inn and Suites

Hydrant ID	Hyd Ser
H323	-

Pressure Statistics
Min: 39 psi Max: 44 psi Avg: 43 psi

- ◉ PR-01
- ○ PR-02
- ○ PR-03
- ○ PR-04
- ○ PR-05
- ○ PR-06

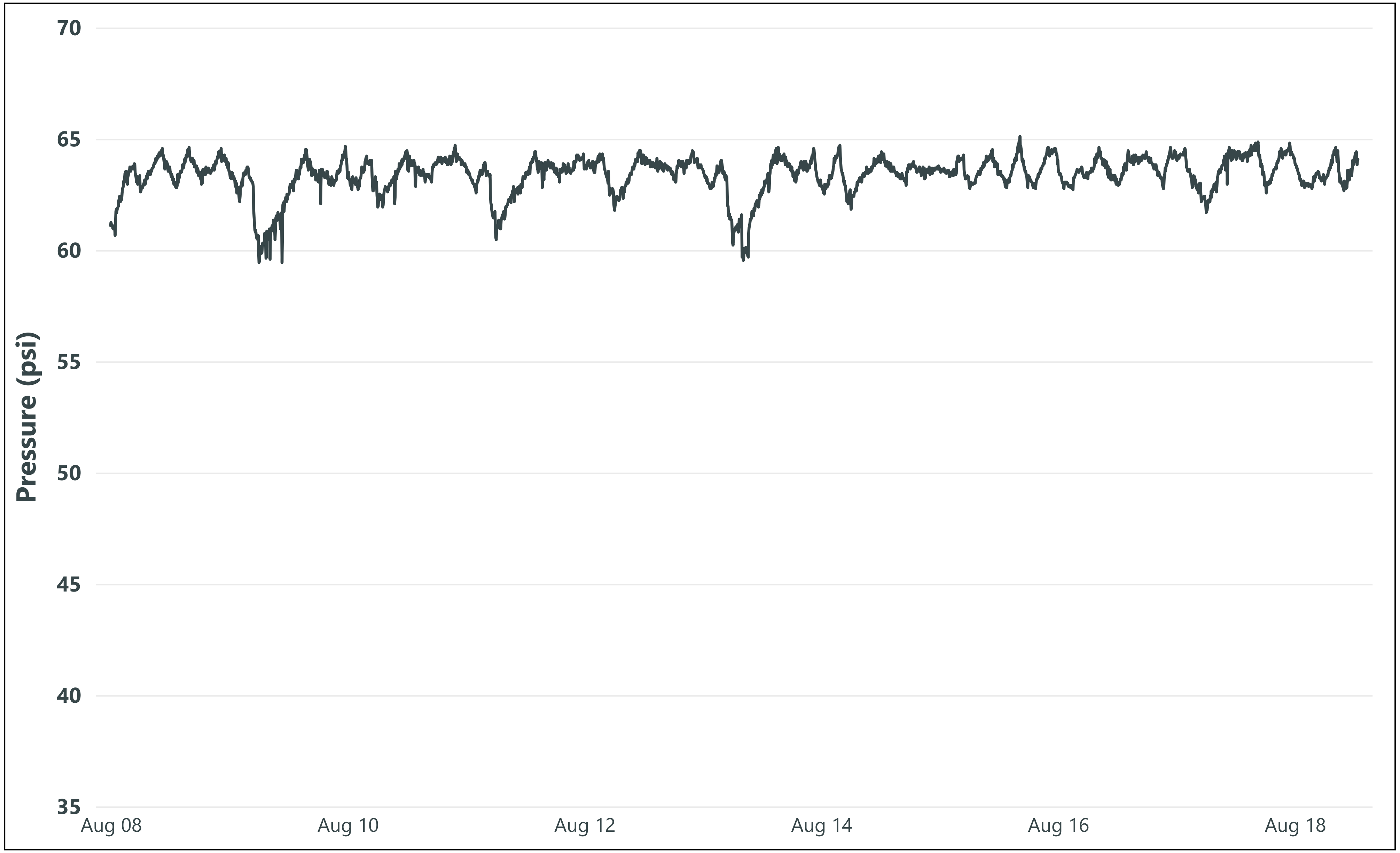
8/8/2021 8/18/2021

City of Tomball

Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

Pressure Recorder: PR-02



Location

Off of FM 2920, in front of long grey office building

Hydrant ID	Hyd Ser
-	-

Pressure Statistics

Min: 59 psi
Max: 65 psi
Avg: 63 psi

- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

City of Tomball

Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: **PR-03**

Location
Off Ulrich Rd. by Juergens Park and Ulrich EST

Hydrant ID	Hyd Ser
H483	-

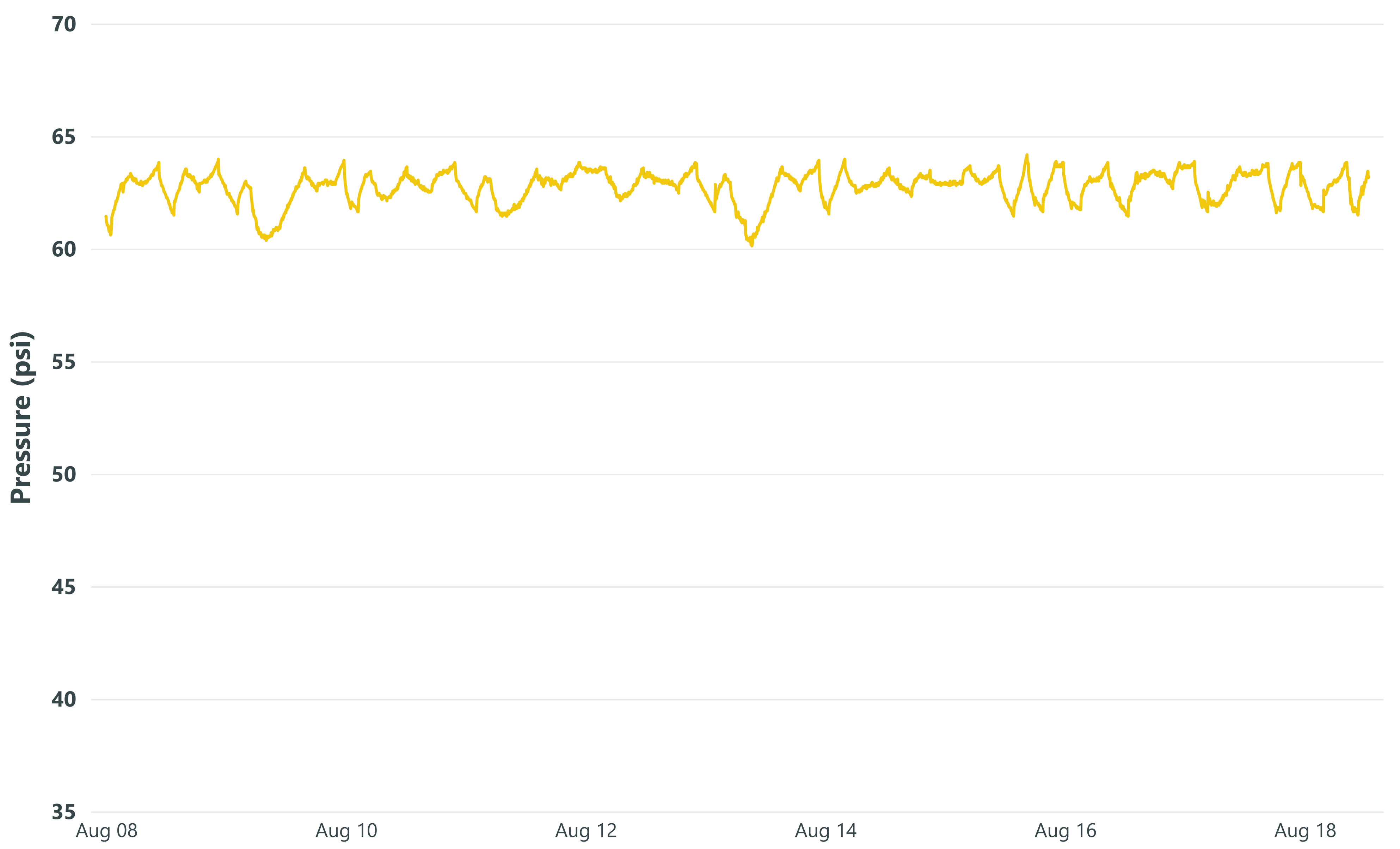
Pressure Statistics
Min: 58 psi Max: 63 psi Avg: 62 psi

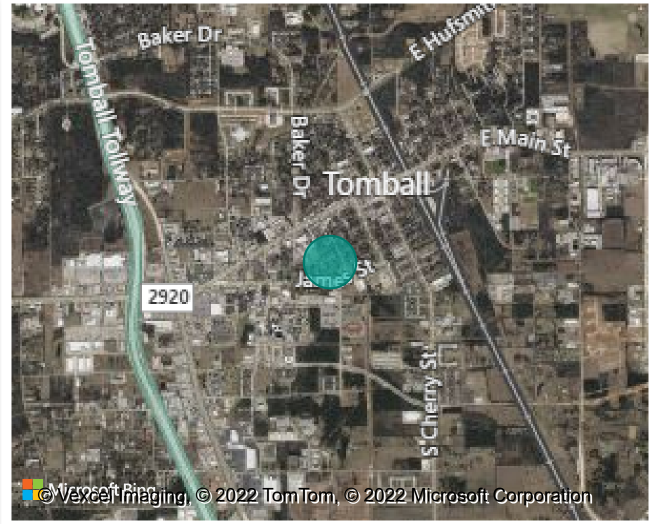
- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

City of Tomball
Water and Wastewater Impact Fee Update - Phase I
Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-04





Location

Next to New Haven sign, Intersection of S Pin St. and James

Hydrant ID	Hyd Ser
-	668990

Pressure Statistics

Min: 60 psi
Max: 64 psi
Avg: 63 psi

- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

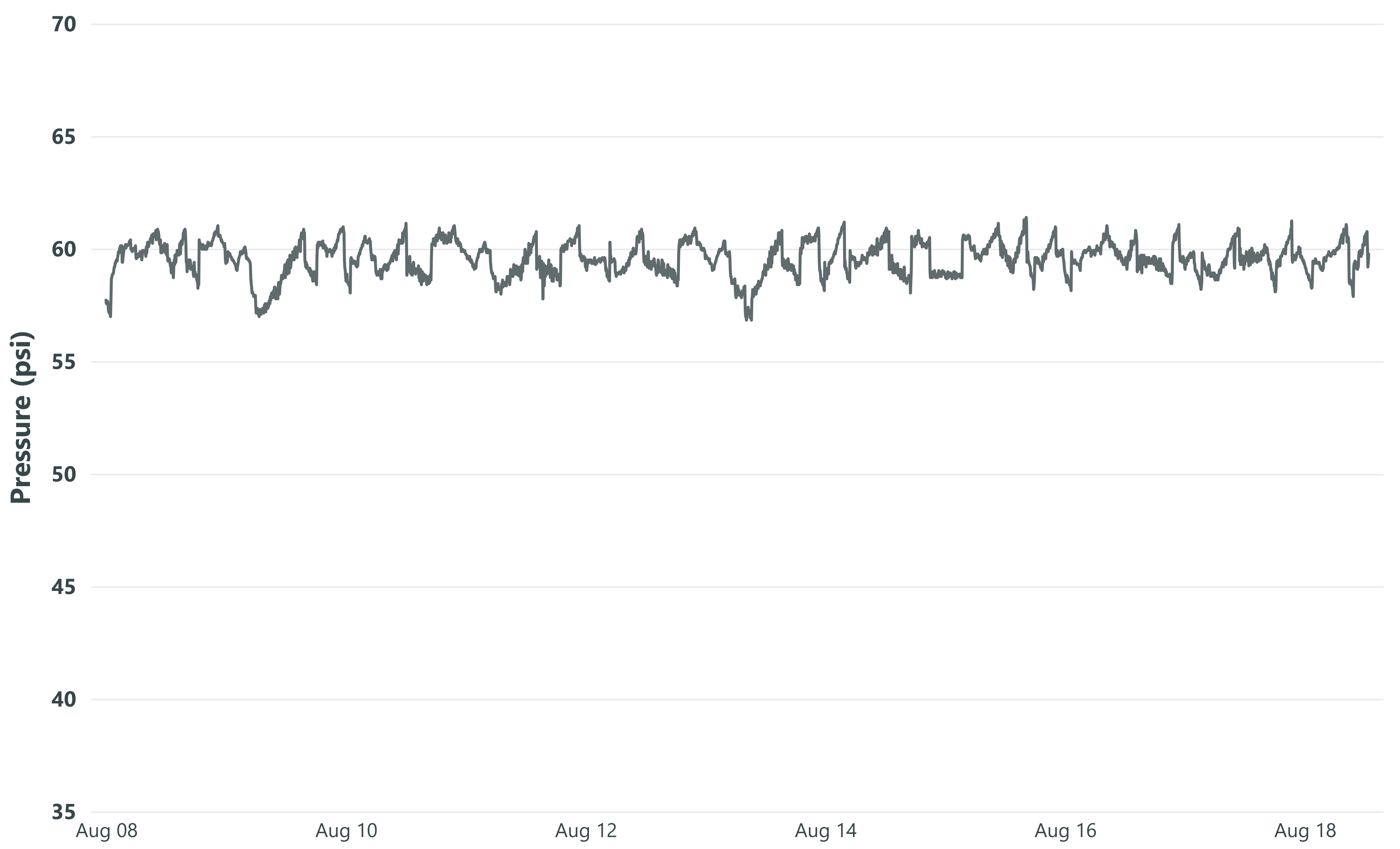
City of Tomball

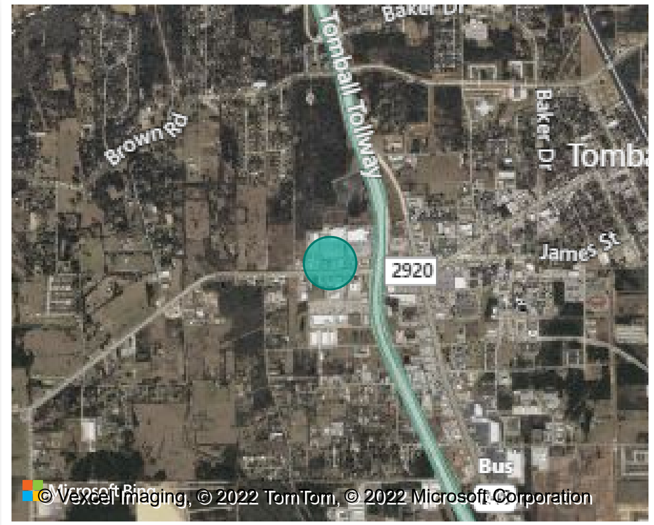
Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-05





Location
Chase Bank parking lot, Off of FM 2920

Hydrant ID	Hyd Ser
H213	-

Pressure Statistics

Min: 57 psi
Max: 61 psi
Avg: 60 psi

- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

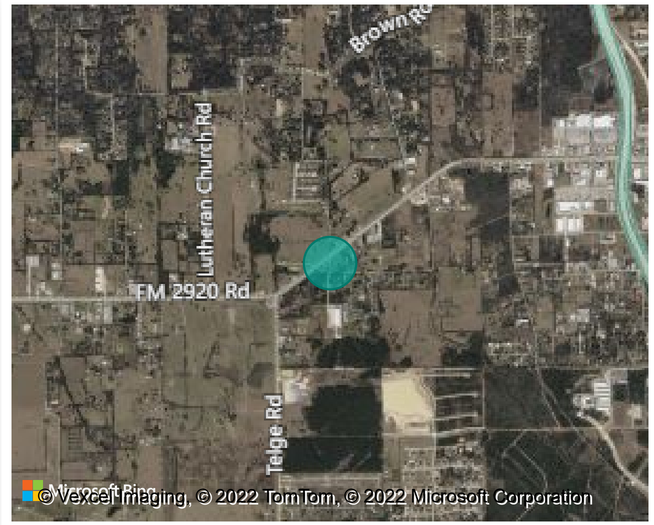
City of Tomball

Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-06



Location
Off FM 2920 Rd, by RM 2920 Water Plant

Hydrant ID	Hyd Ser
-	-

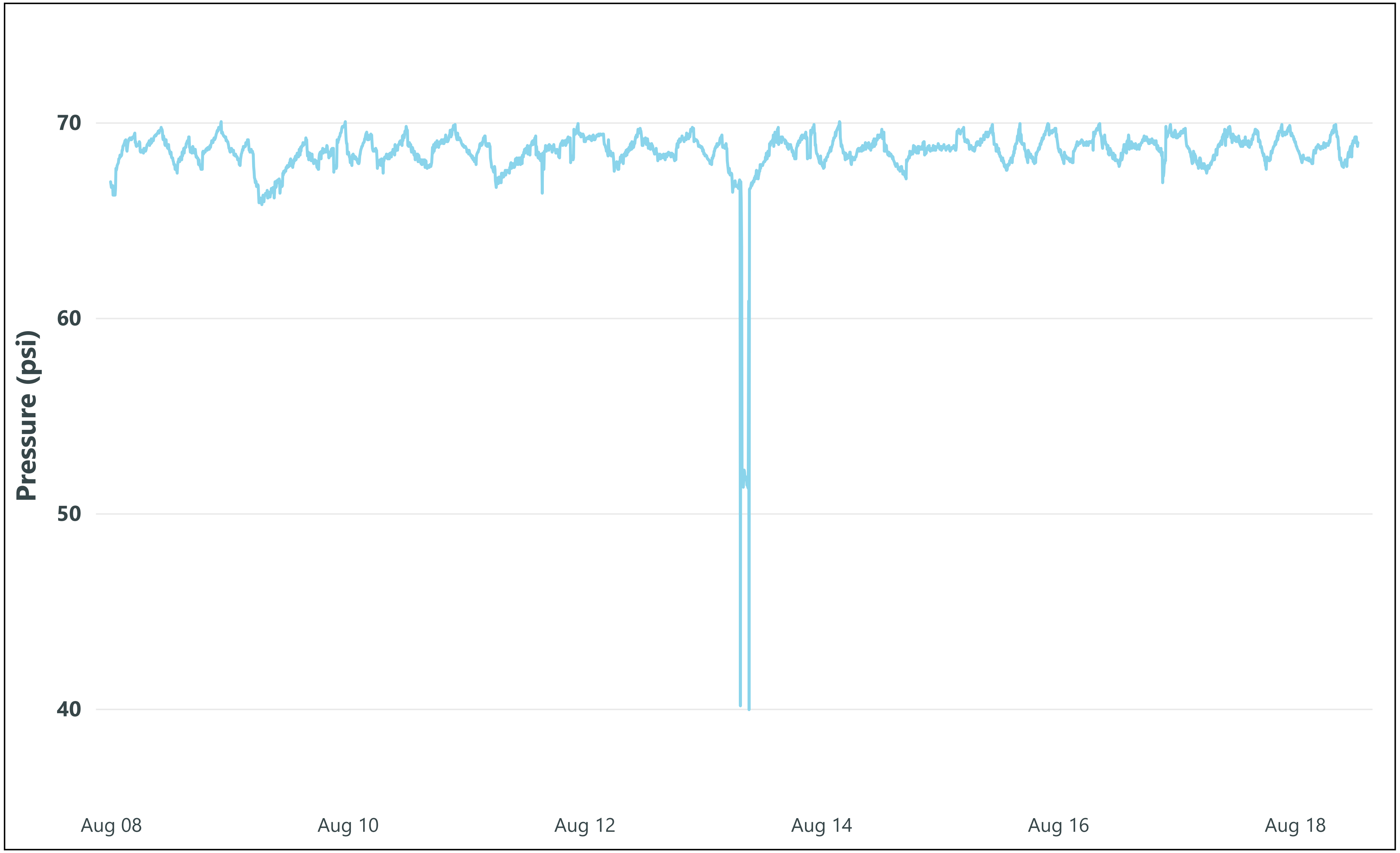
Pressure Statistics
Min: 63 psi Max: 74 psi Avg: 69 psi

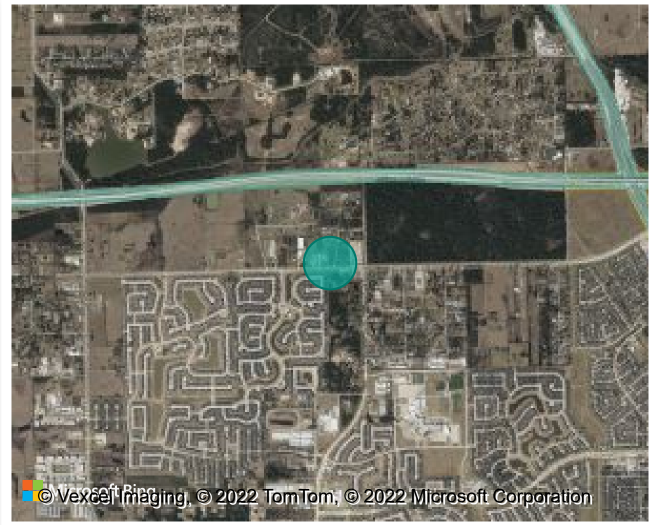
- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

City of Tomball
Water and Wastewater Impact Fee Update - Phase I
Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-07





Location

At corner of Hoffman Estates Blvd. and Boudreaux Rd.

Hydrant ID	Hyd Ser
-	-

Pressure Statistics

Min: 40 psi
Max: 70 psi
Avg: 68 psi

- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

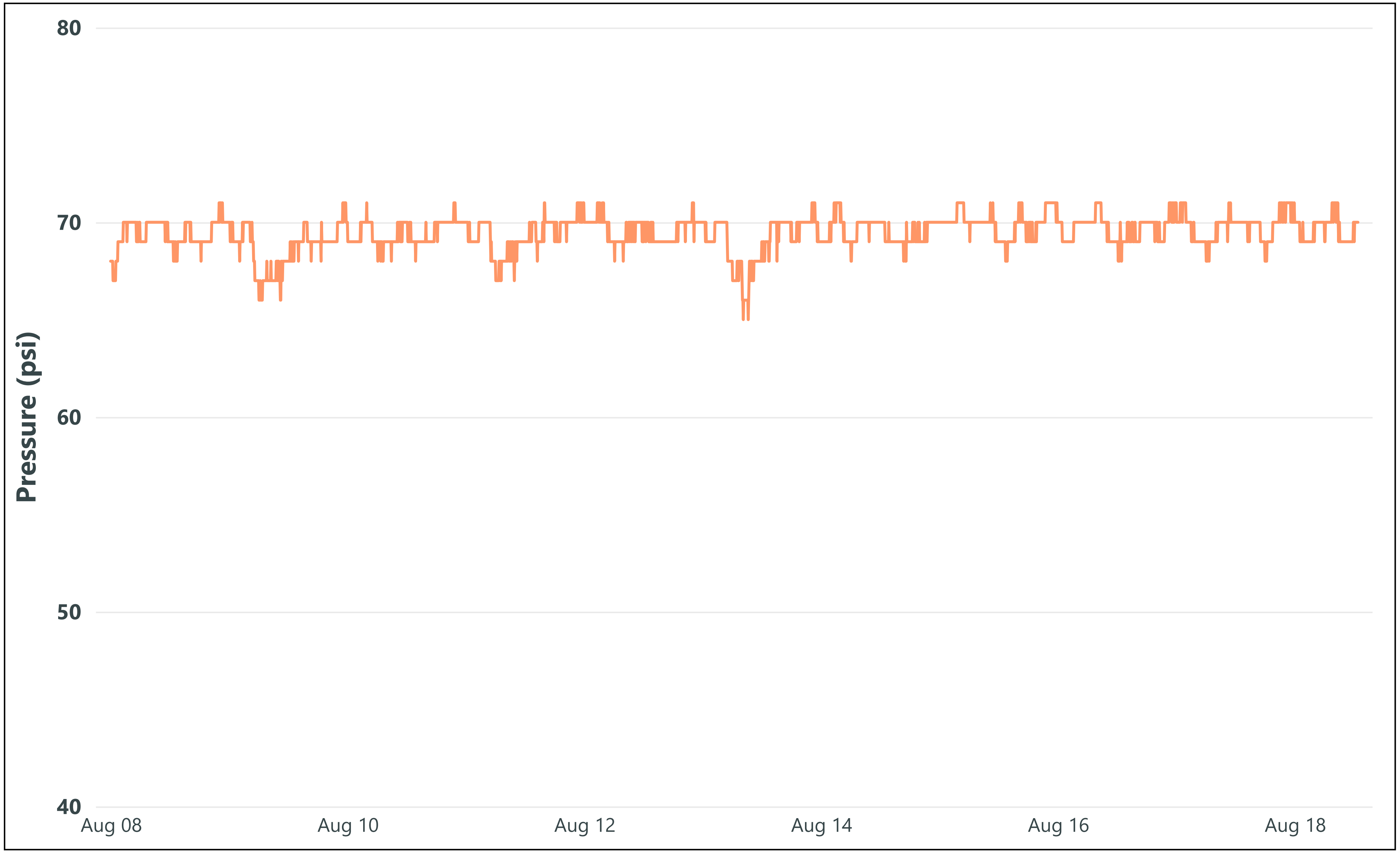
City of Tomball

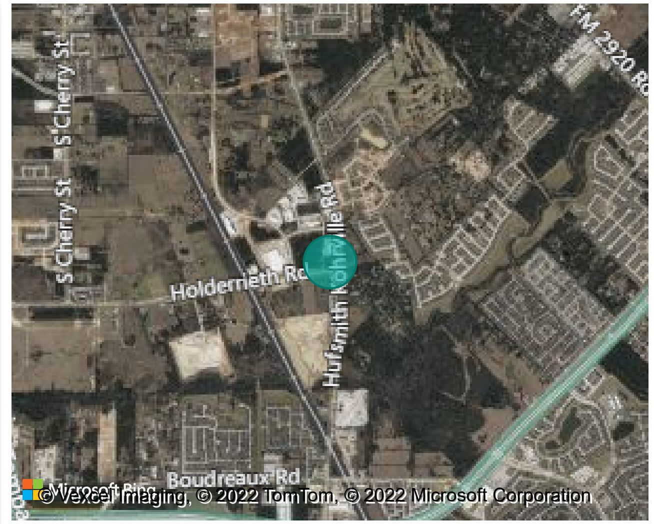
Water and Wastewater Impact Fee Update - Phase I

Pressure Testing Results

8/8/2021 8/18/2021

Pressure Recorder: PR-08





Location

Next to gas station, off of Hufsmith-Kohrville Rd.

Hydrant ID	Hyd Ser
H633	-

Pressure Statistics

Min: 65 psi
Max: 71 psi
Avg: 69 psi

- PR-01
- PR-02
- PR-03
- PR-04
- PR-05
- PR-06

APPENDIX D:

APPENDIX D

WATER MODEL CALIBRATION

City of Tomball

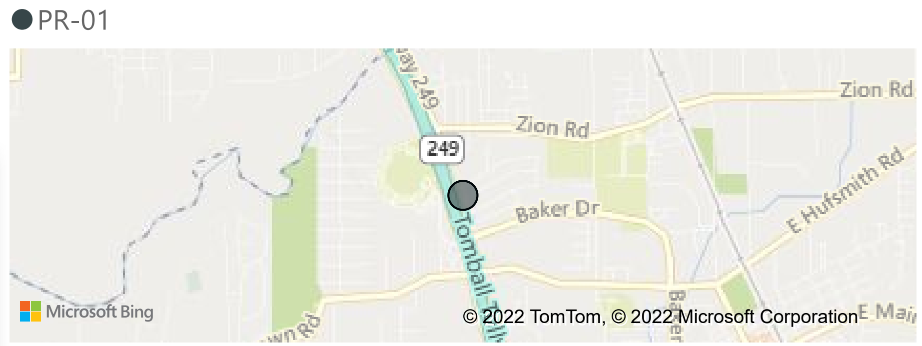
Water and Wastewater Impact Fee Update - Phase 1

Water Model Calibration

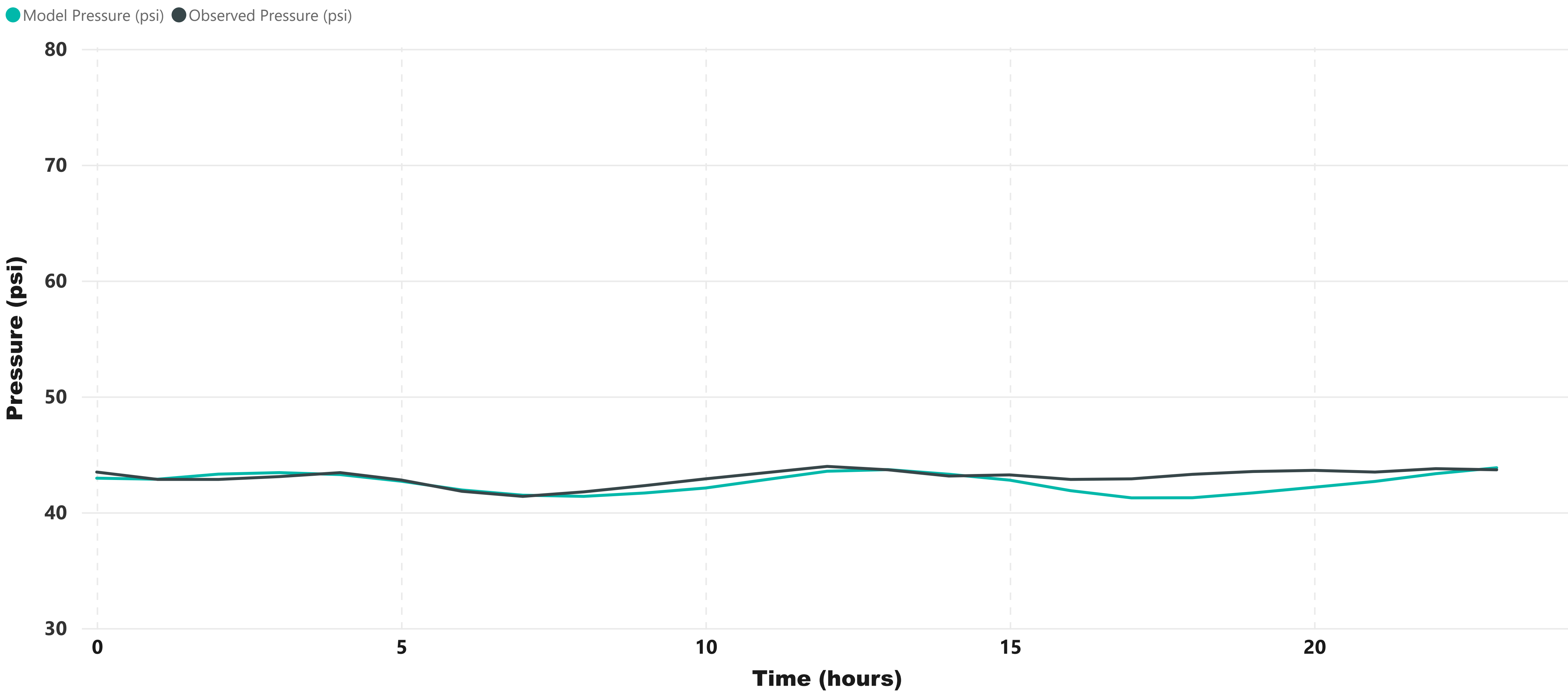
Pressure Recorder ID

PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location



Model Calibration Results



within 10 psi
100.00%

within 5 psi
100.00%

within 3 psi
100.00%

City of Tomball

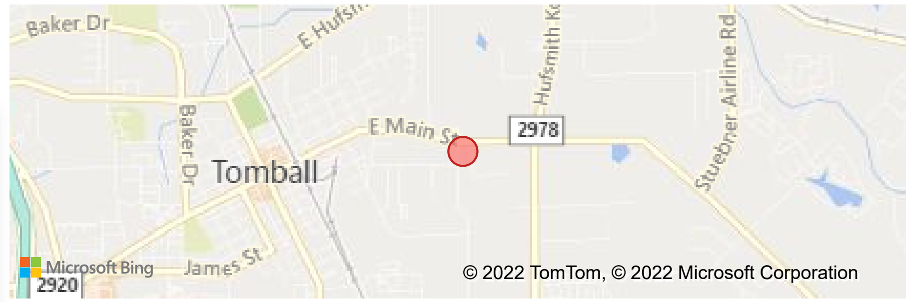
Water and Wastewater Impact Fee Update - Phase 1

Water Model Calibration

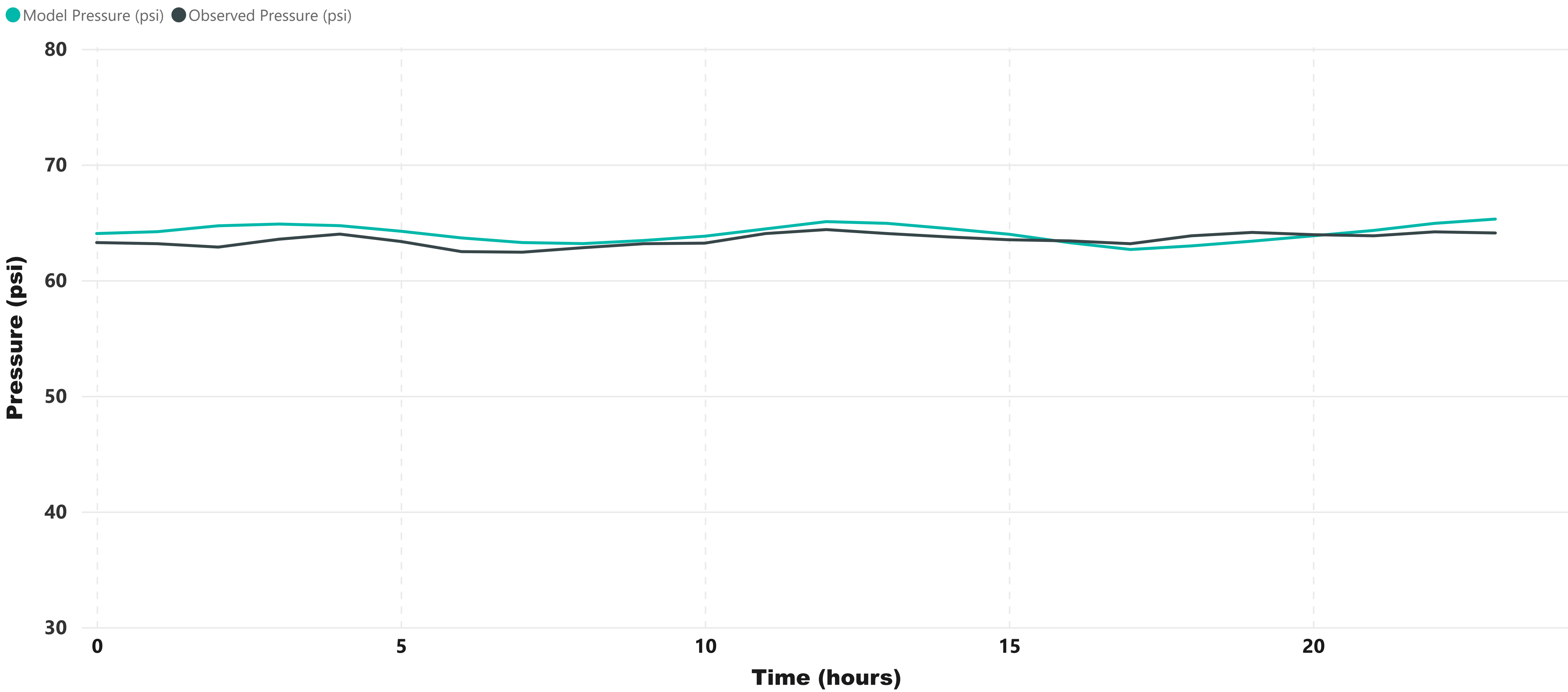
Pressure Recorder ID

PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location



Model Calibration Results



within 10 psi

100.00%

within 5 psi

100.00%

within 3 psi

100.00%

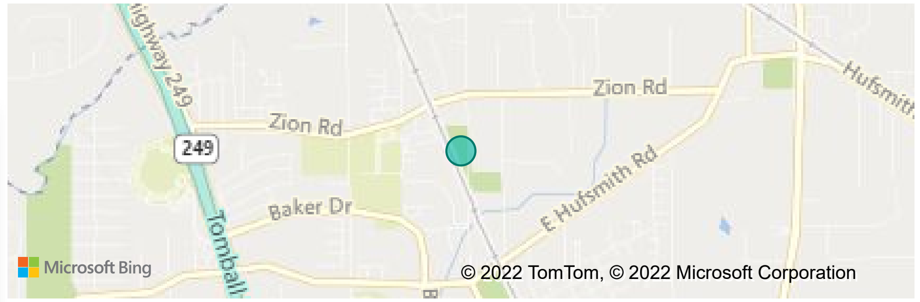
City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
Water Model Calibration

Pressure Recorder ID

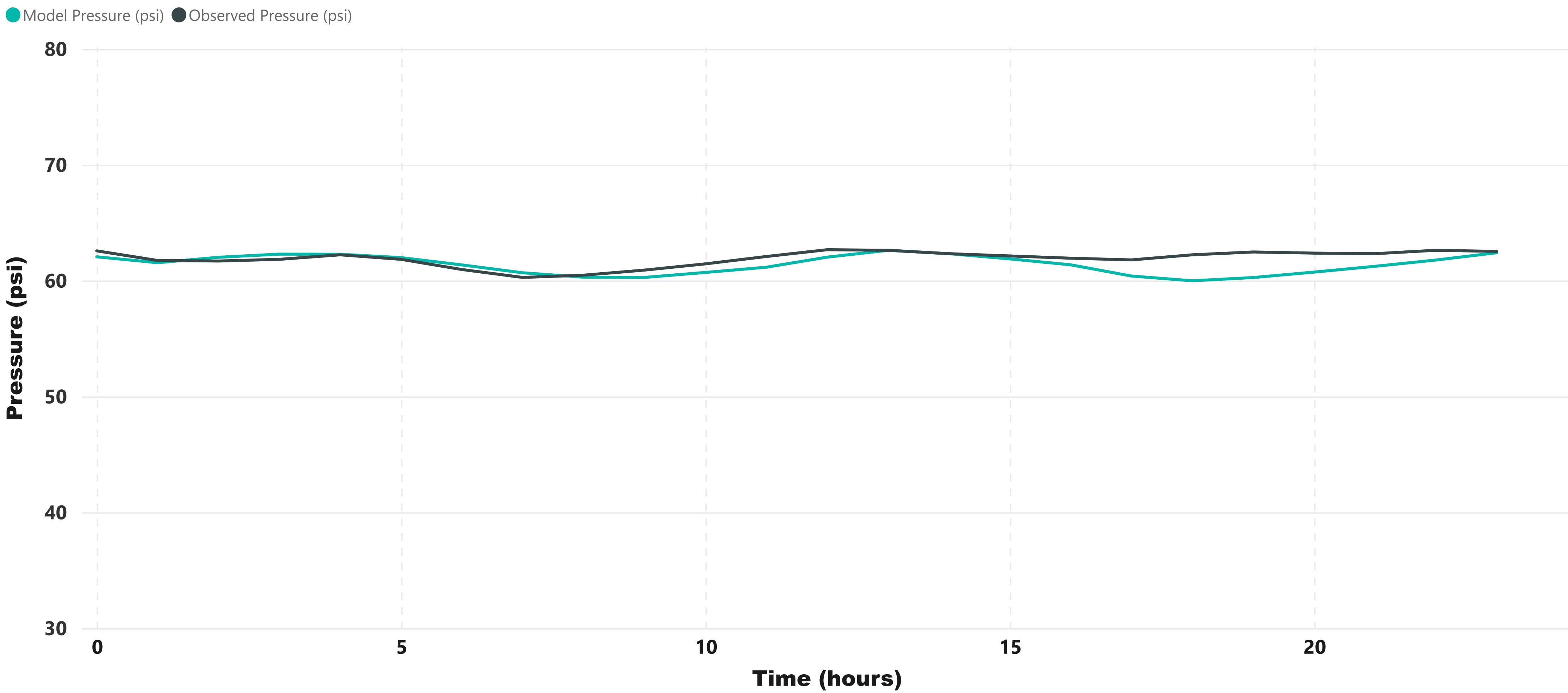
PR-01 | PR-02 | PR-03 | PR-04 | PR-05 | PR-06 | PR-07 | PR-08

Pressure Recorder Location

PR-03



Model Calibration Results



within 10 psi

100.00%

within 5 psi

100.00%

within 3 psi

100.00%

City of Tomball

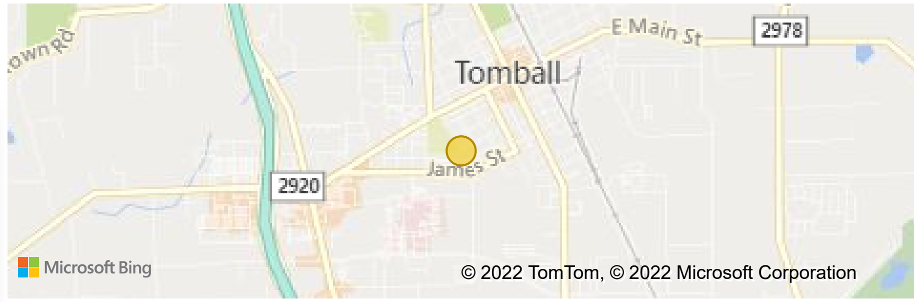
Water and Wastewater Impact Fee Update - Phase 1

Water Model Calibration

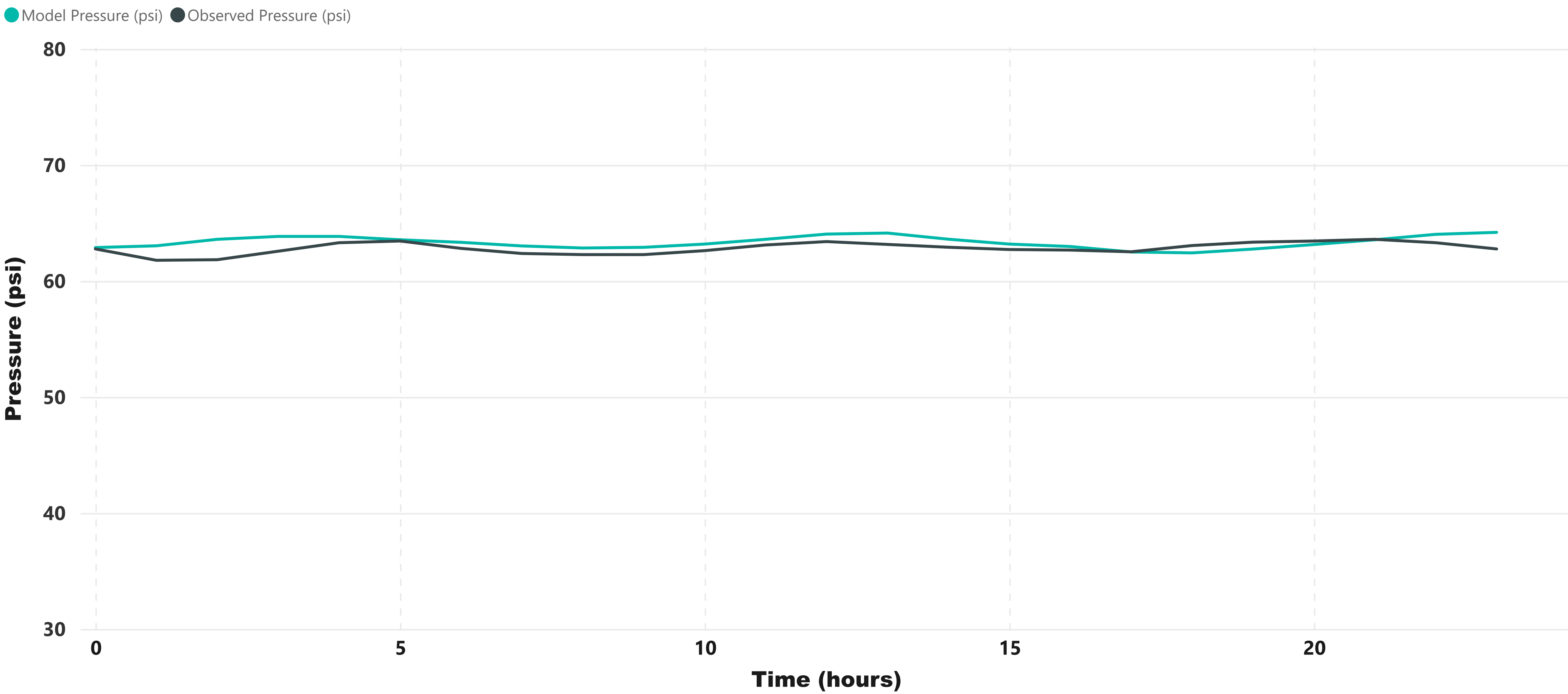
Pressure Recorder ID

PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location



Model Calibration Results



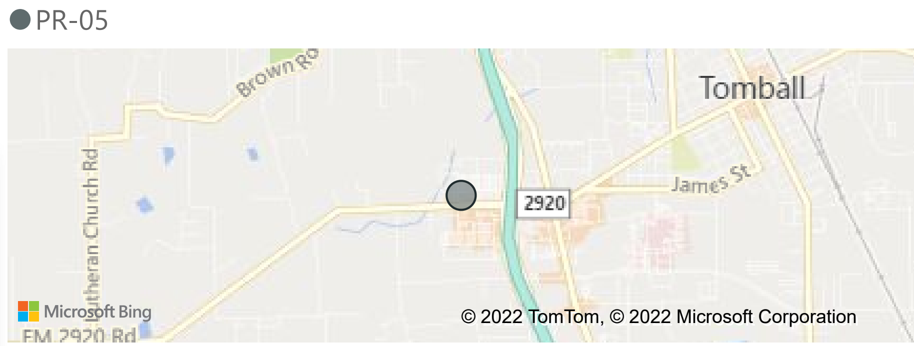
within 10 psi	within 5 psi	within 3 psi
100.00%	100.00%	100.00%

City of Tomball
Water and Wastewater Impact Fee Update - Phase 1
Water Model Calibration

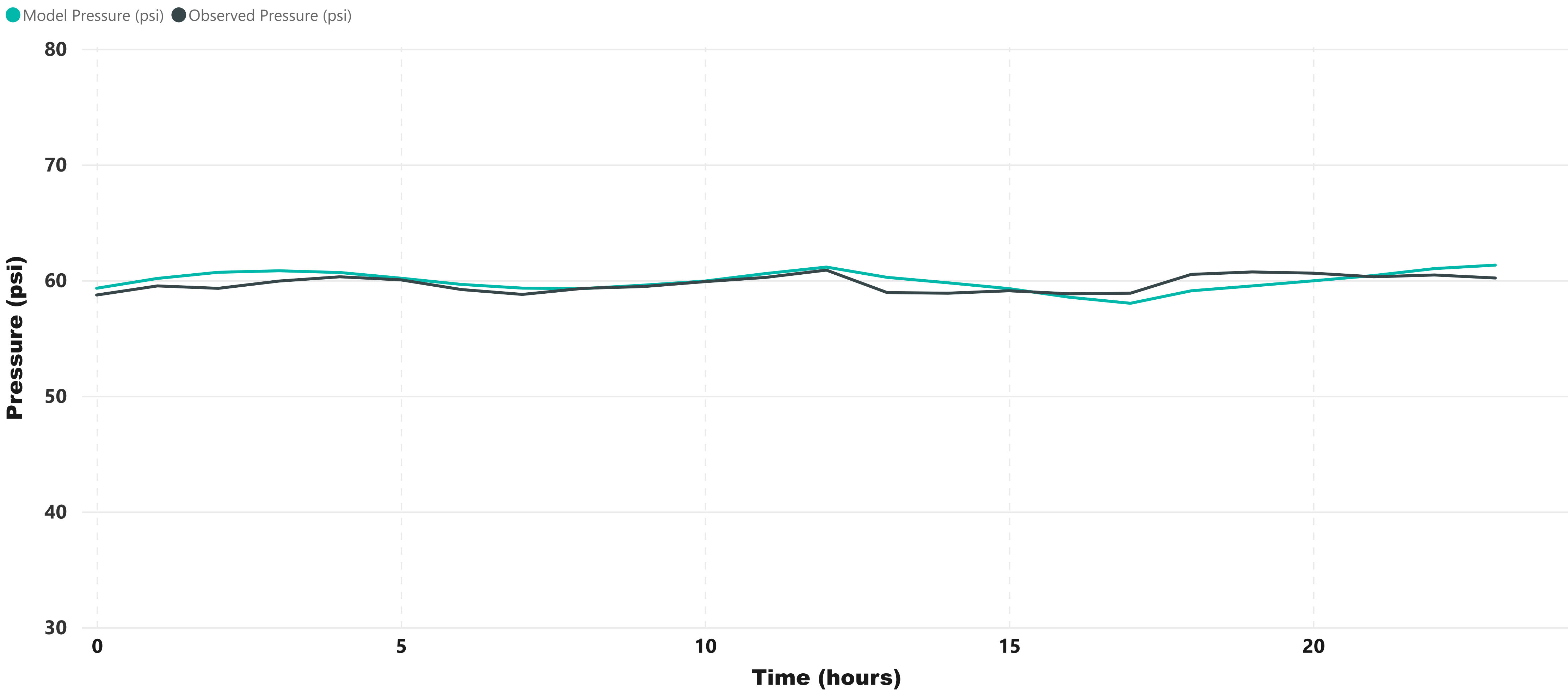
Pressure Recorder ID

PR-01 | PR-02 | PR-03 | PR-04 | **PR-05** | PR-06 | PR-07 | PR-08

Pressure Recorder Location



Model Calibration Results



within 10 psi

100.00%

within 5 psi

100.00%

within 3 psi

100.00%

City of Tomball

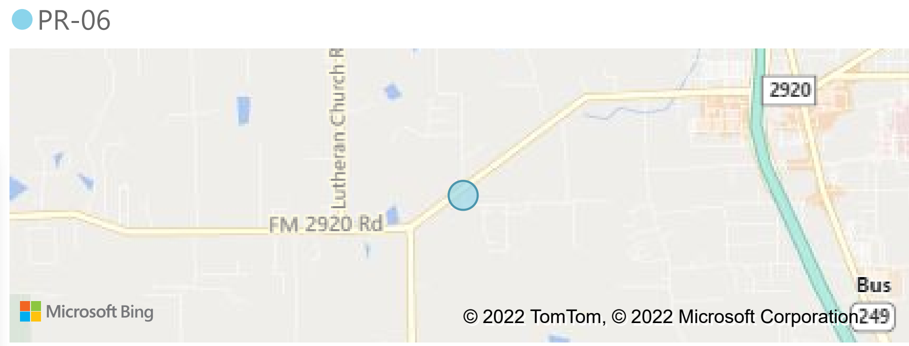
Water and Wastewater Impact Fee Update - Phase 1

Water Model Calibration

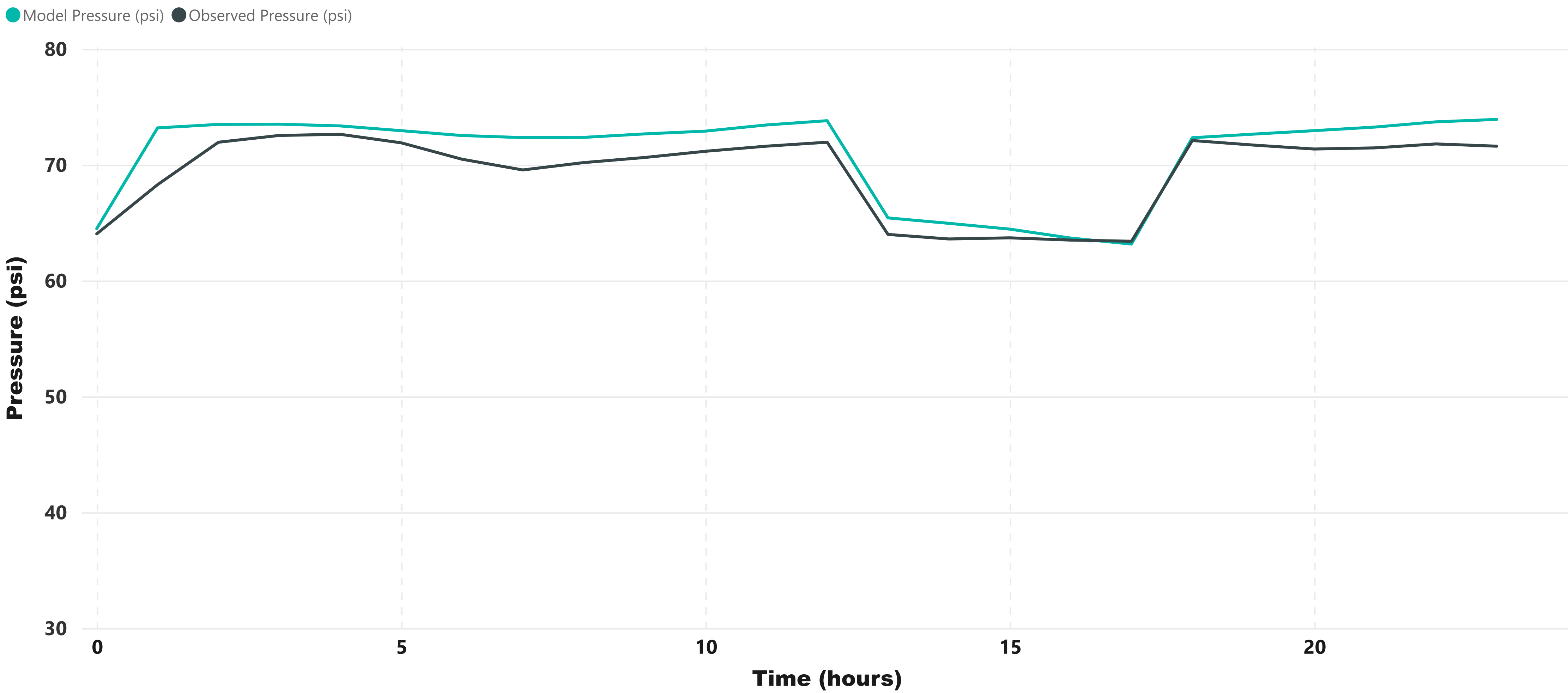
Pressure Recorder ID

PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location



Model Calibration Results



within 10 psi	within 5 psi	within 3 psi
100.00%	100.00%	95.83%

City of Tomball

Water and Wastewater Impact Fee Update - Phase 1

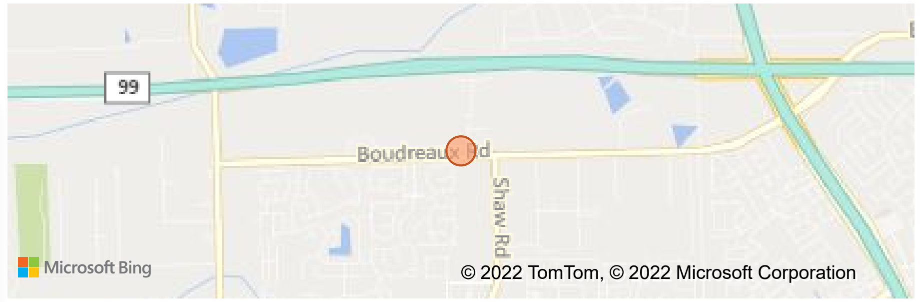
Water Model Calibration

Pressure Recorder ID

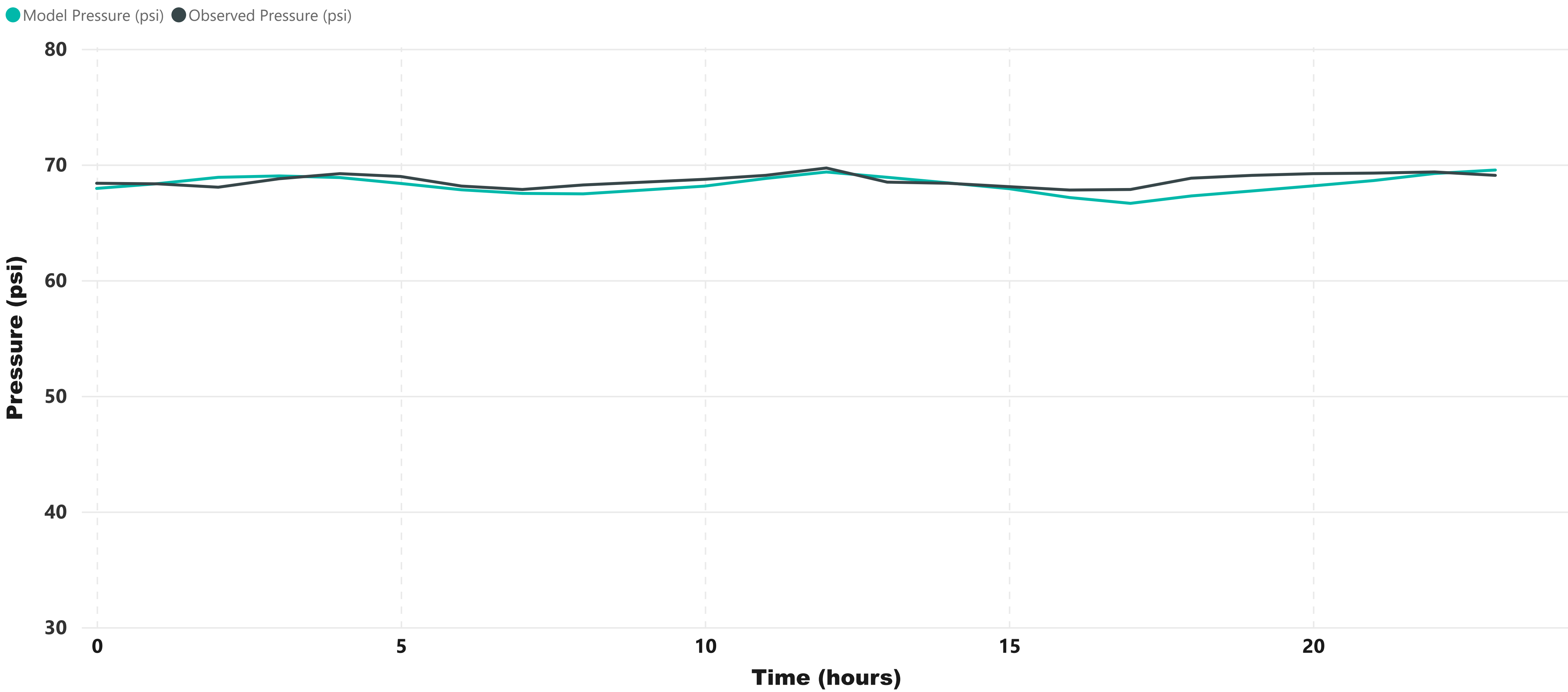
PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location

PR-07



Model Calibration Results



within 10 psi

100.00%

within 5 psi

100.00%

within 3 psi

100.00%

City of Tomball

Water and Wastewater Impact Fee Update - Phase 1

Water Model Calibration

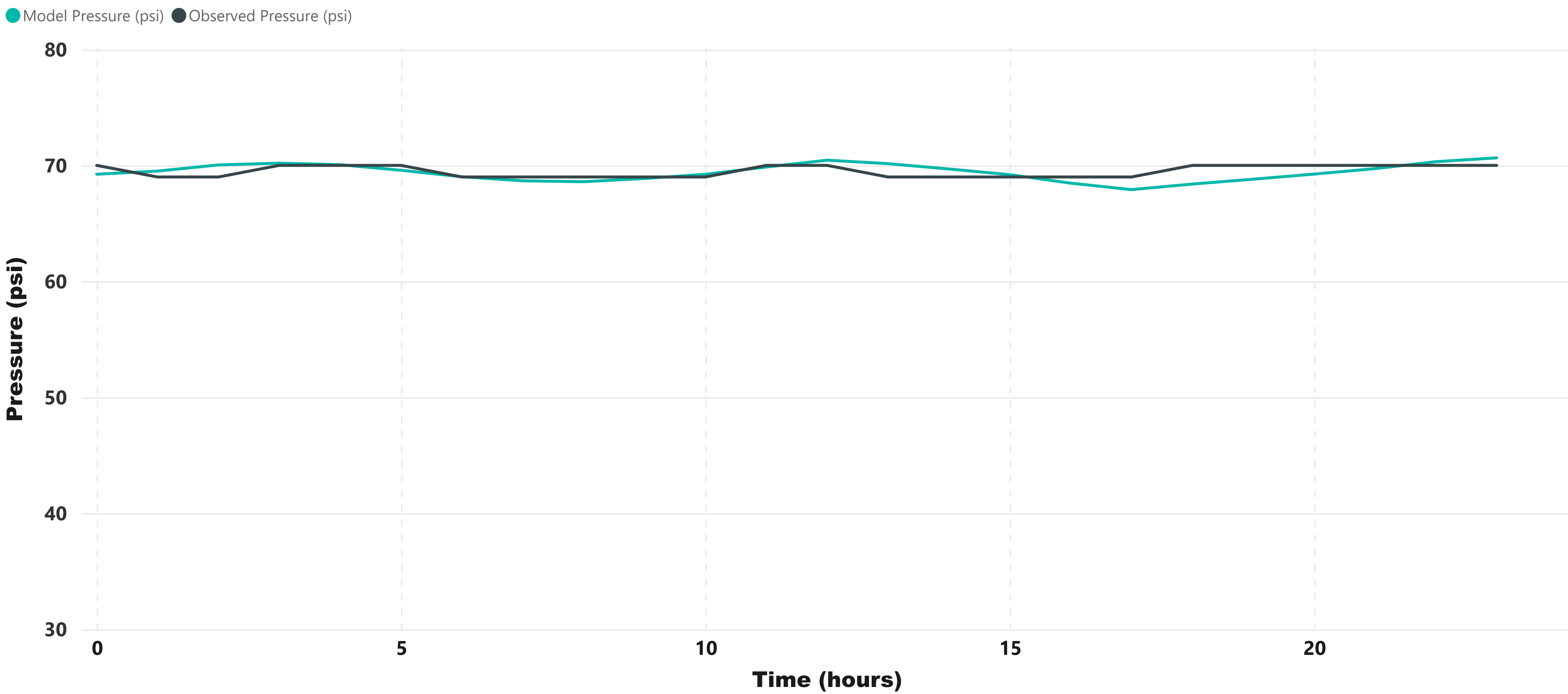
Pressure Recorder ID

PR-01	PR-02	PR-03	PR-04	PR-05	PR-06	PR-07	PR-08

Pressure Recorder Location

PR-08

Model Calibration Results



within 10 psi

100.00%

within 5 psi

100.00%

within 3 psi

100.00%

APPENDIX E
Historical Water Production Data

City of Tomball

2023 Water and Wastewater Master Plan Update

2017 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUNE 2017	JULY 2017	AUG 2017	SEPT 2017	OCT 2017	NOV 2017	DEC 2017	Total
1	1.73	1.62	2.07	1.72	2.03	2.34	2.86	3.23	1.89	2.11	1.61	1.97	
2	1.32	1.57	1.71	1.98	2.97	1.82	2.39	3.05	1.57	2.02	1.60	1.88	
3	1.45	1.67	1.68	1.88	4.76	2.07	2.89	2.65	1.90	2.37	2.10	2.24	
4	1.68	1.38	1.72	1.63	4.54	1.95	3.49	2.23	1.79	1.68	1.90	1.57	
5	1.31	1.62	1.49	2.05	3.27	1.89	2.76	2.53	2.27	2.13	1.82	1.83	
6	1.64	1.69	1.46	2.22	2.46	1.90	3.21	2.21	2.01	2.23	2.01	1.74	
7	1.35	1.45	1.63	2.01	2.28	1.96	2.44	1.99	1.92	2.47	2.10	1.56	
8	2.47	1.95	1.60	2.01	2.49	2.56	3.02	1.92	2.15	1.87	1.93	1.56	
9	2.14	1.81	1.43	2.03	2.82	2.59	2.47	1.81	2.42	2.52	1.63	1.40	
10	1.79	1.71	1.59	2.24	2.29	2.41	1.72	2.23	2.17	2.49	2.05	1.65	
11	1.55	1.60	1.76	1.84	2.57	2.38	2.17	2.20	2.24	2.01	1.59	1.78	
12	1.87	1.65	1.23	1.49	2.48	2.55	2.28	2.24	2.51	2.43	1.91	1.88	
13	1.61	1.80	1.91	1.84	2.73	2.85	2.35	2.31	2.26	2.40	2.08	1.48	
14	1.35	1.82	1.63	1.75	2.68	2.37	2.39	2.44	2.83	2.62	2.01	1.65	
15	1.82	1.19	1.61	1.54	2.58	2.88	2.38	2.77	2.35	2.28	2.09	2.05	
16	1.46	1.78	1.40	2.05	2.93	2.71	2.44	2.76	2.52	1.94	1.84	1.69	
17	1.57	1.43	2.00	1.75	2.87	2.96	2.30	2.72	2.50	2.50	2.06	1.34	
18	1.47	1.46	1.61	1.47	2.71	2.77	2.32	2.97	3.38	2.25	1.91	1.50	
19	1.63	1.57	1.96	1.70	2.86	2.86	2.25	3.45	2.01	2.31	1.92	1.72	
20	1.61	1.37	1.75	1.65	2.93	2.97	2.42	2.66	2.08	2.12	1.94	2.01	
21	1.44	1.66	2.11	2.04	2.61	2.81	2.71	2.84	2.33	2.10	2.05	1.60	
22	1.36	1.47	2.05	2.10	2.34	2.62	3.10	2.92	1.88	1.74	2.05	1.86	
23	1.60	1.48	2.03	1.50	2.05	2.30	2.18	2.95	2.20	1.63	2.08	1.49	
24	1.72	1.68	2.48	2.05	1.94	2.75	2.64	2.85	1.91	2.25	1.57	1.39	
25	1.65	1.45	1.85	2.28	2.44	1.75	2.83	2.38	2.08	1.98	1.81	1.54	
26	1.70	1.68	2.09	2.04	2.28	2.11	2.86	1.76	2.22	1.80	1.80	1.25	
27	1.81	1.76	2.06	2.34	2.76	2.18	2.96	1.23	2.39	2.19	2.01	1.37	
28	1.23	1.74	2.24	2.36	2.42	2.14	3.04	1.93	2.72	1.96	2.21	1.44	
29	1.66		2.05	2.35	1.96	2.54	3.58	1.20	2.31	1.96	2.26	1.47	
30	1.58		1.79	2.09	1.95	2.76	3.38	1.53	2.54	1.96	1.91	1.72	
31	1.74		2.18		2.43		2.54	1.77		2.20		1.19	
Total Monthly Flow	50.27	45.04	56.17	58.00	82.41	72.73	82.36	73.69	67.34	66.54	57.85	50.81	763.21
Average Daily Flow per Month	1.62	1.61	1.81	1.93	2.66	2.42	2.66	2.38	2.24	2.15	1.93	1.64	2.09
Maximum Daily Flow per Month	2.47	1.95	2.48	2.36	4.76	2.97	3.58	3.45	3.38	2.62	2.26	2.24	4.76
Minimum Daily Flow per Month	1.23	1.19	1.23	1.47	1.94	1.75	1.72	1.20	1.57	1.63	1.57	1.19	1.19
Trend													

City of Tomball
2023 Water and Wastewater Master Plan Update
2018 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2018	FEB 2018	MAR 2018	APR 2018	MAY 2018	JUNE 2018	JULY 2018	AUG 2018	SEPT 2018	OCT 2018	NOV 2018	DEC 2018	Total
1	1.44	1.66	1.45	1.91	2.31	2.64	2.48	2.35	2.78	1.91	1.60	1.92	
2	1.28	1.55	1.78	1.98	2.27	2.69	2.63	2.52	2.51	1.90	1.79	1.61	
3	1.62	1.53	1.60	2.25	2.27	2.77	2.65	2.84	2.07	1.90	1.66	1.59	
4	1.63	1.43	1.41	1.83	2.21	2.56	2.82	2.77	2.01	1.94	1.79	1.75	
5	1.58	1.34	1.68	1.89	2.10	3.20	1.68	2.40	2.06	1.82	1.49	1.83	
6	1.46	1.77	1.75	2.32	1.90	2.72	1.91	2.85	2.15	2.01	1.82	1.79	
7	1.69	1.36	1.71	2.41	1.98	3.05	2.76	2.32	2.35	1.80	1.63	1.66	
8	1.17	1.43	1.93	1.21	2.21	3.20	1.66	2.44	2.17	1.94	1.63	1.37	
9	1.51	1.53	1.68	2.15	2.45	2.81	1.98	2.52	2.22	1.99	1.69	1.54	
10	1.63	1.58	1.84	1.64	2.57	2.48	2.14	2.47	1.72	1.89	1.94	1.66	
11	1.32	1.35	1.66	1.92	2.45	2.89	2.13	2.61	2.30	1.88	1.45	1.43	
12	1.38	1.13	1.52	1.98	2.51	3.43	2.47	2.30	1.75	1.77	1.51	1.49	
13	1.60	1.42	1.85	2.24	2.55	2.95	2.15	2.34	2.11	2.09	1.52	1.65	
14	1.20	1.46	2.23	1.80	2.39	3.24	2.34	2.03	2.11	2.01	1.78	0.98	
15	1.48	1.66	2.21	1.83	2.93	2.24	2.25	3.01	1.75	1.93	1.46	1.29	
16	1.52	1.47	1.89	1.74	2.79	2.70	2.32	3.06	1.70	2.92	1.70	1.34	
17	2.33	1.37	1.59	1.95	2.91	2.39	2.44	2.79	2.01	3.65	1.53	1.19	
18	2.74	1.70	2.15	2.15	3.14	1.90	2.66	2.78	2.44	3.69	1.58	1.15	
19	3.08	1.40	1.86	1.87	3.08	1.86	2.58	2.77	2.17	2.02	1.23	1.27	
20	1.53	1.76	2.27	2.07	3.04	1.76	2.78	2.66	2.66	1.80	1.73	1.43	
21	1.62	1.64	2.09	2.19	2.33	1.74	3.02	2.90	2.02	1.30	1.53	1.89	
22	1.57	1.34	2.07	1.70	1.80	2.12	2.79	3.02	1.86	1.39	1.66	1.50	
23	1.73	1.48	2.12	1.67	2.11	2.01	2.74	2.98	1.76	1.81	1.21	1.54	
24	1.58	1.48	2.12	1.88	2.05	2.32	2.95	3.31	1.75	1.47	1.61	1.45	
25	1.59	1.38	2.07	1.93	2.17	1.99	2.80	3.24	1.92	1.83	1.47	1.53	
26	1.41	1.58	2.18	1.96	1.86	2.42	3.43	3.12	2.17	1.89	1.55	1.39	
27	1.59	1.43	2.25	2.13	2.16	2.37	3.04	3.09	1.77	1.69	1.64	1.33	
28	1.45	1.60	1.79	2.04	2.02	2.55	3.35	3.36	1.95	1.74	1.75	1.59	
29	1.51		1.74	2.24	2.53	2.73	3.28	2.47	2.04	1.97	1.64	1.56	
30	1.50		2.13	2.18	2.40	3.13	2.73	2.57	1.75	1.98	1.63	1.52	
31	1.62		1.93		2.82		3.46	2.69		1.78		1.42	
Total Monthly Flow	50.35	41.81	58.54	59.04	74.31	76.84	80.41	84.57	62.00	61.70	48.19	46.68	744.44
Average Daily Flow per Month	1.62	1.49	1.89	1.97	2.40	2.56	2.59	2.73	2.07	1.99	1.61	1.51	2.04
Maximum Daily Flow per Month	3.08	1.77	2.27	2.41	3.14	3.43	3.46	3.36	2.78	3.69	1.94	1.92	3.69
Minimum Daily Flow per Month	1.17	1.13	1.41	1.21	1.80	1.74	1.66	2.03	1.70	1.30	1.21	0.98	0.98
Trend													

City of Tomball

2023 Water and Wastewater Master Plan Update

2019 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2019	FEB 2019	MAR 2019	APR 2019	MAY 2019	JUNE 2019	JULY 2019	AUG 2019	SEPT 2019	OCT 2019	NOV 2019	DEC 2019	Total
1	1.32	1.46	1.47	1.84	2.26	2.48	1.82	2.50	2.94	2.93	1.84	1.65	
2	1.37	1.67	1.63	2.02	1.98	2.28	1.87	2.73	3.23	2.48	2.05	1.95	
3	1.35	1.18	1.46	2.03	1.85	2.40	1.66	2.92	2.85	2.90	1.99	1.66	
4	1.57	1.30	1.30	1.89	1.89	2.55	1.88	2.19	3.17	2.77	1.65	1.91	
5	1.55	1.55	1.56	1.86	1.63	2.36	1.98	2.69	3.51	2.80	2.07	1.60	
6	1.46	1.44	1.61	1.79	1.87	1.84	2.16	2.95	3.73	2.59	2.18	1.93	
7	1.49	1.65	1.41	1.79	1.70	2.28	2.13	2.65	3.61	2.79	1.83	1.79	
8	1.44	1.39	1.60	1.65	1.63	2.37	2.33	3.21	3.54	2.53	1.91	1.72	
9	1.66	1.65	1.59	1.51	1.60	3.06	2.28	3.23	3.29	2.55	1.86	1.94	
10	1.60	1.35	1.47	1.97	1.65	2.65	2.33	3.29	3.43	2.78	1.67	1.65	
11	1.63	1.34	1.43	1.79	1.72	2.58	2.69	3.44	2.77	2.70	1.94	1.52	
12	1.49	1.62	1.56	1.98	1.51	2.44	2.57	2.85	3.19	2.55	1.76	1.81	
13	1.54	1.38	1.42	1.76	1.67	2.63	2.46	3.49	3.13	2.07	1.87	1.69	
14	1.39	1.57	1.60	1.58	1.72	2.78	2.36	3.26	3.42	2.16	1.67	1.52	
15	1.48	1.38	1.41	1.73	1.91	3.10	2.19	3.09	3.57	2.40	1.72	2.02	
16	1.76	1.74	1.74	2.08	2.16	2.66	1.97	2.72	3.10	2.22	1.81	1.63	
17	1.45	1.34	1.50	1.90	1.90	1.94	2.25	3.14	3.10	1.90	1.78	1.69	
18	1.62	1.56	1.52	1.86	1.85	2.20	2.45	2.77	2.42	2.04	1.62	1.80	
19	1.31	1.33	1.76	1.69	1.93	2.26	2.03	2.76	2.18	2.31	1.71	1.62	
20	1.50	1.62	1.68	1.86	2.18	2.35	2.58	3.02	1.98	2.27	1.99	2.02	
21	1.57	1.35	1.99	1.67	2.37	2.56	2.59	2.85	2.33	2.25	1.73	2.07	
22	1.35	1.68	1.78	1.81	2.15	2.90	2.17	2.99	1.92	3.41	2.01	1.98	
23	1.47	1.49	2.43	2.02	2.44	2.21	2.40	3.14	2.19	5.08	1.56	1.85	
24	1.57	1.55	1.70	2.01	2.50	1.89	2.68	3.02	2.44	4.98	1.51	1.81	
25	1.53	1.74	1.68	1.95	2.37	1.99	2.66	2.79	2.47	3.21	1.92	1.64	
26	1.43	2.80	2.07	2.19	2.48	2.12	2.58	2.42	2.66	2.07	1.74	1.42	
27	1.41	2.65	1.59	2.20	2.20	1.93	3.00	3.31	2.83	1.90	2.00	1.61	
28	1.58	1.27	3.24	2.24	2.77	1.89	2.81	2.97	2.56	2.18	1.63	1.60	
29	1.15		2.01	1.90	2.53	1.97	2.12	3.38	2.61	2.03	1.52	1.60	
30	1.43		2.05	2.23	2.48	1.76	2.51	3.10	2.45	1.94	1.73	1.49	
31	1.44		1.60		2.17		2.21	3.33		1.76		1.38	
Total Monthly Flow	**45.90**	**44.03**	**52.85**	**56.76**	**63.04**	**70.43**	**71.69**	**92.18**	**86.62**	**80.56**	**54.24**	**53.56**	**771.85**
Average Daily Flow per Month	**1.48**	**1.57**	**1.70**	**1.89**	**2.03**	**2.35**	**2.31**	**2.97**	**2.89**	**2.60**	**1.81**	**1.73**	**2.11**
Maximum Daily Flow per Month	**1.76**	**2.80**	**3.24**	**2.24**	**2.77**	**3.10**	**3.00**	**3.49**	**3.73**	**5.08**	**2.18**	**2.07**	**5.08**
Minimum Daily Flow per Month	**1.15**	**1.18**	**1.30**	**1.51**	**1.51**	**1.76**	**1.66**	**2.19**	**1.92**	**1.76**	**1.51**	**1.38**	**1.15**
Trend													

City of Tomball
2023 Water and Wastewater Master Plan Update
2020 Daily Total Production

Water Production in MGD													
DAY OF	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Total
MONTH	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	
1	1.59	1.70	1.68	1.66	1.82	1.63	3.34	2.51	3.35	2.75	1.92	1.69	
2	1.24	1.30	1.66	1.83	1.79	2.03	2.86	2.22	3.40	2.01	2.09	1.75	
3	1.75	1.72	1.49	1.75	2.16	2.23	2.70	2.17	3.58	2.60	1.94	1.73	
4	1.40	1.42	1.89	1.70	2.00	1.80	3.12	2.62	3.11	2.30	2.16	1.61	
5	1.61	1.76	1.55	1.26	2.10	2.17	2.48	2.49	2.79	2.65	2.11	2.00	
6	1.43	1.61	1.85	1.49	2.16	2.19	2.24	3.10	2.31	2.48	2.22	1.45	
7	1.80	1.56	1.76	1.40	2.14	2.43	2.60	2.88	2.34	2.68	2.74	1.62	
8	1.65	1.56	1.69	1.71	2.16	2.32	2.52	3.32	2.07	2.48	1.75	1.62	
9	1.59	1.64	1.53	1.55	2.20	2.42	3.27	2.77	2.42	2.36	2.04	1.73	
10	1.64	1.47	1.78	1.43	2.36	2.75	2.77	2.96	2.62	2.83	2.22	1.79	
11	1.72	1.58	1.71	1.69	1.92	2.63	3.20	2.93	2.41	2.14	2.16	1.55	
12	1.46	1.49	2.13	1.49	2.86	2.94	3.06	3.11	2.91	2.43	2.21	1.81	
13	1.57	1.32	1.83	1.57	2.08	2.04	3.00	3.39	2.42	2.62	2.15	1.45	
14	1.51	1.70	2.16	1.71	2.36	3.67	3.39	3.28	2.18	2.57	2.25	1.54	
15	1.66	1.59	1.81	1.63	1.98	2.76	3.28	3.61	2.55	3.09	2.12	1.53	
16	1.58	1.50	1.91	1.87	1.94	3.13	3.46	3.43	2.63	2.24	2.10	1.67	
17	1.50	1.67	1.79	2.10	1.70	2.77	3.50	3.11	2.81	2.18	1.98	1.43	
18	1.66	1.61	2.05	1.86	1.66	3.45	3.54	2.65	2.36	1.85	2.28	1.75	
19	1.41	1.47	1.65	1.53	2.13	3.12	3.31	2.70	3.01	2.34	2.18	1.78	
20	1.63	1.48	1.88	1.40	2.34	3.08	2.85	3.37	2.61	1.99	2.22	1.79	
21	1.47	1.14	1.64	1.52	2.60	3.12	3.00	3.06	1.90	2.46	2.29	1.59	
22	1.64	1.56	1.23	1.62	2.42	2.27	2.64	3.50	1.77	2.15	1.90	1.74	
23	1.65	1.56	1.41	1.80	1.88	2.05	2.91	2.85	1.73	2.32	2.12	1.49	
24	1.68	1.59	1.50	1.94	2.73	2.00	2.51	2.77	1.66	2.15	2.06	1.76	
25	1.50	1.94	1.61	1.80	2.01	1.97	3.04	3.22	2.07	2.10	2.10	1.48	
26	1.49	1.32	1.58	1.64	1.70	1.73	1.94	2.74	2.29	1.76	1.72	1.35	
27	1.67	1.49	1.95	2.05	1.91	2.26	1.99	2.63	2.20	3.08	1.89	1.28	
28	1.47	1.81	1.69	2.14	1.79	2.03	2.23	3.36	2.14	4.14	1.41	1.85	
29	1.63		1.64	1.78	1.55	2.03	2.29	3.32	2.17	3.88	1.72	1.54	
30	1.32		1.83	1.61	2.21	3.04	2.03	3.14	2.15	2.53	1.59	1.54	
31			1.66		1.75		2.45	3.13		2.01		1.70	
Total Monthly Flow	46.89	43.55	53.52	50.49	64.43	74.05	87.50	92.32	73.93	77.16	61.62	50.58	776.03
Average Daily Flow per Month	**1.56**	**1.56**	**1.73**	**1.68**	**2.08**	**2.47**	**2.82**	**2.98**	**2.46**	**2.49**	**2.05**	**1.63**	**2.13**
Maximum Daily Flow per Month	**1.80**	**1.94**	**2.16**	**2.14**	**2.86**	**3.67**	**3.54**	**3.61**	**3.58**	**4.14**	**2.74**	**2.00**	**4.14**
Minimum Daily Flow per Month	**1.24**	**1.14**	**1.23**	**1.26**	**1.55**	**1.63**	**1.94**	**2.17**	**1.66**	**1.76**	**1.41**	**1.28**	**1.14**
Trend													

City of Tomball
2023 Water and Wastewater Master Plan Update
2021 Daily Total Production

Water Production in MGD													
DAY OF	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Total
MONTH	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	2021	
1	1.48	1.78	1.67	1.82	1.62	1.90	2.23	3.28	3.21	1.88	2.19	2.54	
2	1.41	1.70	1.49	2.11	1.67	1.96	2.31	2.27	2.88	1.51	1.68	1.58	
3	1.53	1.75	1.66	2.06	1.79	1.83	2.42	2.65	2.80	1.97	2.18	1.84	
4	1.81	1.70	1.57	1.70	2.08	1.77	1.68	2.84	2.94	1.90	1.90	1.94	
5	1.50	1.65	1.60	2.00	1.92	1.83	2.04	2.87	2.91	2.16	1.84	1.78	
6	2.11	1.58	1.69	2.18	2.19	2.09	1.45	2.76	3.18	2.25	2.05	2.12	
7	1.59	1.51	1.56	2.21	2.19	1.80	2.04	2.65	2.82	1.98	2.01	1.65	
8	1.55	1.50	1.61	2.06	2.67	1.88	2.12	3.43	2.92	2.01	2.01	2.01	
9	1.63	1.74	1.86	2.19	2.23	2.12	1.81	2.91	3.10	2.08	2.14	1.86	
10	1.54	1.74	1.58	2.66	1.88	2.24	1.62	3.09	3.16	2.05	2.16	1.97	
11	1.33	1.64	1.81	2.07	2.60	2.21	1.96	3.10	3.13	1.90	2.05	1.95	
12	1.70	1.31	1.99	2.09	2.30	2.46	2.11	2.99	3.26	1.94	1.97	1.61	
13	1.47	1.34	1.78	2.55	2.22	2.44	1.87	3.08	2.51	2.09	2.00	1.72	
14	1.60	0.75	1.75	2.03	1.98	2.76	1.76	3.32	2.16	2.57	1.85	1.81	
15	1.31	1.16	1.32	1.88	2.28	2.80	1.85	2.93	2.01	1.78	2.08	1.91	
16	1.80	2.12	1.57	1.66	2.24	2.40	1.72	2.45	1.97	1.94	1.95	2.28	
17	1.47	4.98	1.48	1.81	1.86	2.27	2.10	2.30	2.09	2.04	2.13	1.67	
18	1.57	5.45	1.80	1.59	1.68	2.48	1.80	2.36	2.41	2.18	2.38	1.94	
19	1.60	5.73	1.67	1.95	1.74	2.96	1.98	2.17	2.13	2.22	1.74	1.50	
20	1.63	3.81	1.78	2.02	1.52	2.54	2.07	2.39	2.28	2.25	2.09	1.55	
21	1.58	2.18	1.78	2.17	1.73	2.16	2.23	2.87	2.73	2.47	1.96	1.78	
22	1.65	1.88	1.83	2.05	1.65	2.23	2.16	2.93	2.43	2.28	1.99	1.79	
23	1.35	2.26	1.76	2.06	1.68	2.25	2.08	2.85	2.60	2.35	2.08	1.62	
24	1.44	1.98	1.81	2.00	1.50	2.64	2.51	3.14	2.96	2.17	1.97	1.70	
25	1.31	1.73	1.57	1.90	1.63	2.55	2.47	3.08	2.38	2.27	1.96	1.56	
26	1.82	1.62	1.92	2.09	1.88	2.83	2.34	3.05	2.55	3.35	1.43	1.72	
27	1.50	1.76	2.02	2.30	1.75	2.43	2.65	2.67	2.50	4.34	1.54	1.71	
28	1.72	1.60	2.06	2.27	1.94	2.14	2.60	2.96	2.71	4.30	1.69	1.70	
29	1.50		1.23	2.23	1.95	1.73	3.03	2.85	2.04	3.37	1.91	2.04	
30	1.92		1.96	2.17	1.83	1.97	2.50	2.52	1.99	2.25	1.53	1.76	
31			1.96		1.71		2.90	2.98		2.11		1.81	
Total Monthly Flow	**47.40**	**59.93**	**53.11**	**61.86**	**59.90**	**67.64**	**66.40**	**87.74**	**78.75**	**71.96**	**58.45**	**56.40**	**769.52**
Average Daily Flow per Month	**1.58**	**2.14**	**1.71**	**2.06**	**1.93**	**2.25**	**2.14**	**2.83**	**2.62**	**2.32**	**1.95**	**1.82**	**2.11**
Maximum Daily Flow per Month	**2.11**	**5.73**	**2.06**	**2.66**	**2.67**	**2.96**	**3.03**	**3.43**	**3.26**	**4.34**	**2.38**	**2.54**	**5.73**
Minimum Daily Flow per Month	**1.31**	**0.75**	**1.23**	**1.59**	**1.50**	**1.73**	**1.45**	**2.17**	**1.97**	**1.51**	**1.43**	**1.50**	**0.75**
Trend													

City of Tomball
2023 Water and Wastewater Master Plan Update
2022 Daily Total Production

Water Production in MGD													
DAY OF MONTH	JAN 2022	FEB 2022	MAR 2022	APR 2022	MAY 2022	JUNE 2022	JULY 2022	AUG 2022	SEPT 2022	OCT 2022	NOV 2022	DEC 2022	Total
1	1.64	1.53	1.47	1.97	2.31	3.21	3.73	3.84	2.47	3.81			
2	1.54	1.54	1.82	2.04	2.43	2.94	3.88	4.25	2.14	3.21			
3	1.69	1.48	1.72	2.15	2.72	2.84	3.60	4.24	2.38	3.73			
4	1.69	1.87	1.70	2.25	2.73	3.12	3.42	4.15	2.23	3.89			
5	1.74	2.49	1.89	1.98	2.48	3.06	4.38	4.13	2.03	3.36			
6	1.95	1.80	1.66	2.17	2.42	2.95	4.00	4.01	2.46	3.85			
7	1.73	1.63	1.80	2.19	2.18	3.37	4.35	3.53	2.50	3.66			
8	1.69	1.62	1.69	2.30	2.44	3.19	4.17	4.02	2.78	3.73			
9	1.40	1.65	1.50	2.16	2.64	3.74	4.43	3.96	2.84	3.57			
10	1.77	1.52	1.41	2.45	2.53	3.50	4.11	4.06	3.24	3.34			
11	1.69	1.71	1.82	2.24	2.81	3.71	4.25	3.56	3.18	3.85			
12	1.50	1.83	1.54	2.12	2.72	3.48	3.34	3.12	2.76	3.67			
13	1.83	1.42	1.64	2.08	2.88	3.80	3.72	3.40	3.37	3.36			
14	1.76	1.88	1.93	2.06	2.69	3.97	4.23	3.48	3.32	3.67			
15	1.70	1.55	1.59	2.49	2.82	3.88	3.81	3.39	3.28	3.41			
16	1.76	2.04	1.76	2.06	2.99	3.80	3.44	3.86	3.18	3.34			
17	1.86	1.62	1.58	2.16	2.95	4.13	3.96	3.70	3.49	3.40			
18	1.84	1.35	1.85	2.14	3.17	4.03	4.17	3.78	3.45	2.73			
19	1.84	1.70	1.83	2.63	3.40	4.07	4.30	3.17	3.46	2.89			
20	1.73	1.49	2.03	2.37	3.23	3.97	3.93	3.79	3.54	3.12			
21	1.49	1.73	1.64	2.30	3.40	4.19	4.49	3.64	3.54	2.77			
22	1.77	1.71	1.57	2.66	2.99	4.24	4.42	2.84	3.48	3.43			
23	1.68	1.65	1.56	2.48	2.08	4.13	4.55	3.10	3.76	3.31			
24	1.83	1.54	1.83	2.47	2.40	4.02	4.00	3.03	3.83	2.92			
25	1.46	1.55	1.69	2.19	2.24	4.47	4.33	3.02	3.40	3.91			
26	1.87	1.40	1.97	2.05	2.09	4.49	4.10	2.53	3.58	4.96			
27	1.50	1.68	1.91	1.99	2.56	4.15	4.42	3.22	3.64	4.82			
28	1.74	1.37	2.05	2.03	2.64	3.99	4.19	2.66	3.75	3.61			
29	1.70		2.04	2.23	2.93	4.26	3.75	3.05	3.94	2.27			
30	1.53		2.01	2.48	2.87	4.15	3.72	2.83	3.23	2.45			
31			1.84		2.92		4.01	2.22		2.19			
Total Monthly Flow	**50.89**	**46.32**	**54.38**	**66.87**	**83.63**	**112.83**	**125.19**	**107.55**	**94.24**	**106.21**			**848.10**
Average Daily Flow per Month	**1.70**	**1.65**	**1.75**	**2.23**	**2.70**	**3.76**	**4.04**	**3.47**	**3.14**	**3.43**			**2.79**
Maximum Daily Flow per Month	**1.95**	**2.49**	**2.05**	**2.66**	**3.40**	**4.49**	**4.55**	**4.25**	**3.94**	**4.96**			**4.96**
Minimum Daily Flow per Month	**1.40**	**1.35**	**1.41**	**1.97**	**2.08**	**2.84**	**3.34**	**2.22**	**2.03**	**2.19**			**1.35**
Trend													

APPENDIX F
Water System Analysis Figures

FIGURE D-1

CITY OF TOMBALL

2023 WATER AND WASTEWATER MASTER PLAN UPDATE EXISTING WATER SYSTEM MINIMUM PRESSURES

LEGEND

- Water Well
- Elevated Storage Tank
- Ground Storage Tank
- 8" and Smaller Water Line
- 10" and Larger Water Line
- Grand Parkway 99
- Railroad
- Stream
- City Limit
- ETJ Boundary
- Houston ETJ Boundary
- County Line

FREESE AND NICHOLS

Created By Freese and Nichols, Inc.
Job No.: TMB22779
Location: H:\W_WW_PLANNING\01_DELIVERABLES\00_FINAL_REPORT\02_Master_Plan_Report\Appendix\(Figure_D-1)-Existing_Water_System_Minimum_Pressure.mxd
Updated: Monday, October 30, 2023 3:16:12 PM
User Name: 03812

Created By Freese and Nichols, Inc.
Job No.: TMB22779
Location: H:\W_WW_PLANNING\01_DELIVERABLES\00_FINAL_REPORT\02_Master_Plan_Report\Appendix\(Figure_D-2)-Existing_Water_System_Fireflow.mxd
Updated: Monday, October 30, 2023 3:16:42 PM
User Name: 03812

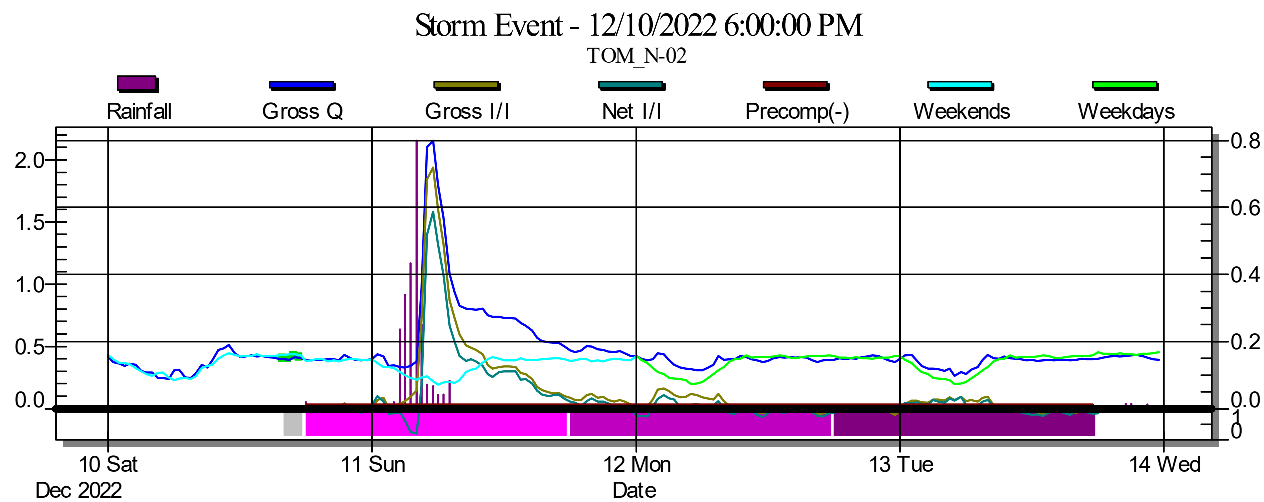
Created By Freese and Nichols, Inc.
Job No.: TMB22779
Location: H:\W_WW_PLANNING\01_DELIVERABLES\00_FINAL_REPORT\02_Master_Plan_Report\Appendix\(Figure_D-3)-Buildout_Water_System_Minimum_Pressure.mxd
Updated: Monday, October 30, 2023 3:19:02 PM
User Name: 03812


FIGURE D-4
CITY OF TOMBALL
BUILDOUT WATER SYSTEM
FIREFLOW
LEGEND
Proposed Improvements
Well
Ground Storage Tank
Elevated Storage Tank
Water Treatment Plant
Water Line
Existing System
Water Well
Elevated Storage Tank
Ground Storage Tank
8" and Smaller Water Line
10" and Larger Water Line
Grand Parkway 99
Railroad
Stream
City Limit
ETJ Boundary
County Line
FREESE AND NICHOLS
FIREFLOW
Less than 1,000 gpm
1,000 - 1,500 gpm
1,500 - 2,500 gpm
2,500 - 4,000 gpm
Greater than 4,000 gpm
Ulrich Road
0.50 MG Elevated Storage Tank
Overflow: 338.75'
Replace with 1.5 MG EST
Baker Drive Water Plant
1,000 gpm Firm Capacity Pump Station
(1) - 0.5 MG Ground Storage Tank
1,000 gpm Well Supply
New East Water Plant
3,000 gpm Firm Capacity Pump Station
(1) - 1 MG Ground Storage Tank
2,000 gpm Well Supply
Expand to 6,000 gpm Firm Capacity Pump Station
(1) - 2.0 MG Ground Storage Tank
(2) - 1,250 gpm Off-Site Well
School Well #2 = 679 gpm
Pine Street Water Plant
Well #1 = 502 gpm
Well #2 = 1,588 gpm
(3) - 1,000 gpm Pumps
0.4 MG Ground Storage Tank
0.75 MG Elevated Storage Tank
Overflow: 338.37'
0.4 MG Ground Storage Tank and Condition Assessment
Decommission Pine Street EST
FM 2920 Water Plant
Well #5 = 714 gpm
Well #6 = 651 gpm
(3) - 1,000 gpm Pumps
0.5 MG Ground Storage Tank
5,000 gal Hydropneumatic Tank
Expand to 4,000 gpm Firm Capacity Pump Station
(3) - 0.50 MG Ground Storage Tanks
(1) - 1,600 gpm Groundwater Well
New West Water Plant
2,500 gpm Firm Capacity Pump Station
(1) - 0.75 MG Ground Storage Tank
(1) - 2,000 gpm Groundwater Well
Expand to 3,500 gpm Firm Capacity Pump Station
(2) - 0.50 MG Ground Storage Tank
(1) - 500 gpm Groundwater Well
New 1.0 MG Grand Parkway
Elevated Storage Tank
Overflow Elevation 338'
0
1,300
2,600
SCALE IN FEET

APPENDIX G
Sewer System Performance Report (by ADS)

Sewer System Performance Report

Tomball TX Wastewater Collection System



PREPARED FOR

Freese and Nichols, Inc.

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Fort Worth, Texas 76102

SUBMITTED

February 2023

ADS ENVIRONMENTAL SERVICES®

Sewer System Performance Report

Tomball TX Wastewater Collection System

Prepared for:

Freese and Nichols, Inc.

ADS Environmental Services
340 The Bridge Street, Suite 204
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800.633.7246

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Wet Weather Performance 16

Rainfall-Dependent Inflow and Infiltration 16

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Appendix A – Flow Monitor Site Installation Details

Appendix B – Detailed Flow Monitor Specifications

Appendix C – Flow Monitor RDII Performance Graphics

Introduction

ADS Environmental Services (ADS) was retained by Freese and Nichols, Inc. (Engineer) to gather and evaluate flow monitor and rainfall data within selected portions of the existing Tomball TX collection system. The scope of this study is to characterize dry weather and wet weather flow conditions at select locations within the sewer system, evaluate key performance indicators, and rank the relative severity of observed rainfall-dependent inflow and infiltration (RDII) to assist the City to direct subsequent planning and rehabilitation activities.

Methodology

Dry weather and wet weather performance data were obtained by installing sewer flow monitors to observe and document existing flow conditions. A total of 10 sewer basins (or sub-basins) were evaluated from a total 10 deployed temporary flow monitors. Rain data was obtained from 2 temporary rain gauges, RG01 and RG02 to represent the North and South area basins evaluated. ADS maintained the temporary flow monitors during the study. Descriptions of the temporary flow monitor locations, equipment, and data graphics are included in the Appendices.

Flow Monitor Locations

Preliminary flow monitor locations were selected and final locations were reviewed by ADS based on observed flow conditions, site access, and site safety considerations. A general flow monitor schematic displays the relationship between each flow monitor and is shown in Figure 1. Descriptions of each sewer basin and its associated flow monitor are provided in Table 1. Diameters reported in Table 1 are based upon the largest pipe (in cases where multiple flow sites represent a basin) and on field measurements by ADS personnel. There are often instances where a basin (i.e. net flow) is defined by directly subtracting flow data readings from upstream flow meters. In this study, each location was isolated. For example, basin N-03 is defined as flow recorded from that flow monitor minus flow recorded at upstream flow monitors N-01 and N-02 (shown as upstream subtractions in Table 1).

Figure 1: Tomball TX Flow Monitor Schematic

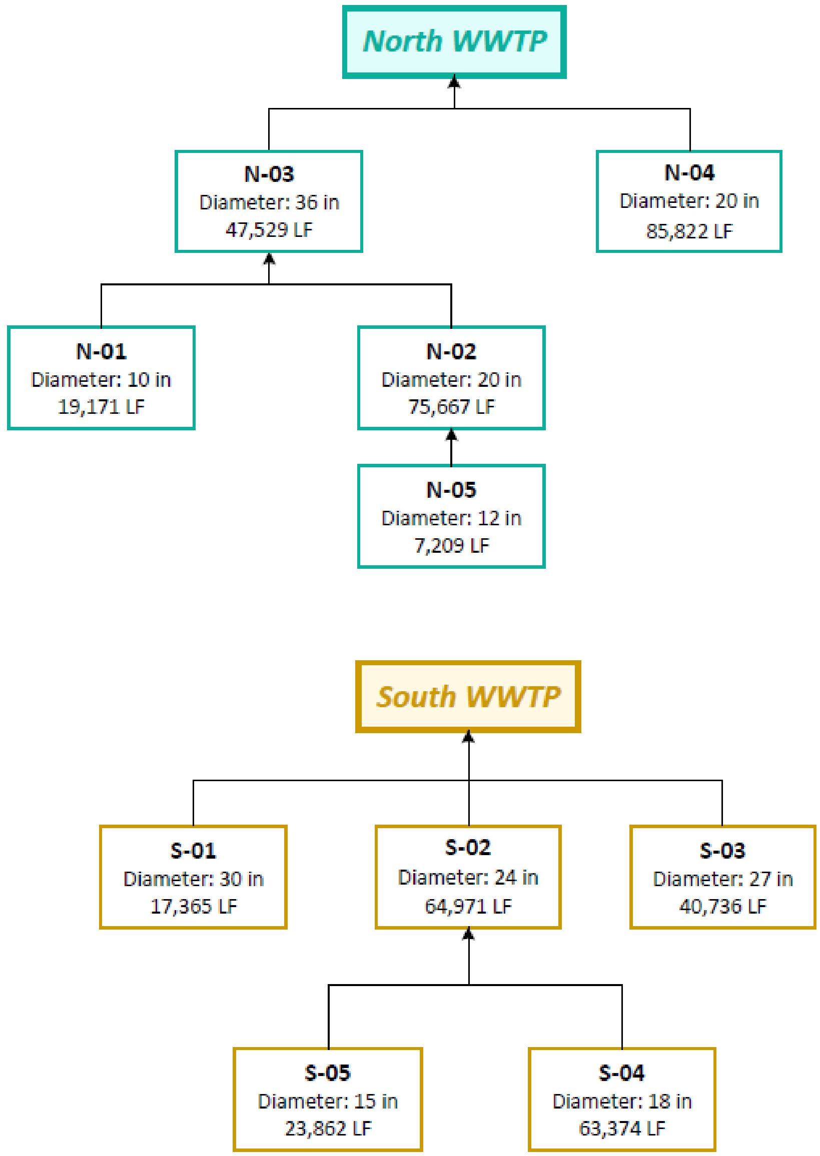


Table 1: Flow Monitor and Basin Descriptions

Monitor/ Basin	Basin Definition (related monitors)	Diameter (Height - inches)	Basin Size (LF)
N-01	+(N-01)	9.3	19,171
N-02	+(N-02) – (N-05)	20.5	75,667
N-03	+(N-03) – (N-01) – (N-02)	36.0	47,529
N-04	+(N-04)	20.0	85,822
N-05	+(N-05)	12.0	7,209
S-01	+(S-01)	29.0	17,365
S-02	+(S-02) – (S-04) – (S-05)	23.0	64,971
S-03	+(S-03)	26.3	40,736
S-04	+(S-04)	16.8	63,374
S-05	+(S-05)	13.8	23,862

Site installation reports with more detailed location information for each flow monitor are provided in Appendix A.

Flow Monitor Equipment

Sewer flow monitoring was performed using Triton+ flow monitors manufactured, installed, and maintained by ADS. Each flow monitor is mounted near the top of a manhole and is connected to depth and velocity sensors positioned in an incoming sewer. Detailed specifications of the flow monitor equipment used for this project are provided in Appendix B.

Flow Monitor Study Period

The temporary Flow monitors were installed and operated and the study evaluation period was from November 18, 2022 through January 19, 2023.

Flow Monitor Data Format

Flow depth (d), flow velocity (v), and flow rate (Q) data from each sewer flow monitor are plotted on a variety of hydrographs and scattergraphs provided in Appendix C. Hydrographs display flow rate data vs. time for the duration of the observation period, along with associated rainfall data. Scattergraphs display flow depth vs. flow velocity data for each location. Electronic copies of the data are provided in Microsoft Excel format.

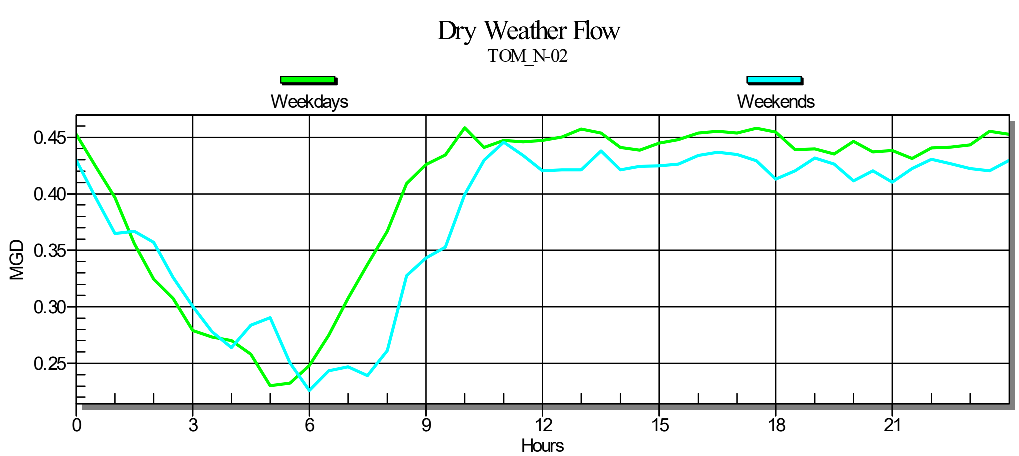
Results

Flow monitor data provide insight into sewer performance – revealing important information about how the existing sewer system accommodates observed flow rates. The following sections evaluate flow monitor data observed during both dry weather and wet weather periods using a variety of key performance indicators (KPIs). The next two sections on flow and depth peaks pertain only to conditions observed at the specific flow monitor locations whereas Rainfall Dependent Infiltration and Inflow (RDII) KPIs pertain to the identified tributary areas or basins (refer to Table 1).

Flow Rates and Peaking Factors

Dry weather flow conditions are characterized by evaluating flow monitor data observed during normal conditions, excluding wet weather events and the periods associated with the recovery from these events. The average dry day pattern is identified as a diurnal pattern and results from the collective sewer use of residential, commercial, institutional, and industrial users located upstream from a given flow monitor. Land use within a particular area affects the shape of the diurnal pattern. An example of a representative diurnal pattern observed during the study period is shown in Figure 2.

Figure 2: Dry Weather Hydrograph



The minimum, average, and maximum (30 min. interval) dry weather gross (as observed at the monitor) flow rates ($Q_{min\text{-}D}$, $Q_{avg\text{-}D}$, and $Q_{max\text{-}D}$) are determined from the dry weather diurnal pattern for each flow monitor location and are provided in Table 2, along with the resulting gross dry weather peaking factor (PF_D). The maximum gross wet weather flow rate ($Q_{max\text{-}W}$) determined for each flow monitor location is also provided, along with the resulting gross wet weather peaking factor (PF_W).

Table 2: Gross Dry and Wet Weather Flow Rates and Peaking Factors

Monitor	Q_{min-D} (mgd)	Q_{avg-D} (mgd)	Q_{max-D} (mgd)	Q_{max-W} (mgd)	Peaking Factor PF_D	Peaking Factor PF_W
N-01	0.01	0.03	0.06	0.51	1.8	16.3
N-02	0.23	0.40	0.46	2.16	1.2	5.4
N-03	0.29	0.53	0.68	2.99	1.3	5.6
N-04	0.12	0.35	0.53	2.70	1.5	7.7
N-05	0.15	0.26	0.33	0.66	1.3	2.5
S-01	0.05	0.07	0.08	0.40	1.2	5.7
S-02	0.38	0.70	0.90	3.17	1.3	4.5
S-03	0.11	0.20	0.28	0.78	1.4	3.9
S-04	0.23	0.38	0.52	1.22	1.4	3.2
S-05	0.05	0.10	0.15	0.44	1.4	4.3

Peaking factors are commonly used to estimate maximum flow rates based on average flow rate estimates and play a key role in sewer design. Peaking factors are typically inversely proportional to the population served and generally decrease as the average dry weather flow rate increases.

Depth-to-Diameter Ratios

Once dry weather and wet weather flow rates are characterized, the hydraulic conditions under which they occur are evaluated. The maximum (hourly interval) flow depth observed during dry weather (d_{max-D}) and wet weather (d_{max-W}) and their corresponding flow depth-to-diameter (d/D) ratios observed during the study period are provided in Table 3. The D values shown in the table represent field measurements for each pipe. The maximum dry weather flow depth is the flow depth associated with the maximum dry weather flow rate and is the approximate maximum flow depth (to the nearest 0.1 inch) that is consistently observed each day during normal dry weather conditions. The maximum wet weather flow depth may or may not be directly associated with the maximum wet weather flow rate, depending on the hydraulic conditions observed at a given flow monitor location.

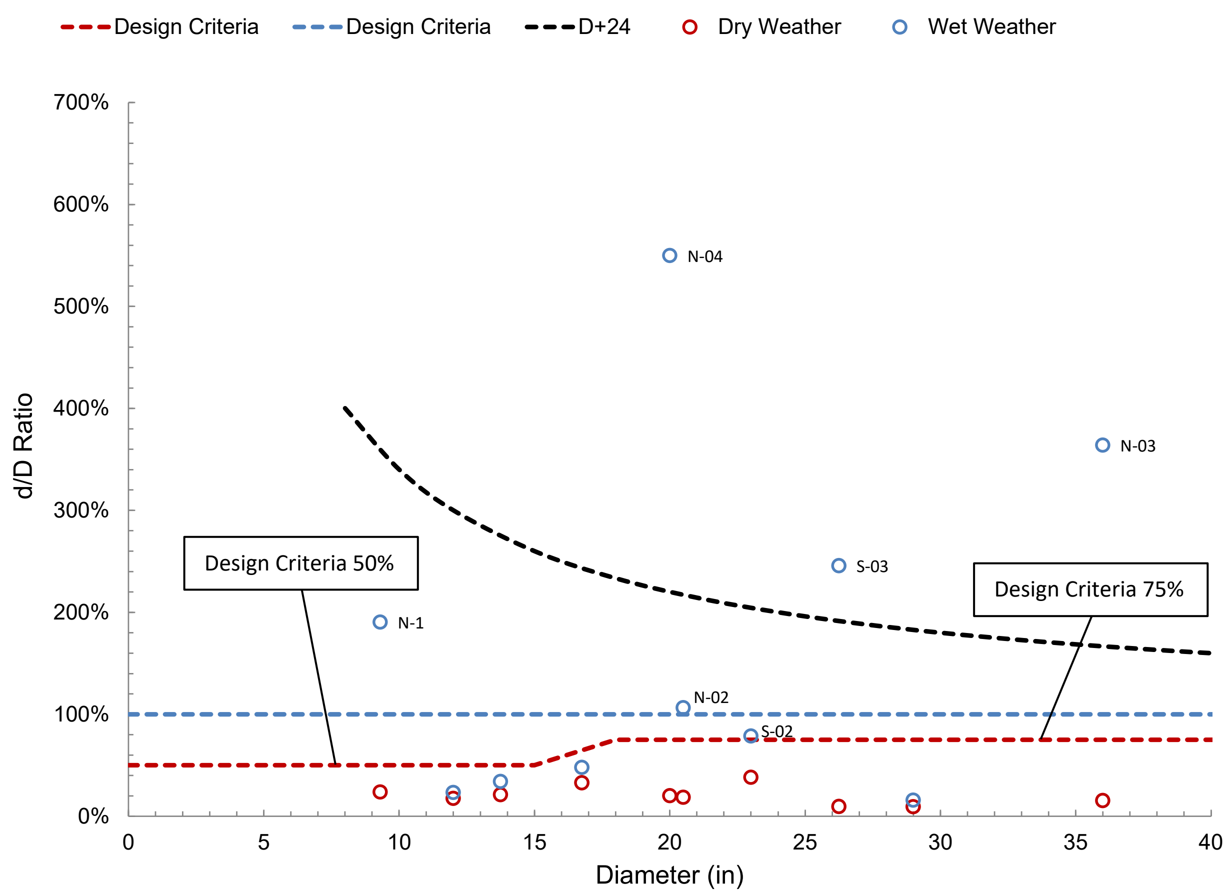
Table 3: Dry and Wet Weather Depth-to-Diameter Ratios

Monitor	D (inches)	d_{max-D} (inches)	d_{max-D} / D (%)	d_{max-W} (inches)	d_{max-W} / D (%)
N-01	9.3	2.2	24%	17.7	190% (B)
N-02	20.5	3.8	19%	21.8	106% (B)
N-03	36.0	5.5	15%	131.0	364% (B)
N-04	20.0	4.0	20%	110.0	550% (B)
N-05	12.0	2.1	18%	2.8	23%
S-01	29.0	2.7	9%	4.6	16%
S-02	23.0	8.8	38%	18.1	79% (B)
S-03	26.3	2.5	10%	64.5	246% (B)
S-04	16.75	5.5	33%	8.0	48%
S-05	13.75	2.9	21%	4.7	34%

The d/D ratio is a performance indicator used to assess sewer capacity. Sewers are often designed to flow under open channel flow conditions with some reserve capacity. As a result, ASCE and WEF recommend that sewers with diameters up to 15 inches be designed to flow with dry weather d/D ratios of 50%, and larger diameter sewers be designed to flow with dry weather d/D ratios of 75% (based on hourly averaged values). Sewers are not generally designed to operate under surcharge conditions with wet weather d/D ratios greater than 100%. Observed wet weather d/D ratios are also compared to additional capacity assurance criteria, designed to highlight portions of the sewer system where flow depths are greater than 24 inches above the crown of the sewer (D+24). These design and capacity assurance criteria are useful for comparison to observed d/D ratios as shown in Figure 3.

It is notable that 6 locations experienced significant backwater during at least one of the storm events. Those are noted in Table 3 by a letter "(B)" after the d/D values in the last column of the table. This suggests the higher values of wet weather d/D values are the primary result of backwater episodes and not necessarily associated with deficient pipe capacity.

Figure 3: Flow Depth-to-Diameter Ratios Compared to Design Criteria



During dry weather conditions, each of the observed d/D ratios are within design criteria recommended by ASCE and WEF.

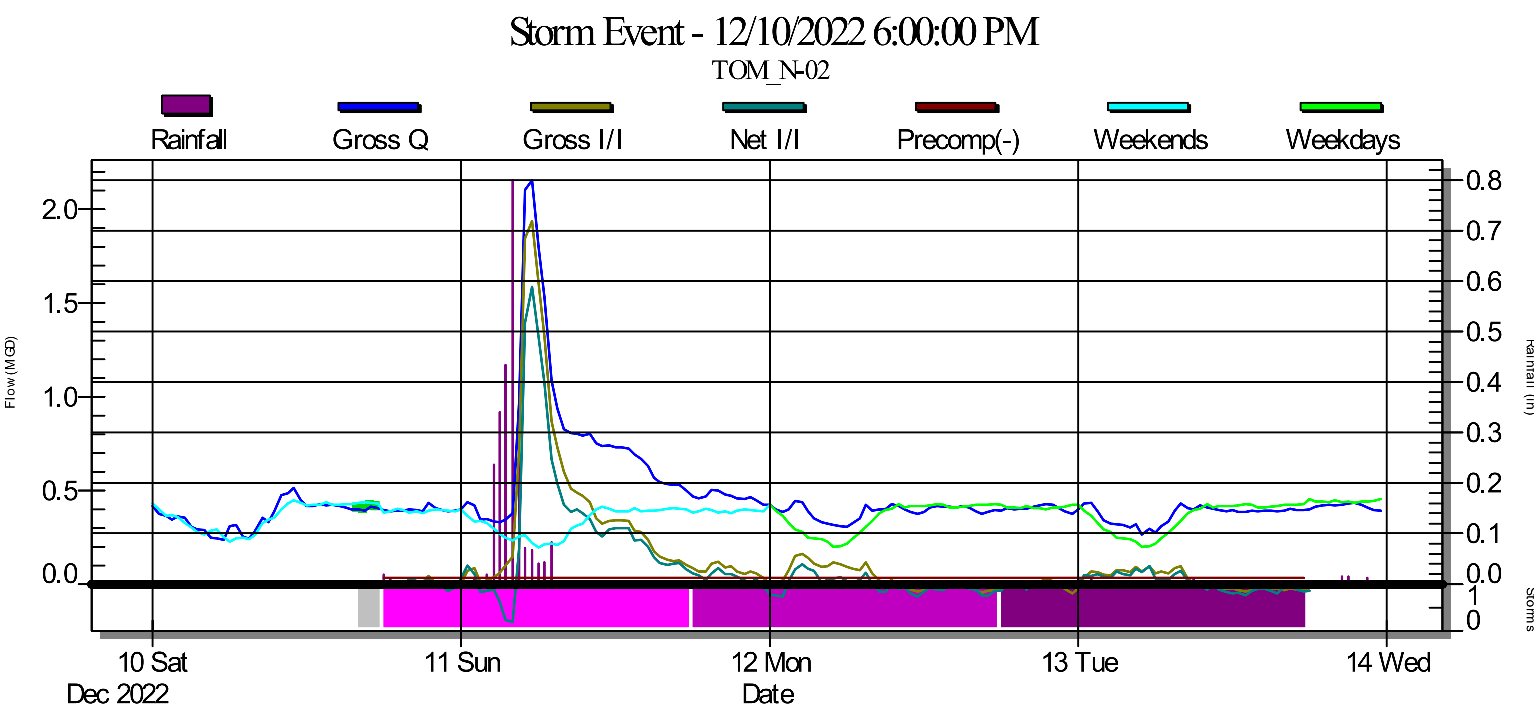
During wet weather conditions, the observed d/D ratios at 5 sites exceed 100% during the study period and exceed the design criteria recommended by ASCE and WEF.

Rainfall-Dependent Inflow and Infiltration (RDII)

During wet weather events, significant amounts of extraneous water can enter a sewer system, resulting in sanitary sewer overflows (SSOs), basement backups, and/or problems at the wastewater treatment plant (WWTP). A comparison of flow monitor data from dry weather and wet weather periods provides a quantification of rainfall-dependent inflow and infiltration (RDII), which is calculated by the difference in the measured flow (Gross Q) during a rainfall event from the flow pattern of an average dry day in the study period. A wet weather storm decomposition hydrograph is provided in Figure 4 for site N-02. The storm event is depicted by the purple bands, and a precompensation period prior to the storm is depicted by the light gray band. The precompensation period allows adjustments to the average dry day pattern (no significant adjustment in the case of N-02) as needed to account for antecedent conditions by adjusting the dry day pattern so it more closely matches observed conditions prior to each storm event.

The Gross RDII (or Gross I/I in the decomposition hydrographs) represent the difference between gross flow during the storm events vs. normal expected dry weather flow. For locations with upstream site subtractions, the decomposition hydrograph will also show net RDII (or Net I/I) which represents the RDII attributable to only the net flow (after subtraction of upstream flows).

Figure 4: Storm Decomposition Hydrograph



There were 5 storm events evaluated for each temporary flow monitor basin, with event rainfall totals between approximately 0.37 and 2.47 inches. Storm decomposition hydrographs are provided in Appendix C for the 4 largest storm events and show the observed responses to rainfall during the study period. A summary of the storm events observed at each rain gauge used during the study is shown below in Table 4.

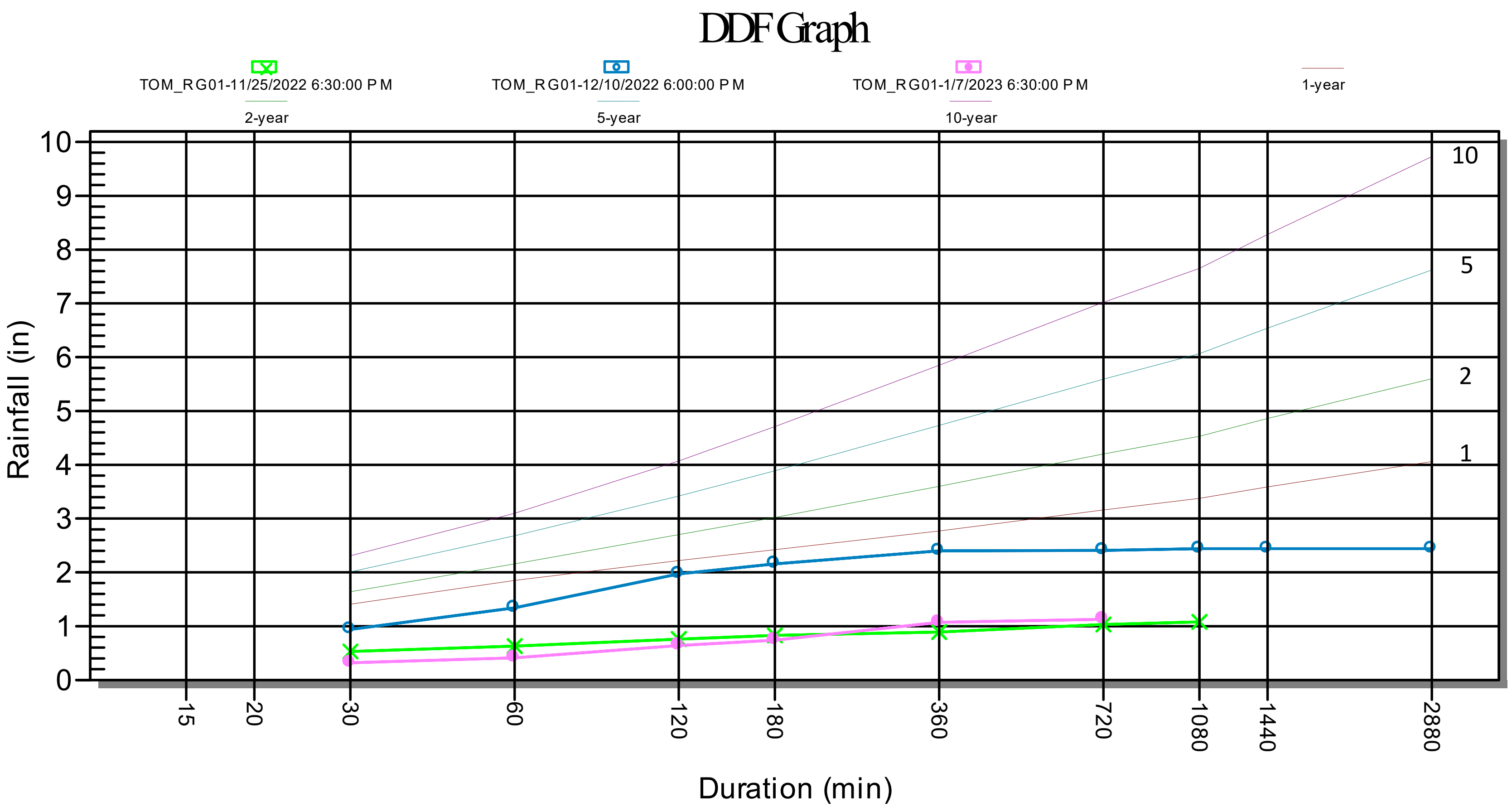
Table 4: Storm Summary

Date	Approx. Duration (hours)	RG01 (inches)	RG02 (inches)
11/24/2022	12	0.37	0.72
11/25/2022	12	1.08	1.44
12/10/2022	6	2.47	2.28
12/29/2022	1	0.77	0.97
1/7/2023	6	1.13	1.37

A rainfall accumulation chart was prepared (called a Depth-Duration-Frequency or DDF graph or chart) based on the "Tomball" public rain gauge and is depicted in Figure 5 showing the 3 highest volume storms. This chart was used to compare captured rainfall to historical rainfall statistics for the area (thin color lines on the DDF chart)[1]. The storms plotted on the DDF graph show how they compare to statistical records for the area. All of the storm events captured are less than 1 year return frequency events. However, the largest event starting on 12/10 represents just below a 1yr, 3hr event.

[1] NOAA Precipitation Frequency Data Server (https://hdsc.nws.noaa.gov/hdsc/pfds), Station Name: TOMBALL.

Figure 5: Rainfall Depth Duration Frequency (DDF) Graph



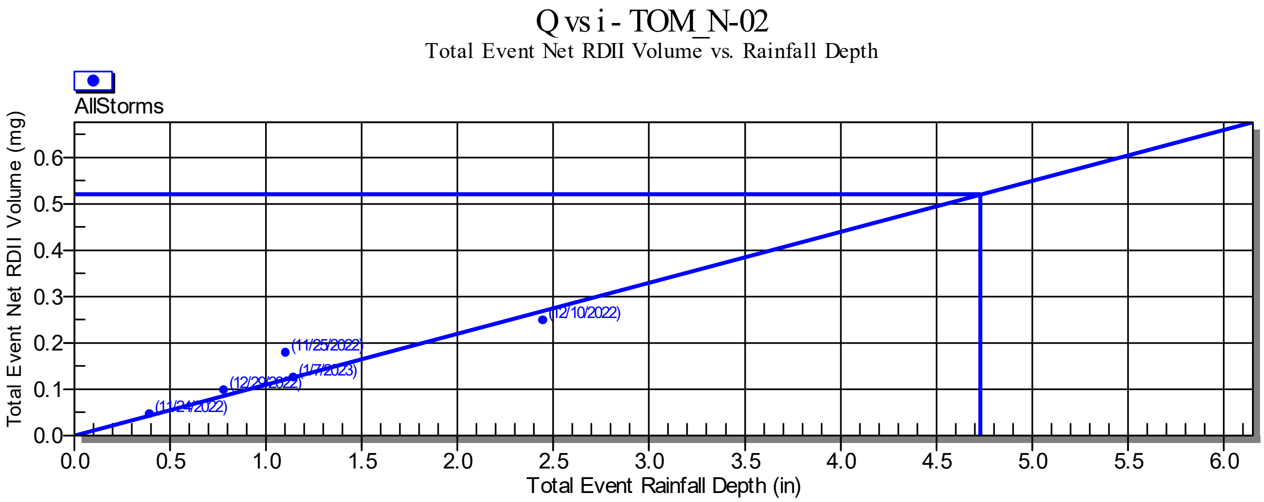
The basins were assigned rainfall from the rain gauges as indicated in Table 5.

Table 5: RG Assignment Per Basin

Basin	RG01	RG02
N-01	X	
N-02	X	
N-03	X	
N-04	X	
N-05	X	
S-01		X
S-02		X
S-03		X
S-04		X
S-05		X

After the RDII calculations are determined for each storm event, the results are plotted as a function of rainfall total. An example is shown in Figure 6 in which the relationship between the Storm Event RDII volume (mg) is plotted with respect to the Storm Event rainfall (inches) for each storm event. These relationships are called Q vs i diagrams and can then be used to evaluate the consistency of rainfall responses within the sanitary sewer system and estimate the RDII response for various rainfall amounts. Figure 6 also shows a best fit trend line on the storm data points. A storm volume representing 4.73 in. rain (volume of rain associated with a 5 year, 6 hour event) is also depicted on Figure 6 and can be used to predict (project) expected RDII response for that volume of rain (0.52 mg for 4.73 inches of rain in the case of basin N-02). Q vs i diagrams for each flow monitor basin are provided in Appendix C.

Figure 6: RDII Volume Response vs. Rainfall Depth



Based on the results obtained during the study period, Net RDII volumes are reported for each flow monitor for each storm event. Net RDII volumes are computed by subtracting the Gross RDII volume of any upstream flow monitor basin from the Gross RDII volume measured at the outlet monitor(s) of each basin. The resulting Net RDII volumes for each basin for each storm are shown in Table 6 in millions of gallons (mg). Normalized Net RDII is then calculated by dividing the net RDII volume by the associated basin size, and the results are shown in Table 7 in units of gallons per foot (gal/LF).

If at any site, there is no observable response to a storm, there is significant missing or suspect data during the storm, or there is not a full recovery during the study period, then the related storm is not used in Q vs. i analysis for that site. In this study, there were 3 sites/basins where this occurred. At S-04 during the first storm (on 11/24 – Thanksgiving), the gross flow that day was lower than usual, producing a negative value of RDII, so it was ignored on its Q vs. i plot. At S-02, flow dropped to zero for much of the day on 11/26, so the storm data for the associated 11/25 storm was not included on its Q vs. i plot. At S-05, the flow dropped suddenly immediately following the largest storm event of the study on 12/11 and remained lower until near the end of the day on January 11; therefore the last 3 storms of the study were not included for this basin's Q vs. i plot.

Table 6: Net RDII (Million Gallons - mg) for All Storm Events

Basin	11/24/2022	11/25/2022	12/10/2022	12/29/2022	1/7/2023
N-01	0.03	0.11	0.14	0.11	0.15
N-02	0.04	0.18	0.25	0.10	0.12
N-03	0.18	0.30	0.51	0.46	0.41
N-04	0.05	0.18	0.35	0.08	0.21
N-05	0.00	0.09	0.14	0.03	0.08
S-01	0.01	0.05	0.06	0.04	0.04
S-02	0.15	--	0.71	0.23	0.20
S-03	0.02	0.35	0.15	0.15	0.28
S-04	--	0.17	0.19	0.09	0.09
S-05	0.05	0.12	--	--	--

‘- -‘ *Indicates no valid data available for storm indicated or outside of study period.*

Table 7: Normalized Net RDII (gal/LF) for All Storm Events

Basin	11/24/2022	11/25/2022	12/10/2022	12/29/2022	1/7/2023
N-01	1.38	5.52	7.04	5.79	7.55
N-02	0.58	2.32	3.25	1.25	1.60
N-03	3.79	6.21	10.82	9.60	8.67
N-04	0.60	2.09	4.10	0.95	2.46
N-05	0.40	12.48	19.46	4.74	11.48
S-01	0.82	2.81	3.65	2.36	2.25
S-02	2.35	--	10.96	3.60	3.11
S-03	0.58	8.50	3.70	3.70	6.93
S-04	--	2.60	2.92	1.45	1.34
S-05	2.08	4.96	--	--	--

‘- -‘ *Indicates no valid data available for storm indicated or outside of study period.*

These Normalized RDII values are then normalized per inch of rain by dividing the values in Table 7 for each monitor for each storm by the total inches of rain in each event for the respective site/basin. These values are provided in Table 8 in units of gallons per foot per inch rain (gal/LF/in).

Table 8: Normalized Net RDII (gal/LF/in) for All Storm Events

Basin	11/24/2022	11/25/2022	12/10/2022	12/29/2022	1/7/2023
N-01	3.45	4.96	2.87	7.35	6.56
N-02	1.43	2.09	1.32	1.59	1.39
N-03	9.43	5.59	4.41	12.18	7.52
N-04	1.49	1.88	1.67	1.20	2.14
N-05	0.99	11.22	7.93	6.01	9.97
S-01	1.20	2.00	1.59	2.48	1.67
S-02	3.42	--	4.77	3.78	2.31
S-03	0.84	6.04	1.61	3.89	5.14
S-04	--	1.85	1.27	1.52	1.00
S-05	3.03	3.53	--	--	--

'- -' Indicates no valid data available for storm indicated or outside of study period.

The trend line on the Q vs I charts can be used to provide another means of comparison of the RDII from each basin. Based upon this trend line, the RDII for a 4.73-inch design storm was projected for each site. These values are provided in Table 9.

Table 9: Normalized Net RDII volume for 4.73-inch Design Storm

Basin	RDII (mg)	Basin Size (LF)	RDII (gal/LF)	RDII (gal/LF/in)	Rank
N-01	0.36	19,171	18.8	3.98	5
N-02	0.52	75,667	6.9	1.45	9
N-03	1.26	47,529	26.5	5.61	2
N-04	0.71	85,822	8.3	1.74	7
N-05	0.30	7,209	41.6	8.96	1
S-01	0.14	17,365	8.1	1.74	8
S-02	1.51	64,971	23.2	5.34	3
S-03	0.62	40,736	15.2	3.23	6
S-04	0.41	63,374	6.5	1.36	10
S-05	0.44	23,862	18.4	4.00	4

Based on the analysis, basin N-05 was the highest ranked (worst) basin in regards to normalized RDII, with a value of 8.96 gal/LF/in for a 4.73-inch projected storm. The next highest basins were N-03 and S-02 which produced normalized RDII of 5.61 gal/LF/in and 5.34 gal/LF/in, respectively.

Conclusions and Recommendations

The conclusions and recommendations in this study are based on data gathered using 10 temporary flow monitors and 2 rain gauges. The study period was conducted from November 18, 2022 through January 19, 2023. 5 rain events were observed and evaluated during the study period, with rainfall totals ranging from approximately 0.37 and 2.47 inches. A detailed analysis of dry weather and wet weather periods was performed and included an evaluation of various key performance indicators.

Dry Weather Performance

During dry weather conditions, observed d/D ratios at both locations were within design criteria recommended by ASCE and WEF, indicating that there is largely sufficient capacity to accommodate dry weather flow rates at these locations.

Wet Weather Performance

The largest gross peaking factor observed during the study period was a value of 16.3 at Site N-01.

During wet weather conditions, the observed d/D ratios at 5 sites exceed 100% during the study period and exceed the design criteria recommended by ASCE and WEF.

It is notable that 6 locations experienced significant backwater during at least one of the storm events (see Table 3). This suggests the higher values of wet weather d/D values are the primary result of backwater episodes and not necessarily associated with deficient pipe capacity.

Rainfall-Dependent Inflow and Infiltration

Based on the analysis, basin N-05 was the highest ranked (worst) basin in regards to normalized RDII, with a value of 8.96 gal/LF/in for a 4.73-inch projected storm. The next highest basins were N-03 and S-02 which produced normalized RDII of 5.61 gal/LF/in and 5.34 gal/LF/in, respectively. Investigation of RDII sources may be warranted if capacity issues result from RDII coming from any of these basins.

Definitions

Basin – a designation given to a series of interconnected sewers within a sanitary sewer system that collect and convey wastewater to a common manhole or pump station. The size and geographic extent of a given basin are system specific. Basin designations are established to provide a consistent nomenclature for system components to facilitate effective planning, operation, and maintenance.

Depth-to-Diameter (d/D) Ratio – a ratio of maximum flow depth to sewer diameter. d/D ratios are often calculated to describe both dry weather and wet weather periods and are one measure used to assess sewer capacity utilization. d/D ratios are typically computed using hourly average data.

Infiltration – water that enters a sanitary sewer system from the ground through defective system components including, but not limited to, defective sewers, manholes, service connections, or other system appurtenances. Infiltration is primarily dependent upon groundwater elevations, but may also be influenced by storm events and leaking water mains.

Inflow – storm water runoff that enters a sanitary sewer system from direct connections including, but not limited to, building downspouts, clean-outs, foundation drains, sump pumps, basement and area drains, and cross connections with storm sewer systems.

Peaking Factor (PF) – a ratio of maximum flow rate to average flow rate. Peaking factors are often calculated to describe both dry weather and wet weather periods, where maximum flow rates are compared to average dry weather flow rates. Peaking factors are usually computed using hourly average data.

Rain-Dependent Inflow and Infiltration (RDII) – the collective inflow and infiltration that enter a sewer system as a direct result of rainfall.

Sanitary Sewer Overflow (SSO) – a discharge of untreated wastewater from a sanitary sewer system, caused by a variety of reasons including, but not limited to, inadequate sewer design and construction, insufficient operation and maintenance, power failures, and vandalism.

Sanitary Sewer System – a collection of sewers, manholes, pump stations, and other appurtenances designed for the collection and transportation of wastewater.

References

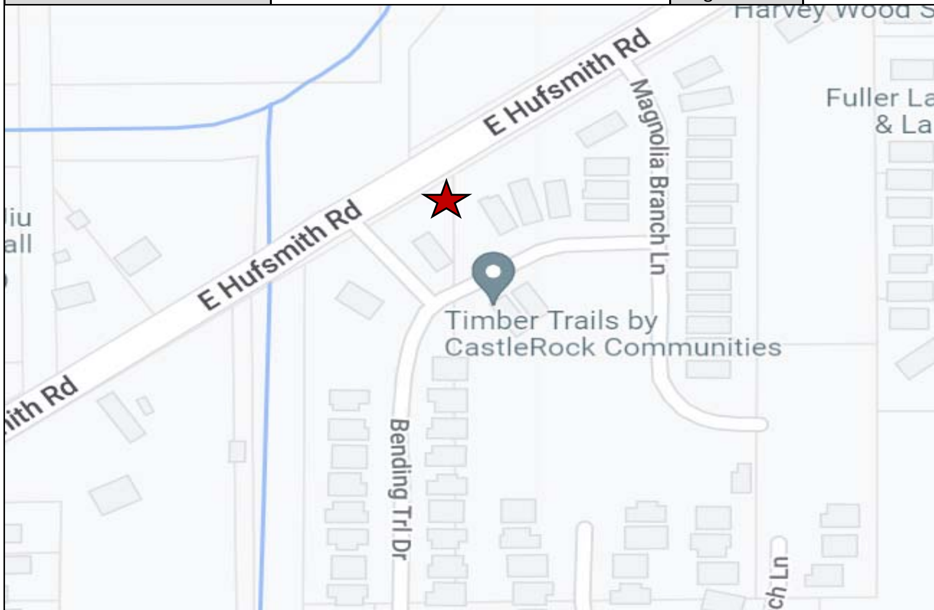
1. Bizier, Paul, Editor (2007). *Gravity Sanitary Sewer Design and Construction*, ASCE Manuals and Reports on Engineering Practice No. 60, American Society of Civil Engineers: Reston, VA.

2. Enfinger, K.L. and Stevens, P.L. (2006). "Scattergraph Principles and Practice – Tools and Techniques to Evaluate Sewer Capacity," *Proceedings of the Pipeline Division Specialty Conference*; Chicago, IL; American Society of Civil Engineers: Reston, VA.

Appendix A – Flow Monitor Site Installation Details

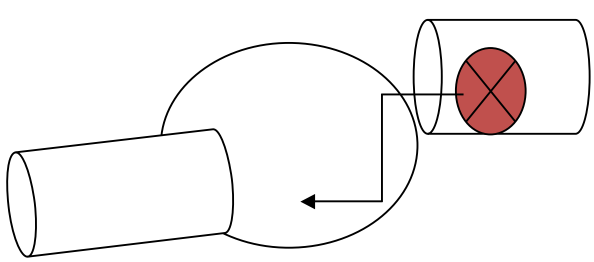
Tomball, Texas		Site Name
Flow Monitoring Site Report	ADS ENVIRONMENTAL SERVICES®	TOM_N01

Site Address /Location:	1107 Bending Trail Drive			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.10866	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.60913	9.25"X 9.75"	Elliptical



Manhole #	System Characteristics
N/A	Other
Access	Traffic
Drive	None

Installation Date:	Installation Type:
Thursday, November 17, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi
Installation Confirmation:	
Confirmation Time:	Pipe Size (HxW)
4:35:00 PM	9.25"X 9.75"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
1.62	
Downlooker Physical Offset (in)	Measurement Confidence (in)
0	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
0.9	0
Silt (in)	Silt Type
0	
Hydraulic Comments:	
good	
Manhole / Pipe Information:	
Manhole Depth (Approx. FT):	Manhole Configuration
9.8	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	
Pipe Material	Pipe Condition:
PVC	Good
Communication Information:	
Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete
Additional Site Info. / Comments:	



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	Location	Location
		
Location		

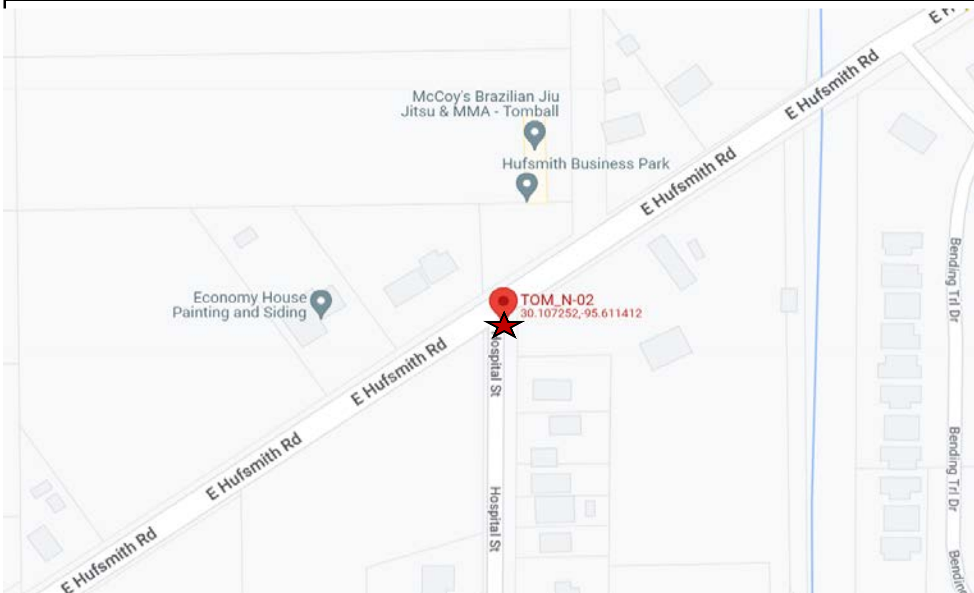
Tomball, Texas

Flow Monitoring Site Report

Site Name

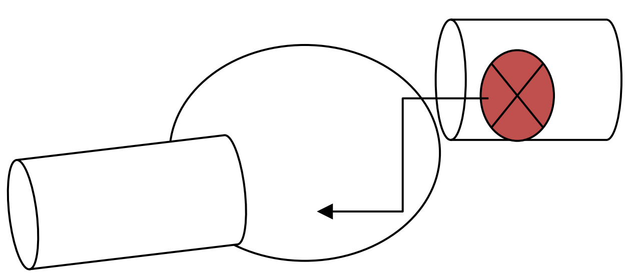
TOM_N-02

Site Address /Location:	723 Hospital St, Tomball, TX 77375			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.107252	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.611412	20.5 X 20.5	Circular



Manhole #	System Characteristics
N/A	Other
Access	Traffic
Drive	None

Installation Information	
Installation Date:	Installation Type:
Thursday, November 17, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi
Installation Confirmation:	
Confirmation Time:	Pipe Size (HxW)
3:36:00 PM	20.5 X 20.5
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
2.88	
Downlooker Physical Offset (in)	Measurement Confidence (in)
0	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
3.34	0
Silt (in)	Silt Type
0	
Hydraulic Comments:	
good	
Manhole / Pipe Information:	
Manhole Depth (Approx. FT):	Manhole Configuration
9.8	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	
Pipe Material	Pipe Condition:
PVC	Good
Communication Information:	
Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete
Additional Site Info. / Comments:	



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	**Location**	**Location**
		
Location		

Tomball, Texas

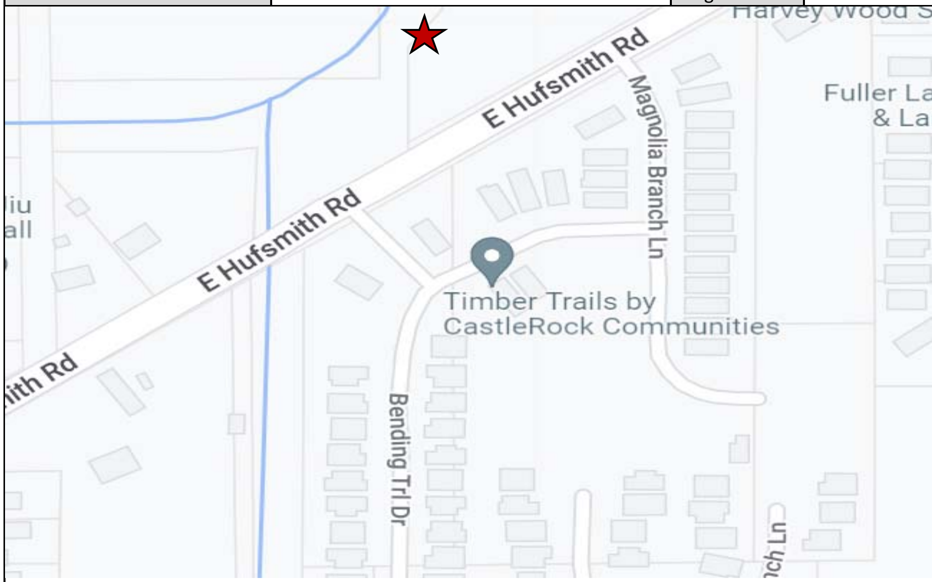
Flow Monitoring Site Report

ADS ENVIRONMENTAL SERVICES

Site Name

TOM_N-03

Site Address /Location:	540 E Hufsmith Road			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.10906	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.60952	36"X36.5"	Elliptical



Manhole #	System Characteristics
	Other
Access	**Traffic**
Drive	None

Installation Information

Installation Date:	Installation Type:
Thursday, November 17, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
5:43:00 PM	36"X36.5"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
5.00	
Downlooker Physical Offset (in)	Measurement Confidence (in)
0	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
1.6	
Silt (in)	Silt Type
0	
Hydraulic Comments:	
good	

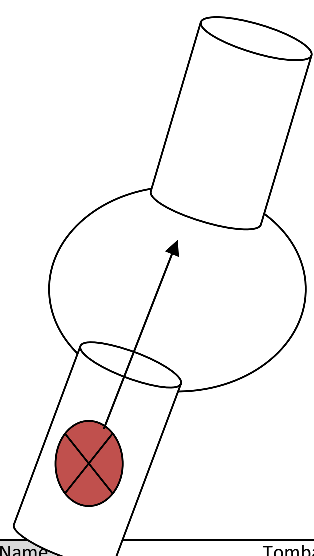
Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
18.9	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	
Pipe Material	Pipe Condition:
Concrete	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	**Location**	**Location**
		
Location		

Tomball, Texas

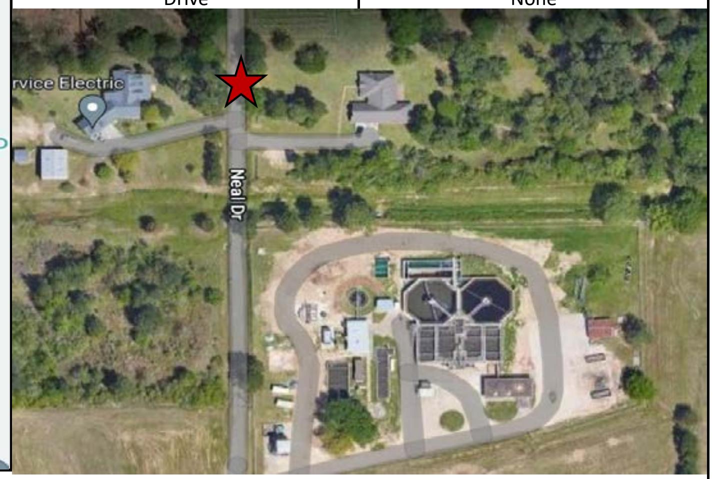
Flow Monitoring Site Report

Site Name

TOM_N-04

Site Address /Location:	1330 Neal Drive			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.11277	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.61108	20"X20"	Circular

Manhole #	System Characteristics
	Other
Access	**Traffic**
Drive	None



Installation Information

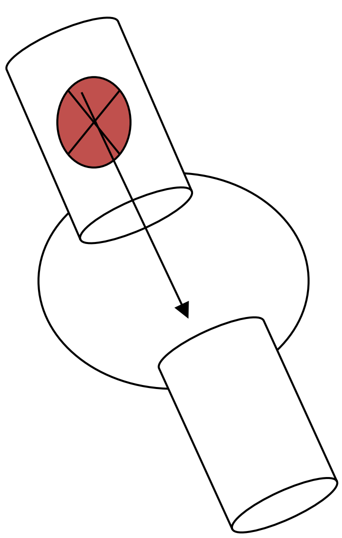
Installation Date:	Installation Type:
Thursday, November 17, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
2:10:00 PM	20"X20"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
4.00	
Downlooker Physical Offset (in)	Measurement Confidence (in)
0	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
3.75	0
Silt (in)	Silt Type
0	

Hydraulic Comments:

good



Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
14	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	
Pipe Material	Pipe Condition:
Concrete	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:

ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream

Downstream

Overflow

Top Down

Location

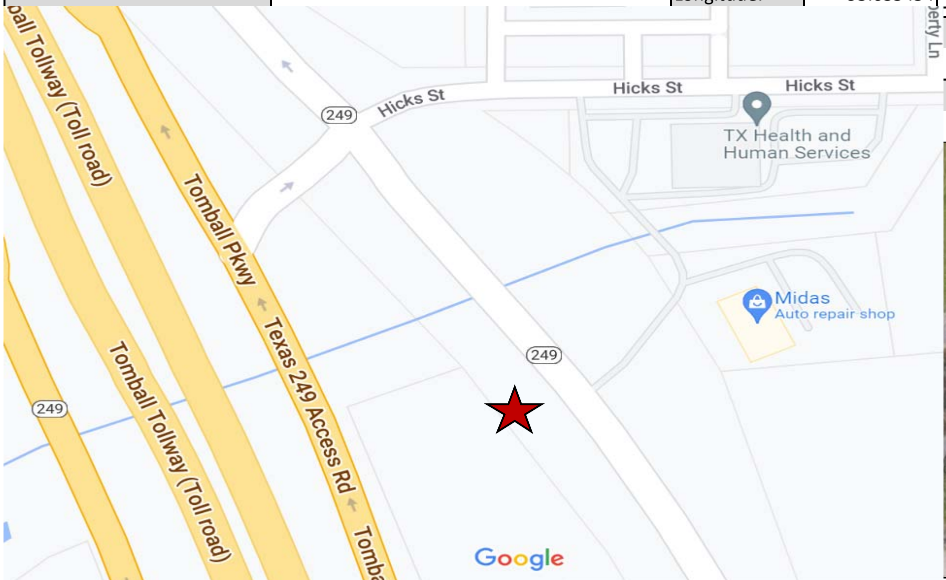
Location

Location

Tomball, Texas	ADS ENVIRONMENTAL SERVICES	Site Name
Flow Monitoring Site Report		TOM_N-05

Site Address /Location:	Across from 29230 Tomball Pkwy.		
Site Access Details:	Drive	Latitude:	30.096699
		Longitude:	-95.635454

Monitor Series	Location Type
TRITON+	Temporary
Pipe Size (H x W)	Pipe Shape
12"X12"	Circular
Manhole #	System Characteristics
N/A	Other
Access	Traffic
Drive	None



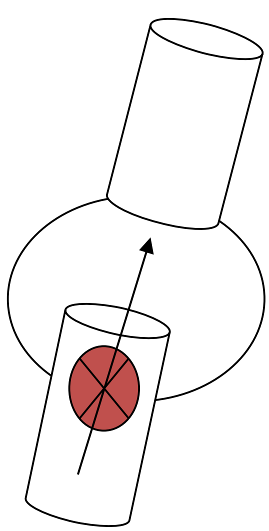
Installation Information

Installation Date:	Installation Type:
Friday, November 18, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
2:51:00 PM	12"X12"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
2.00	
Downlooker Physical Offset (in)	Measurement Confidence (in)
0	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
6.1	0
Silt (in)	Silt Type
0	

Hydraulic Comments:
good



Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
13.8	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	
Pipe Material	Pipe Condition:
PVC	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:

ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	**Location**	**Location**
		
Location		

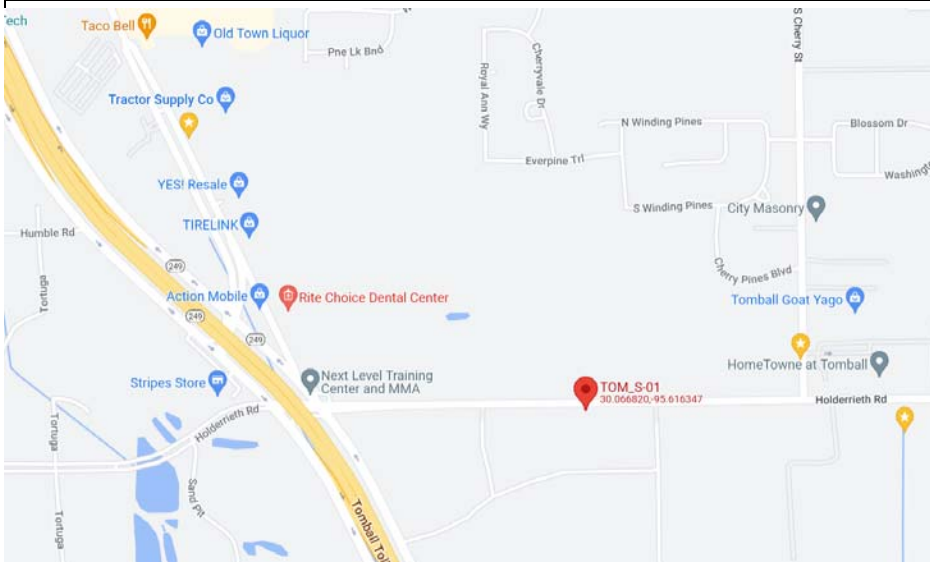
Tomball, Texas

Flow Monitoring Site Report

Site Name

TOM_S-01

Site Address /Location:				Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.06682	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.6163475	29 X 30 "	Elliptical



Manhole #	System Characteristics
	Other
Access	**Traffic**
Drive	None

Installation Information

Installation Date:	Installation Type:
Tuesday, November 15, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
1:09:00 PM	29 X 30 "
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
2.88	
Downlooker Physical Offset (in)	Measurement Confidence (in)
N/A	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
0.45	0
Silt (in)	Silt Type
1	Soft / Loose

Hydraulic Comments:

good

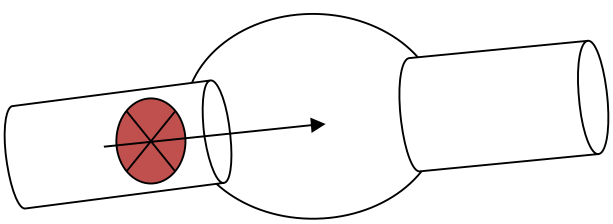
Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
9.9	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
32	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	Good
Pipe Material	Pipe Condition:
PVC	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	Location	Location
		
Location		

Tomball, Texas

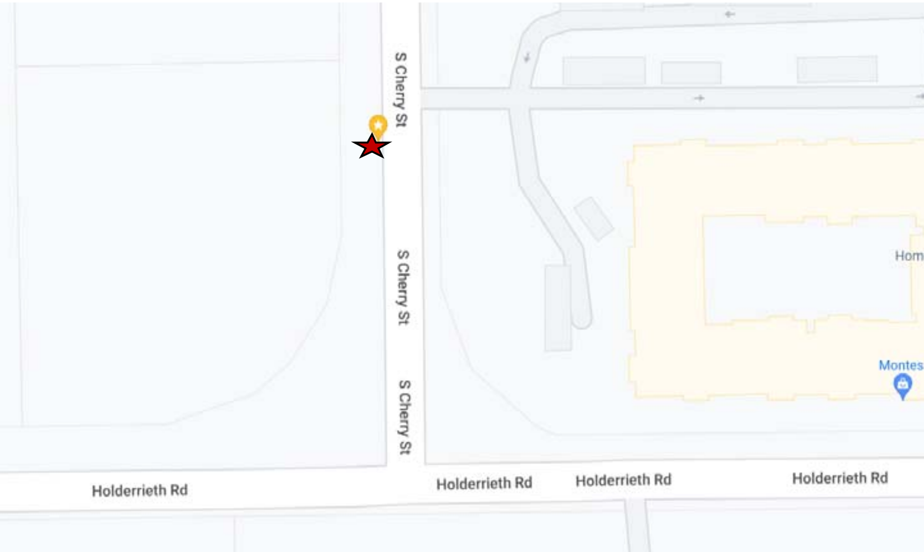
Flow Monitoring Site Report

ADS ENVIRONMENTAL SERVICES

Site Name

TOM_S-02

Site Address /Location:				Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.067820,	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.611344	23 X 23.75"	Elliptical



Manhole #	System Characteristics
N/A	Other
Access	Traffic
Drive	None

Installation Information

Installation Date:	Installation Type:
Tuesday, November 15, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
11:22:00 PM	23 X 23.75"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
8.32	
Downlooker Physical Offset (in)	Measurement Confidence (in)
N/A	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
1.38	0
Silt (in)	Silt Type
0	

Hydraulic Comments:

good

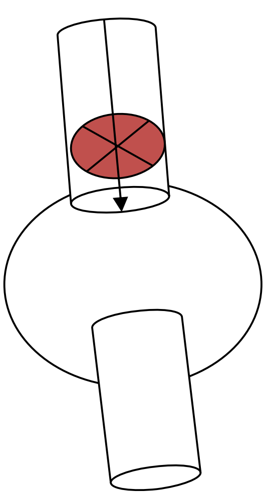
Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
13.75	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
32	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	Good
Pipe Material	Pipe Condition:
PVC	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	Location	Location
		
Location		

Tomball, Texas

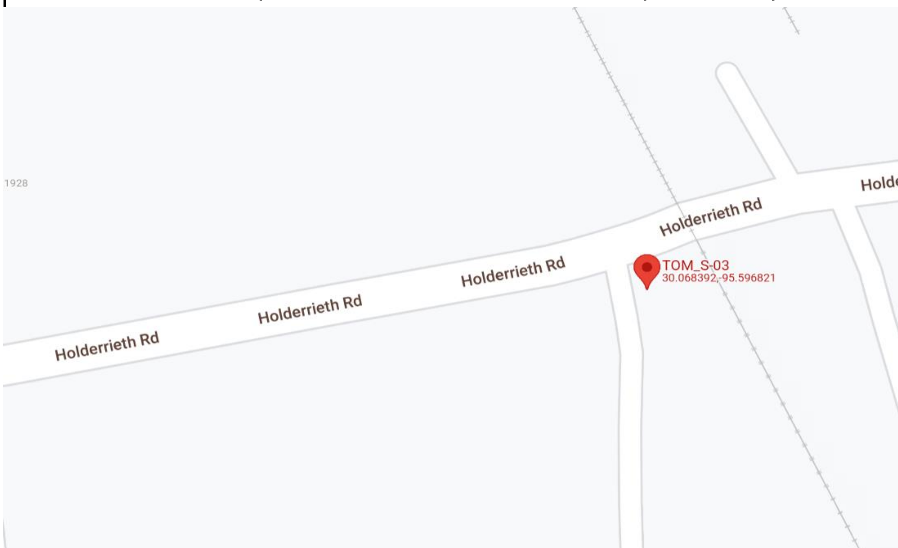
Flow Monitoring Site Report

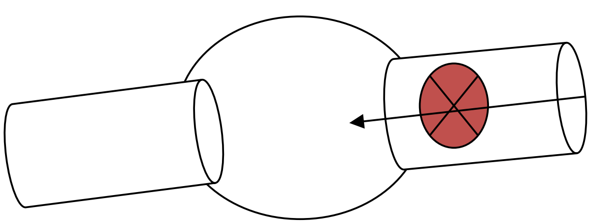
Site Name

TOM_S-03

Site Address /Location:	11807 Holderrieth Road			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive	Latitude:	30.068392	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.596821	26.25 X 26.75	Elliptical

Manhole #	System Characteristics
N/A	Other
Access	Traffic
Drive	None





Installation Information	
Installation Date:	Installation Type:
Tuesday, November 15, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi
Installation Confirmation:	
Confirmation Time:	Pipe Size (HxW)
2:39:00 PM	26.25 X 26.75
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
2.00	
Downlooker Physical Offset (in)	Measurement Confidence (in)
N/A	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
3.35	0
Silt (in)	Silt Type
0	
Hydraulic Comments:	
good	
Manhole / Pipe Information:	
Manhole Depth (Approx. FT):	Manhole Configuration
23.58	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
32	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	Good
Pipe Material	Pipe Condition:
PVC	Good
Communication Information:	
Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete
Additional Site Info. / Comments:	

ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	**Location**	**Location**
		
Location		

Tomball, Texas

Flow Monitoring
Site Report

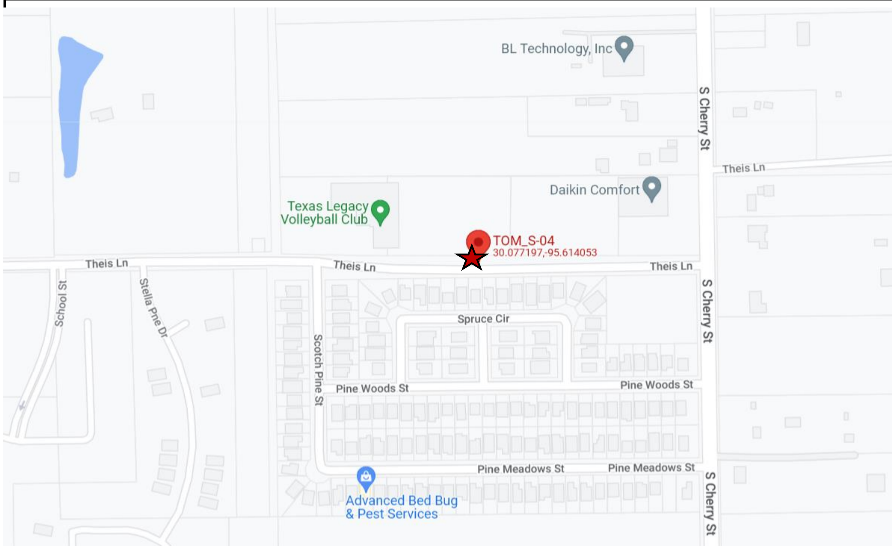
ENVIRONMENTAL SERVICES®

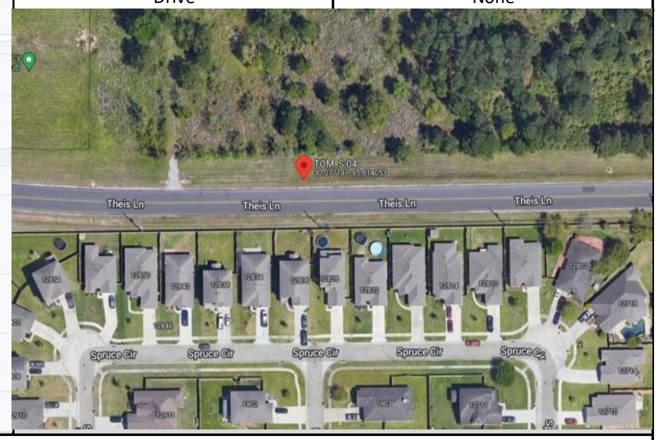
Site Name

TOM_S-04

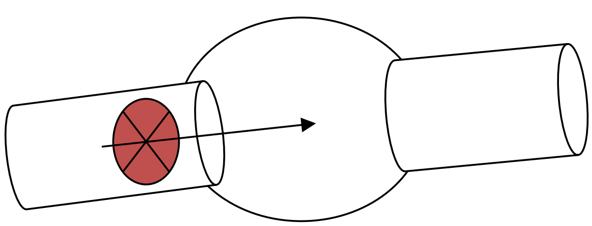
Site Address /Location:	N. of 12806 Spruce Cir, Tomball, TX 77375			Monitor Series	Location Type
				TRITON+	Temporary
Site Access Details:	Drive/grass	Latitude:	30.0771968	Pipe Size (H x W)	Pipe Shape
		Longitude:	-95.6140526	16.75x17.62	Elliptical

Manhole #	System Characteristics
n/a	Other
Access	Traffic
Drive	None





Installation Information	
Installation Date:	Installation Type:
Tuesday, November 15, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi
Installation Confirmation:	
Confirmation Time:	Pipe Size (HxW)
4:42:00 PM	16.75x17.62
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
4.88	
Downlooker Physical Offset (in)	Measurement Confidence (in)
N/A	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
1.9	0
Silt (in)	Silt Type
0	
Hydraulic Comments:	
good	



Manhole / Pipe Information:	
Manhole Depth (Approx. FT):	Manhole Configuration
9.91	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
32	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	Good
Pipe Material	Pipe Condition:
PVC	Good
Communication Information:	
Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:

ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

Upstream	Downstream	Overflow
		
Top Down	Location	Location
		
Location		

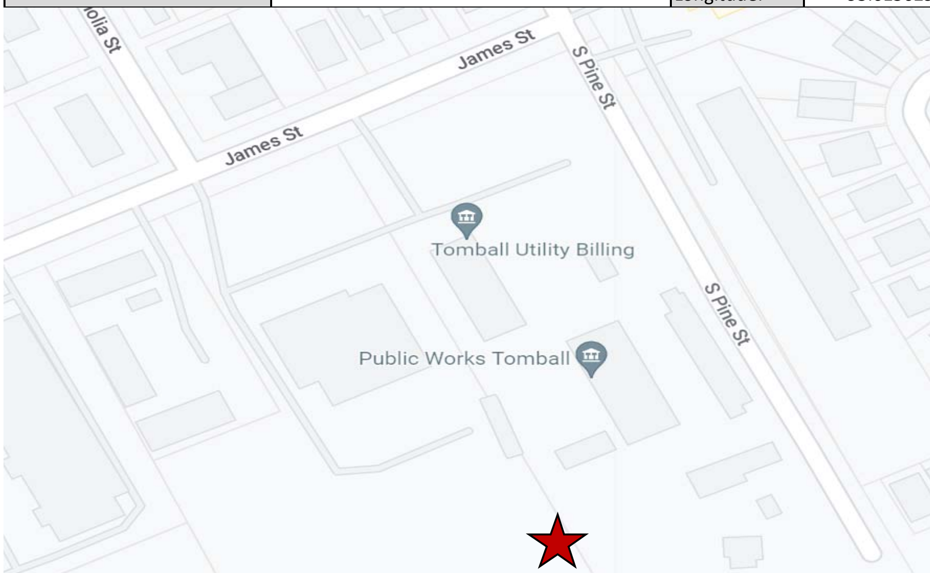
Tomball, Texas

Flow Monitoring Site Report

Site Name
TOM_S05

Site Address /Location:	Behind 501 James St., Tomball Public Works Office				
Site Access Details:	Drive	Latitude:	30.089711		
		Longitude:	-95.615629		

Monitor Series	Location Type
TRITON+	Temporary
Pipe Size (H x W)	Pipe Shape
13.75"X14"	Circular
Manhole #	System Characteristics
	Other
Access	Traffic
Drive	None



Installation Information

Installation Date:	Installation Type:
Thursday, November 17, 2022	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4)	0 - 15 psi

Installation Confirmation:

Confirmation Time:	Pipe Size (HxW)
1:47:00 PM	13.75"X14"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
3.25	
Downlooker Physical Offset (in)	Measurement Confidence (in)
N/A	0.25"
Peak Velocity (fps)	Velocity Sensor Offset (in)
1.75	0
Silt (in)	Silt Type
0	

Hydraulic Comments:
good

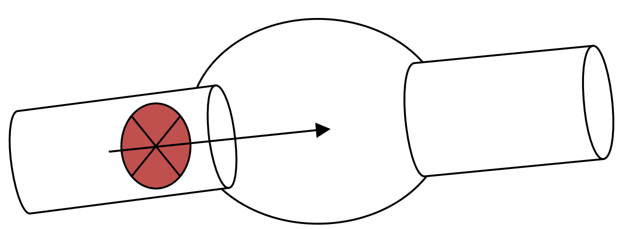
Manhole / Pipe Information:

Manhole Depth (Approx. FT):	Manhole Configuration
9.9	Single
Manhole Material:	Manhole Condition:
Concrete	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
32	Vault
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	Good
Pipe Material	Pipe Condition:
PVC	Good

Communication Information:

Communication Type	Antenna Location
Wireless	Drilled Pavement / Concrete

Additional Site Info. / Comments:



ADS Project Name:	Tomball, Texas
ADS Project Number:	25965.11.325

Additional Photos

<table>
<tr><td>Upstream
</td><td>Downstream
</td><td>Overflow</td></tr>
<tr><td>Top Down
</td><td>Location
</td><td>Location</td></tr>
<tr><td>Location</td><td></td><td></td></tr>
</table>

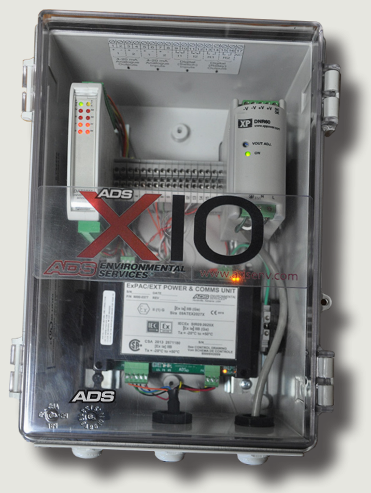
Appendix B – Detailed Flow Monitor Specifications

ADS' Self-Contained Solutions for Power, Communication, Analog and Digital I/O and Modbus

The ***TRITON+*** COMM+EXT PWR port is used for external power via the ADS XIO, XBUS or ExPAC devices, delivery of Modbus output values as well as for on-site, direct monitor communication.

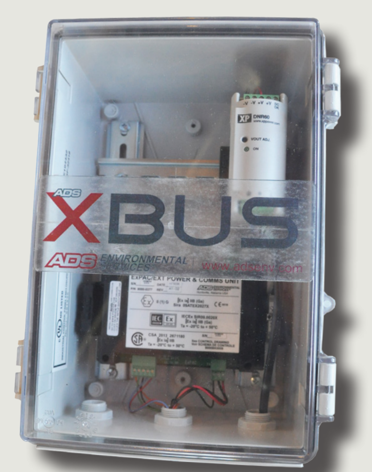
XIO Features

- Process variables measured by the ***TRITON+*** can be converted to two (2) 4-20mA loop output signals for SCADA systems or local display and control
- Logging capabilities of the ***TRITON+*** can be used for two (2) 4-20mA input process variables measured by other instrumentation
- Alarms produced by the ***TRITON+*** Monitor Level Intelligence (MLI) device can be output on the two (2) XIO relay contacts for process actuation
- Two (2) switch, solid state or dry contact digital inputs can be sampled and logged
- Design facilitates easy field wiring
- Supports easy plug and play configuration and start-up
- Associated Apparatus IECEx certification for use with approved equipment in Zone 0 (equivalent to Class I, Division 1, Groups C & D); ATEX Zone 0; and CSA Class I, Zone 0, IIB hazardous areas
- Rugged indoor/outdoor NEMA 4x case with hinged clear cover
- Accepts 85-264 VAC, 120-375 VDC; 47-62 Hz; 1.1A@110/0.59A @250 VAC
- Supplies 8 – 11.5 VDC, 500mA power to the ***TRITON+*** flow monitors



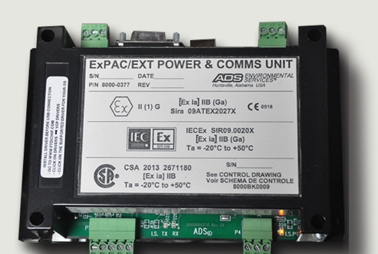
XBUS Features

- Supports Modbus RTU, ASCII and TCP communications
- Wireless Modbus via ***TRITON+*** internal modem communications
- Connects to wired networks via RS485 or RS232
- Supports easy plug and play configuration and start-up
- Associated Apparatus IECEx certification for use with approved equipment in Zone 0 (equivalent to Class I, Division 1, Groups C & D); ATEX Zone 0; and CSA Class I, Zone 0, IIB hazardous areas
- Rugged indoor/outdoor NEMA 4x case with hinged clear cover
- Accepts 85-264 VAC, 120-375 VDC; 47-62 Hz; 1.1A@110/0.59A @250 VAC
- Supplies 8 – 11.5 VDC, 500mA power to the ***TRITON+*** flow monitors



ExPAC Features

- Designed to be housed in another enclosure
- Associated Apparatus IECEx certification for use with approved equipment in Zone 0 (equivalent to Class I, Division 1, Groups C & D); ATEX Zone 0; and CSA Class I, Zone 0, IIB hazardous areas
- Requires DC power input between 9 and 36 volts and a minimum of 15 watts
- Supplies DC power of 8 to 11.5 volts, 500mA to the ***TRITON+*** flow monitors
- RS485 and RS232 Modbus output connections to SCADA systems
- Wireless Modbus via ***TRITON+*** internal modem communications
- Supports Modbus RTU, ASCII and TCP/IP communications



ADS LLC

340 The Bridge Street, Suite 204 - Huntsville, AL 35806
Phone: 256.430.3366/ Fax: 256.430.6633
Toll Free: 1.800.633.7246

www.adsenv.com

 Specifications subject to change without notice. DS-TRIT+080217

HARDWARE

ADS TRITON+®

The ADS TRITON+® is an intrinsically safe, "Fit-for-Purpose" open channel flow monitor for use in sanitary, combined, and storm sewers. It is designed to be the most versatile flow monitoring system available for wastewater collection applications. It supports single pipe or dual pipe flow measurement installations.

ADS TRITON+

This multiple technology flow monitor will power almost every available sensor technology that is used in wastewater applications today. It is the most versatile and cost-effective, multiple-technology flow monitor on the market. The ***TRITON+*** includes four multiple technology sensor options: a Long Range Depth Sensor, a Peak Combo Sensor, a Surface Combo Sensor, and an Ultrasonic Level Sensor (see inside for technology and specifications). This array of monitoring technologies provides for unmatched flexibility in a fully integrated, fit-for-purpose monitoring platform.

The ***TRITON+*** platform adapts to a wide range of customer applications and budgets. It can be configured as an economical single sensor monitor or dual sensor monitor. It offers a longer battery life and fewer parts for a more reliable system. This provides a lower purchase price and a lower ownership cost over the life of the monitor. The ***TRITON+*** has the lowest operational cost per data sample of any Intrinsically Safe flow monitor available.

About ADS

A leading technology and service provider, ADS®LLC has established the industry standard for open channel flow monitoring and has the only ETV-verified flow monitoring technology for wastewater collection systems. These battery-powered monitors are specially designed to operate with reliability, durability, and accuracy in sewer environments.

TRITON+ Features

- Versatile performance that is easy to install and operate
- Two sensor ports supporting 4 interchangeable sensors providing up to 6 sensor readings at a time
- Single or dual pipe/monitoring point measurement capabilities
- Multi-carrier cellular 3G/4G UMTS/HSPA+ or Verzon® CDMA/EV-DO wireless communications; direct serial communications also available
- Industry-leading battery life with a wireless connection providing up to 15 months at the standard 15-minute sample rate (*varies with sensor configuration*)
- External power and Modbus network connectivity option available with an ADS External Power and Communications Unit (ExPAC™) and a 9-36 VDC power supply or an ADS XBUS™ which includes a power supply
- Analog and digital I/O expansion (4-20 mA and dry contacts) available with an ADS External I/O unit (XIO™)
- Modbus protocols enabling RTUs to help simplify SCADA system integration
- Supports the delivery of CSV files to an FTP site at user-defined intervals , and direct monitor SMS and e-mail messaging
- Supports actuation of a water quality sampler for flow proportional or level-based operation
- Monitor-Level Intelligence (MLI®) enables the ***TRITON+*** to effectively operate over a wide range of hydraulic conditions
- Superior noise reduction design for maximizing acoustic signal detection from depth and velocity sensors
- Five software packages for accessing flow information: Q*start*™ (configuration and activation); FlowView Operations (web-based alarming); Sliicer.com® (I/I analysis); FlowView Portal® (online data presentation and reporting); and Profile® (data collection, analysis, and reporting)
- Intrinsically-Safe (IS) certification by ATEX, IECEx and CSA for use in Zone 0 (equivalent to Class I, Division 1, Groups C & D) hazardous areas
- Thick, seamless, high-impact, ABS plastic canister with aluminum end cap (meets IP68 standard)
- Innovative circuit board dome-enclosure protects and limits exposure of electronics when opening the canister to change the battery

To Learn more, visit www.adsenv.com/TRITON+

ADS LLC

Multiple Technology Sensors

The ***TRITON+*** features three depths and two velocities with three sensor options. Each sensor provides multiple technologies for continuous running of comparisons.

Peak Combo Sensor

Dimensions: 6.76 inches (172 mm) long x 1.23 inches (31 mm) wide x 0.83 inches (21 mm) high

This versatile and economical sensor includes three measurement technologies in a single housing: ADS-patented continuous wave peak velocity, uplooking ultrasonic depth, and pressure depth.

<u>Continuous Wave Velocity</u>
Range: -30 feet per second (-9.1 m/s) to +30 ft/sec (9.1 m/s)
Resolution: 0.01 feet per second (0.003 m/s)
Accuracy: +/- 0.2 feet per second (0.06 m/s) or 4% of actual peak velocity (whichever is greater) in flow velocities between -5 and 20 ft/sec (-1.52 and 6.10 m/s)

<u>Uplooking Ultrasonic Depth</u>
Performs with rotation of up to 15 degrees from the center of the invert; up to 30 degrees rotation with Silt Mount Adapter
Operating Range: 1.0 inch (25 mm) to 5 feet (152 cm)
Resolution: 0.01 inches (0.254 mm)
Accuracy: 0.5% of reading or 0.125 inches (3.2 mm), whichever is greater

<u>Pressure Depth</u>
Range: 0-5 PSI up to 11.5 feet (3.5 m); 0-15 PSI up to 34.5 feet (10.5 m); or 0-30 PSI up to 69 feet (21.0 m)
Accuracy: +/-1.0% of full scale
Resolution: 0.01 inches (0.25 mm)

Long Range Depth Sensor

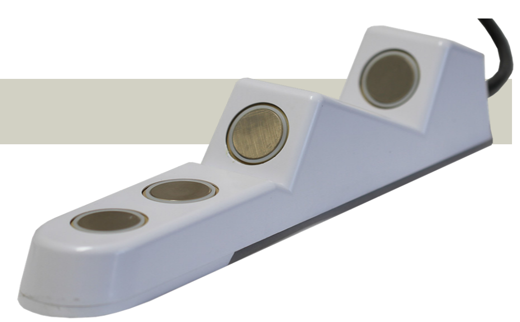
Dimensions: 9.15 inches (232.4 mm) long X 4.40 inches (111.8 mm) wide x 4.22 inches (107.2 mm) high (without bracket)

A narrow, powerful ultrasonic beam allows this depth sensor to perform well over long ranges. Integral Submersion Sensor provides detection of flooding at the point of interest.

<u>Long Range Ultrasonic Depth</u>
Minimum Dead Band: 0.0 inch (0.0 mm) from the bottom of sensor housing; Maximum Operating Air Range: 240 inches (6.1 m)
Beam Angle: +/- 3 degrees
Resolution: 0.01 inch (0.24 mm)
Accuracy: +/- 0.25% of sensor range measurement or 0.13 inches (3.2 mm) whichever is greater, in a homogeneous temperature air column
Drift: 0.0 inches (0.0 mm)
Temperature Compensation: Additional compensation for variable temperature air column supported

<u>Submersion</u>
Detects submersion when fully covered with liquid.

Surface Combo Sensor



Dimensions: 10.61 inches (269 mm) long x 2.03 inches (52 mm) wide x 2.45 inches (62 mm) high

This revolutionary new sensor features four technologies including surface velocity, ultrasonic depth, surcharge continuous wave velocity, and pressure depth.

<u>Surface Velocity</u> *
Minimum air range: 3 inches (76 mm) from the bottom of the rear, descended portion of the sensor
Maximum air range: 42 inches (107 cm)
Range: 1.00 to 15 feet per second (0.30 to 4.57 m/s)
Resolution: 0.01 feet per second (0.003 m/s)
Accuracy: +/-0.25 feet per second (0.08 m/s) or 5% of actual reading (whichever is greater) in flow velocities between 1.00 and 15 ft/sec (0.30 and 4.57 m/s)

** The flow conditions existing in some applications may prevent the surface velocity technology from being used.*

<u>Ultrasonic Depth</u>
(*Does not require electronic offsets*)
Minimum dead band: 1.0 inches (25.4 mm) from the face of the sensor or 5% of the maximum range, whichever is greater
Maximum operating air range: 10 feet (3.05 m)
Resolution: 0.01 inches (0.25 mm)
Accuracy: +/- 0.125 inches (3.2 mm) with 0.0 inches (0 mm) drift, compensating for variations in air temperature

<u>Surcharge Continuous Wave Velocity</u> (*Under submerged conditions, this technology provides the same accuracy and range as* <u>Continuous Wave Velocity</u> *for Peak Combo Sensors*)

<u>Surcharge Pressure Depth</u> (*Under submerged conditions, this technology provides the same accuracy and range as* <u>Pressure Depth</u> *for Peak Combo Sensors*)

Ultrasonic Level Sensor This non-intrusive, zero-drift sennsing method results in s stable, accurate, and reliable flow depth calculation. Two independent ultrasonic transducers allow for independent cross-checking.

TRITON+ Specifications

Connectors
U.S. Military specification MIL-C 26482 series 1, for environmental sealing, with gold-plated contacts

Communications
- Verizon® CDMA/EV-DO cellular wireless modem, or Hepta band UMTS/HSPA+ cellular wireless modem
- Direct connection to PC using an ADS USB serial cable

Monitor Interfaces
- Supports simultaneous interfaces with up to two combo sensors
- Supports optional Analog and Digital I/O with ADS XIO: two 4-20 mA inputs and outputs, two switch inputs and two relay outputs

Power
<u>Internal</u> - Battery life with a cellular modem:
- Over 15 months at a 15-minute sample rate*
- Over 6 months at a 5-minute sample rate*

<u>External</u> - Optional external power available with ADS External Power and Communications Unit (ExPAC) with an ADS- or customer-supplied 9-36 Volt DC power supply

** Rate based on collecting data once a day and varies according to sensor configuration and operating temperature*

Operating and Storage Temperature
-4 degrees to 140 degrees F (-20 degrees to 60 degrees C)

Connectivity
- Modbus ASCII: Wireless; Wired using ADS ExPAC or XBUS
- Modbus RTU: Wireless; Wired using ADS ExPAC or XBUS
- Modbus TCP: Wireless only

Intrinsic Safety Certification
- Certified under the ATEX European Intrinsic Safety standards for Zone 0 rated hazardous areas
- Certified under IECEx (International Electrotechnical Commission) Intrinsic Safety Standards for use in Zone 0 rated hazardous areas (equivalent to Class I, Division 1, Groups C & D)
- CSA Certified to Class 225803 – Process Control Equipment, Intrinsically Safe and Non-Incendive Systems – For Zone 0 Hazardous Locations, Ex ia IIB T3 (152°C) in Canada
- CSA Certified to Class 225883 – Process Control Equipment, Intrinsically Safe and Non-Incendive Systems – For Class I Zone 0 Hazardous Locations, AEx ia IIB T3 (152°C) in the USA (equivalent to Class I, Division 1, Groups C & D)

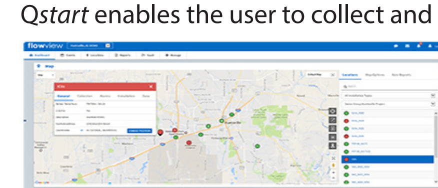
Other Certifications/Compliances
- FCC Part 15 and Part 68 compliant
- ROHS (lead-free) compliant
- Carries the EU CE mark
- Canada IC CS-03 compliant

C US CE IEC IECEx ISO 9001 Registered Company sira CERTIFICATION UKAS MANAGEMENT SYSTEMS 011 Connected by VERIZON

Certificate No: 940056

ADS Flow Monitoring Software

Q*start* is desktop software providing field crews with a simple, easy-to-use tool for quickly configuring and activating ADS monitors. Q*start* enables the user to collect and review the monitor's depth and velocity data in hydrograph and tabular views simultaneously.



FlowView is web-hosted software providing near real-time operational intelligence on the status of flow activity throughout the wastewater collection system. FlowView utilizes dynamic (or smart) alarming to inform clients about the occurrence of rain events, flow performance abnormalities, and data anomalies at the flow monitoring locations.

FlowView Portal is web-hosted software providing robust report delivery, enabling the user to manage data, customize reports, and select viewing parameters. FlowView Portal has a virtually unlimited database for storing and accessing historical data, using data for comparison and trend analysis purposes, and sharing information electronically.

Sliicer.com is web-hosted software providing a powerful set of engineering tools designed for both the consulting and municipal engineer. Sliicer.com's inflow and infiltration tools examine wastewater collection system dry and wet weather flow data and provide rigorous performance measurements in one-tenth the time of other analysis tools.

Profile is desktop software providing the industry's best data analysis tools, from basic flow monitoring data to complex hydraulic analysis. Profile is intuitive software that saves time and improves data quality by compiling project data into one location for analysis and reporting.

FLOW MONITORING APPLICATIONS

- Billing
- Inflow/Infiltration
- Model Calibration
- Combined Sewer Overflows (CSOs)
- Stormwater Monitoring
- Capacity Analysis
- Spill Notification

HARDWARE

ADS RAINALERT III™
Rainfall Monitor

The ADS RainAlert III provides rainfall data acquisition and intelligent alarming to support wastewater capital improvement, operations and maintenance, and regulatory programs. Applications include infiltration and inflow studies, hydraulic modeling, and overflow response and reporting.

The ADS RainAlert III is a low-cost, wireless rainfall monitor that alerts operators via text or email messages when rainfall intensity exceeds a critical threshold. RainAlert III technology is designed for ultra low power consumption, yielding up to a five-year battery life depending on modem and data delivery rate configuration.

* Reliable data delivery through established 3G/4G mobile communications

* Rainfall intensity alarming for faster response to wet weather overflows

* Rugged design for easy installation and low maintenance

* Compatible with a range of tipping bucket rain gauges to match accuracy levels with local rainfall characteristics and design storms of interest

Features

- Priced for deployment as a stand-alone unit or part of a comprehensive flow and rain monitoring network
- Designed for ground-level, pole-mount, and rooftop installations
- Connects to ADS or customer-supplied tipping bucket
- Equipped with multi-carrier cellular 3G/4G UMTS/HSPA+ wireless communications; USB communications also available
- Generates immediate cryouts of alarms and allows instant delivery of logged rain and alarm data
- Logs and time-stamps rainfall totals at user-specified intervals down to one minute
- Automatically notifies up to 5 different addresses via SMS text message and/or email whenever a user-defined rainfall threshold is exceeded
- Powered by long-life, replaceable, internal alkaline battery pack (or via an optional external 6 to 24-V DC, 1-A power supply)
- Uses internal cellular antenna or optional external antenna
- Easily configured and managed using ADS Q*start*™ software
- Provides 100% compatibility with ADS FlowView™ software for accessing and managing all alarm events, alarm history, and stored rain data over the Internet
- Maintains alarm system readiness via daily check-in calls and automatically generates maintenance alarms for low battery conditions
- Two-year warranty

Mounting Options

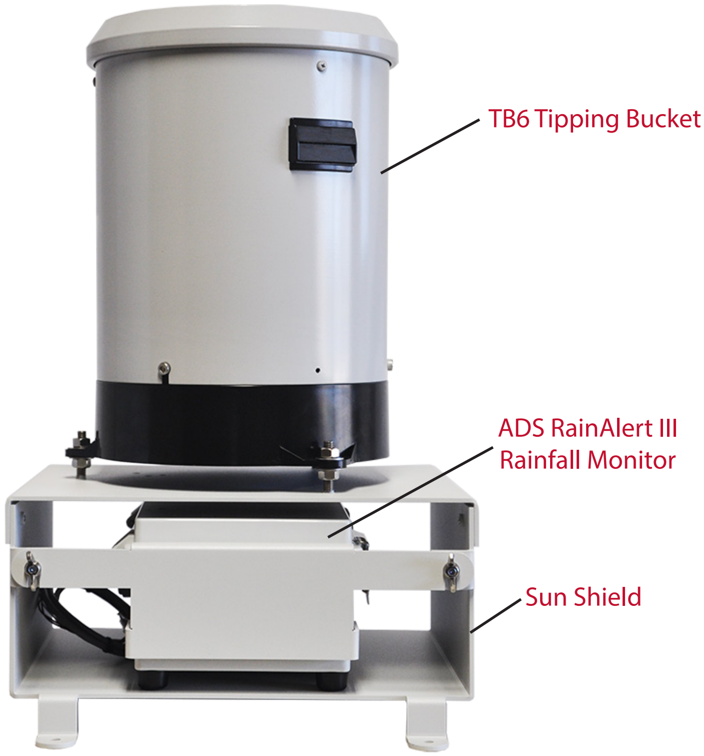
Ground-Level

Pole-Mount

Rooftop

ADS RainAlert III Rain Gauge

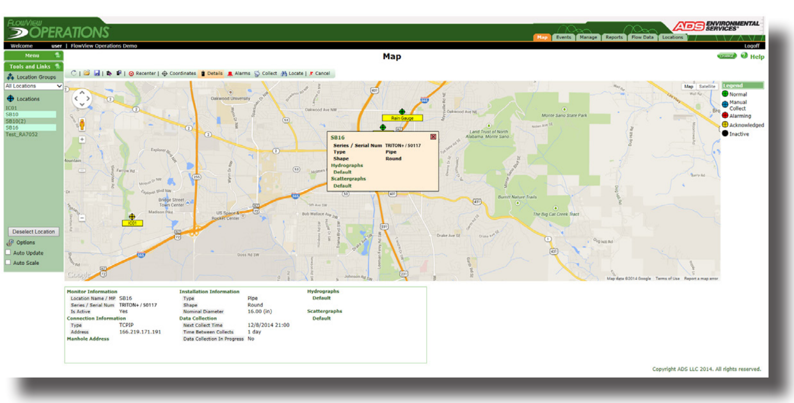
The ADS RainAlert III Rainfall Monitor with tipping bucket and sun shield, provides automated remote rainfall measurement and alarming.



Applications

The ADS RainAlert III rainfall monitor is used to collect and alarm on precipitation data for use in many applications, including the following:

- Precipitation analysis
- CSO and SSO monitoring
- Rehabilitation effectiveness monitoring
- Early warning and notification based on rain intensity
- Infiltration/Inflow programs
- Sewer capacity studies/Trending
- Sewer master plan studies



FlowView 2.3 Software Interface

The intuitive, graphical interface replicates client system maps for quick identification of system assets and provides drill-down functionality.

HARDWARE

Specifications

Enclosure
Polycarbonate enclosure reinforced with 10% glass fiber resin. NEMA Type 4X, IP67, and UL Rated. Access cover includes stainless steel latches and a continuous gasket.

Weight (including battery)
10 pounds (4.54 kg)

Dimensions
10.63 inches (270 mm) high x 7.09 inches (180 mm) wide x 4.53 inches (115 mm) deep

Operating Temperature
-4 to 140 degrees F (-20 to 60 degrees C)

Mounting
Optional sun shield designed for rooftop, ground, or pole-mount installation

Measurement Detail
0.01 inch/tip (United States)
0.1 mm/tip, 0.2 mm/tip, 0.5 mm/tip, 1.0 mm/tip (International)

Processor
Ultralow power ARM Cortex M4 microprocessor

Memory
1MB program memory, 256 KB RAM
8MB NV flash memory, 32KB NV FRAM

Data Storage
At a 5-minute Sample Rate:
3,784,704 bytes, 630,784 storage locations
Approximately 728 days for two stored entities (Rain and Rain Intensity)

Clock
Battery-backed real-time clock module

Firmware Upgrades
Remotely via wireless connection or locally via USB connection

Power
Replaceable 9V 60Ah alkaline battery pack or user-provided external power supply (6 to 24V DC, 1A)

Tipping Bucket Connection
2-Conductor 22 AWG wire provided for connection to tipping bucket rain gauge

Diagnostics
Two primary options for monitoring and acting on diagnostic information:

- Daily Check-In messages delivered automatically to user via text message and or email that provide battery status and other hardware alerts.

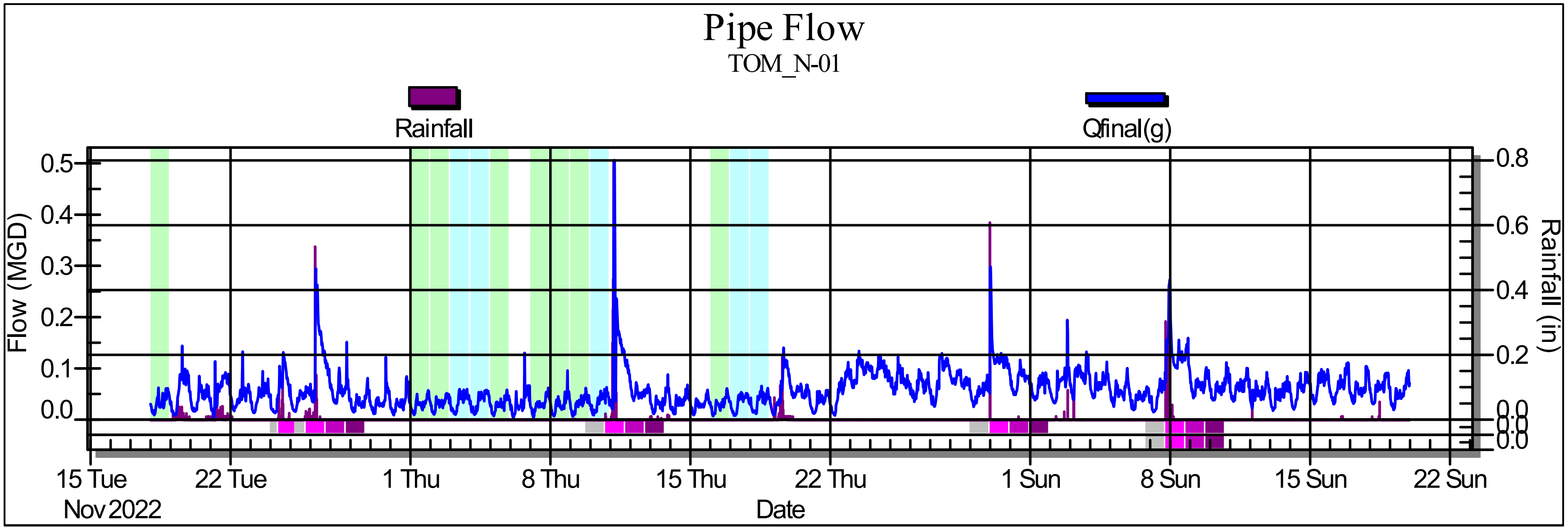
- Direct Calls to the unit through ADS Q*start* software for reading the latest monitor status and performing diagnostics to resolve problems.

Antenna
Delivered with an internal quad-band slot type antenna. An SMA connector on the board is available for applications requiring an external antenna.

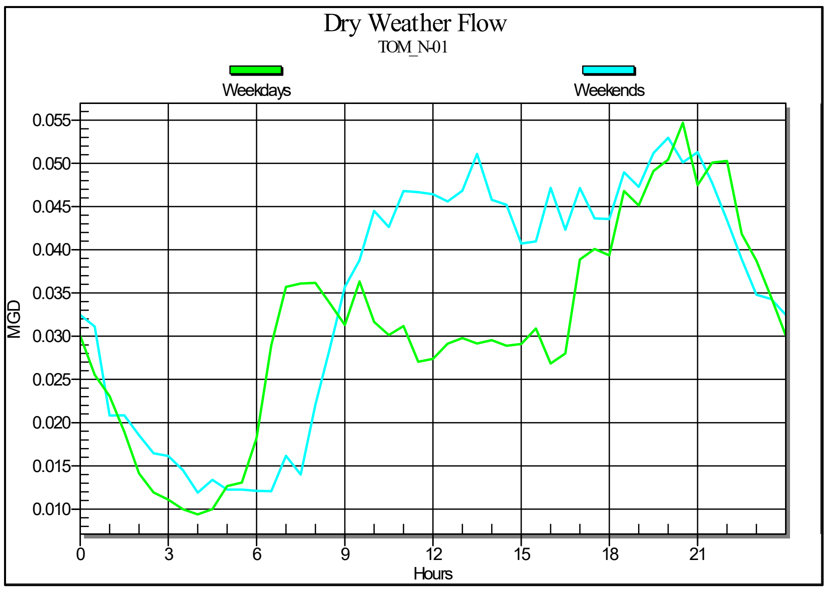
Cellular Modem
Third-party, FCC/IC/EC- and carrier-approved, global coverage, commercial UMTS/HSPA+/GSM modem.
FCC ID: R17HE910.

ADS LLC
340 The Bridge Street, Suite 204, Huntsville, AL 35806
Phone: 256.430.3366/ Fax: 256.430.6333
Toll Free: 1.800.633.7246

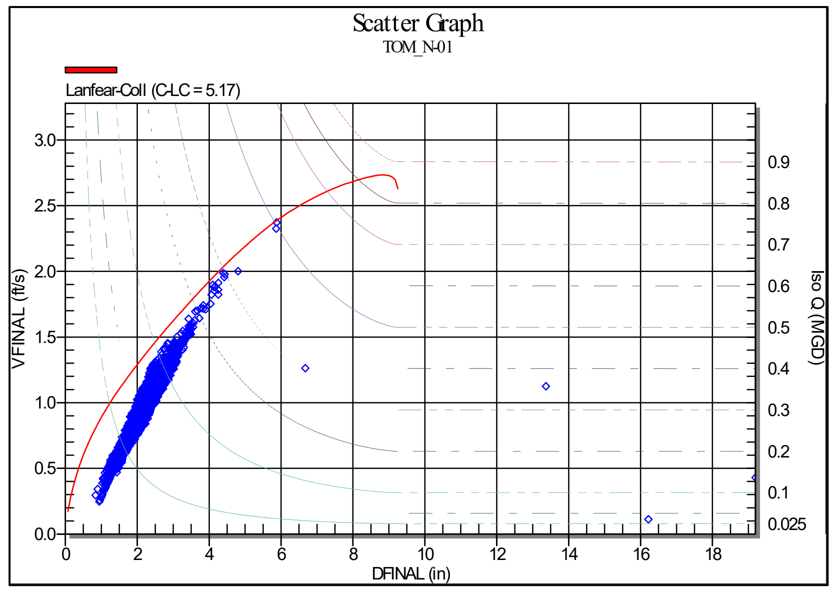
Appendix C – Flow Monitor RDII Performance Graphics



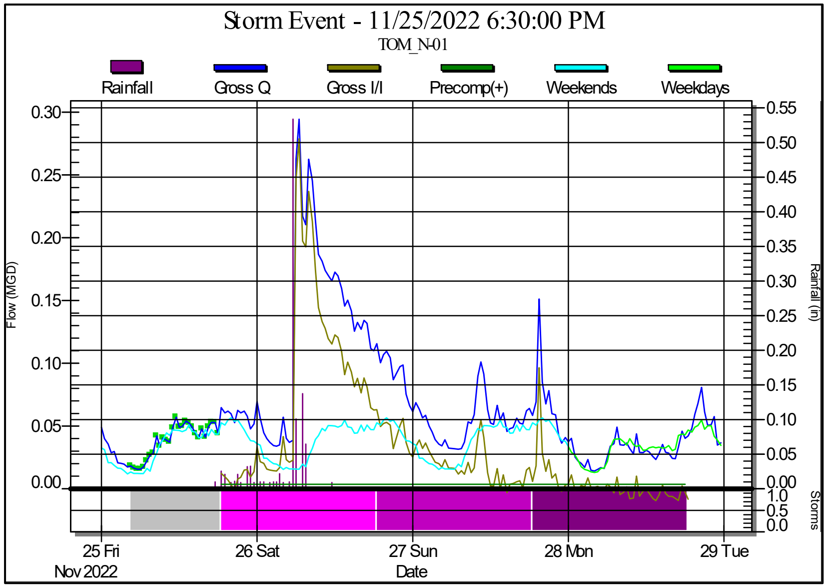
Pipe Flow
TOM_N-01
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
0.5
0.4
0.3
0.2
0.1
0.0
0.8
0.6
0.4
0.2
0.0
15 Tue
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Nov 2022
Date

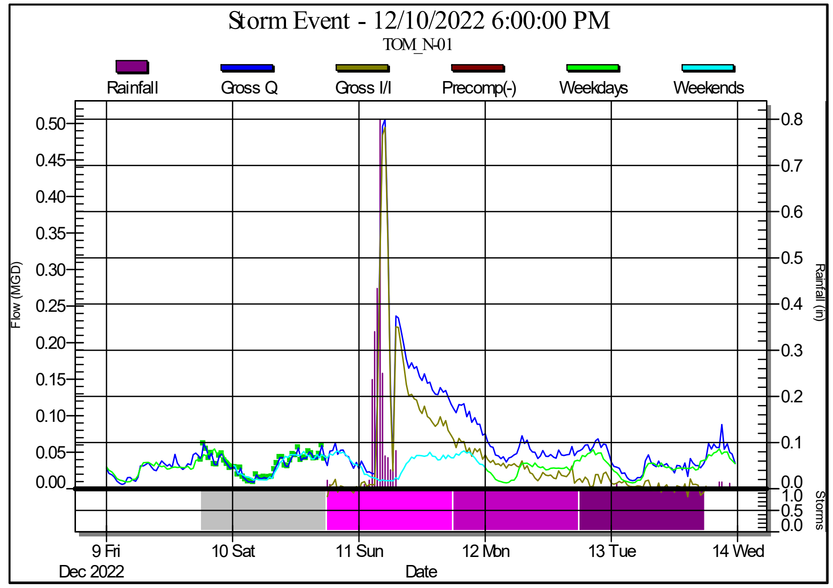


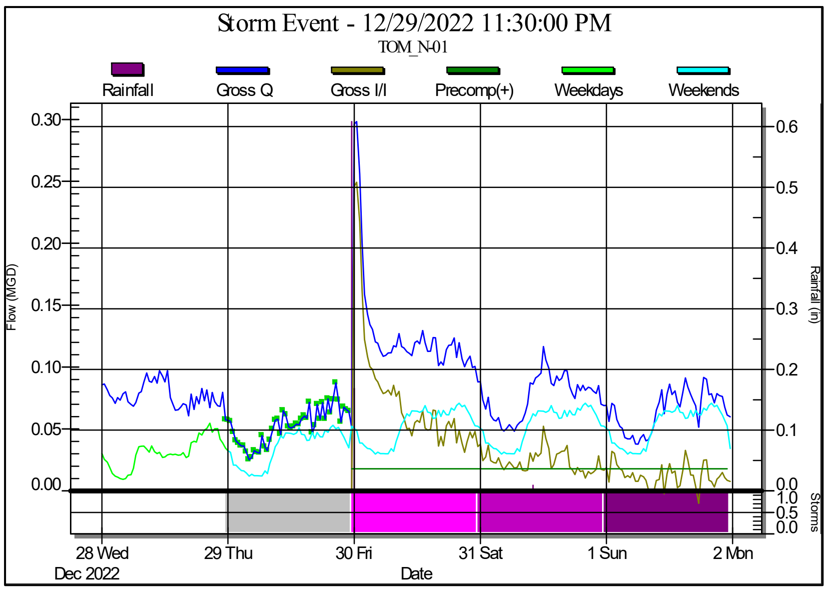
Dry Weather Flow
TOM_N-01
Weekdays
Weekends
MGD
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0
3
6
9
12
15
18
21
Hours

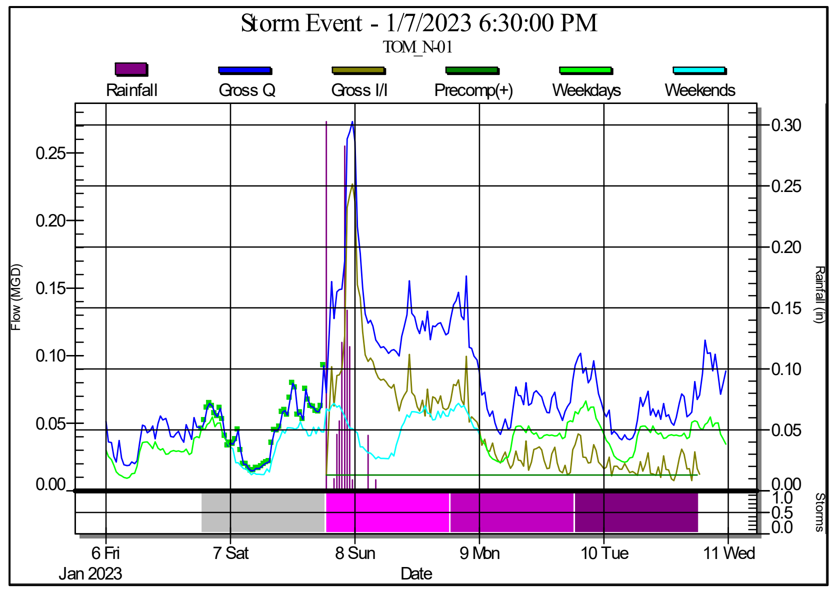


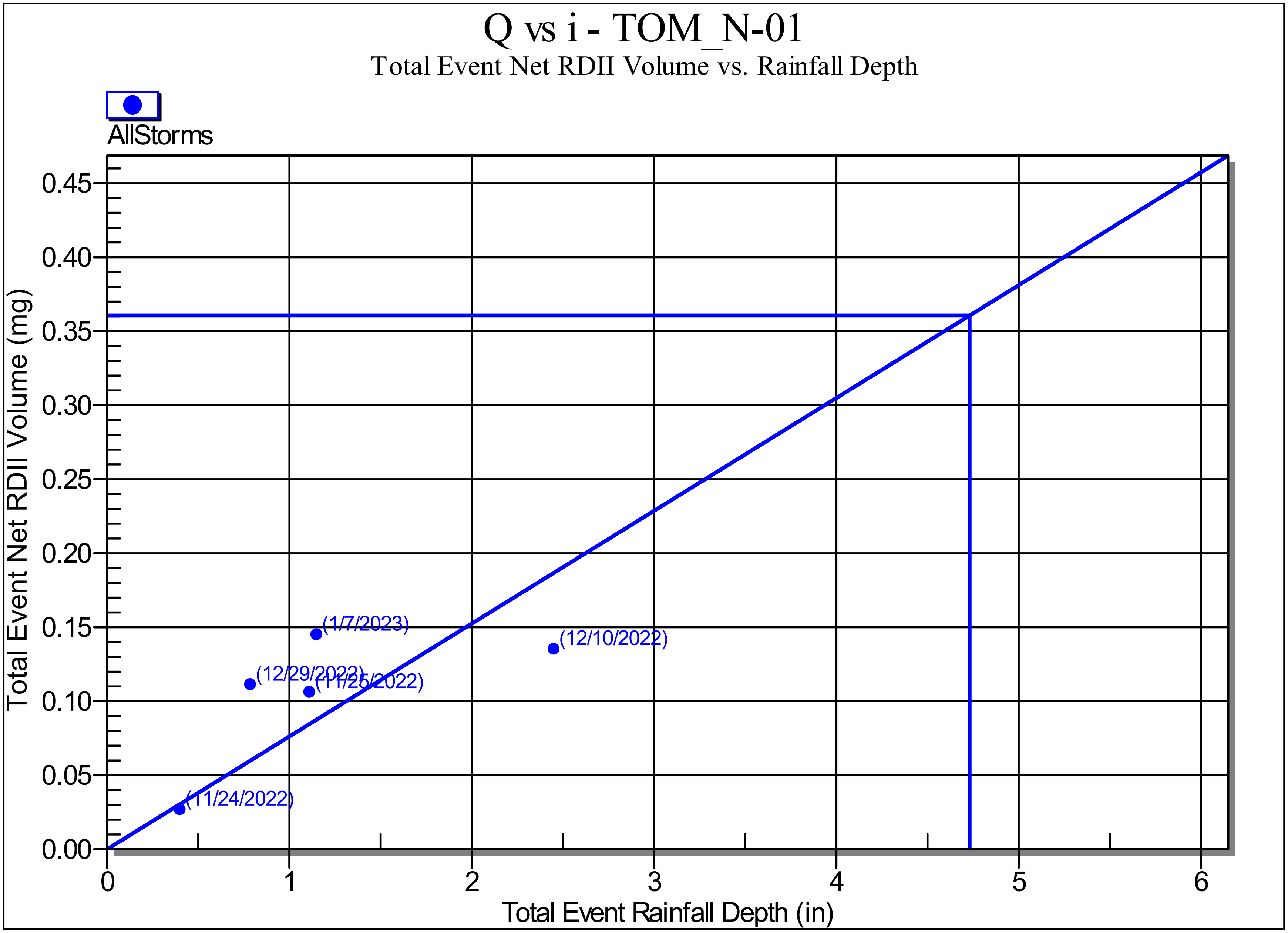
Scatter Graph
TOM_N-01
Lanfear-Coll (C-LC = 5.17)
VFINAL (ft/s)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
DFINAL (in)
Iso Q (MGD)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.025

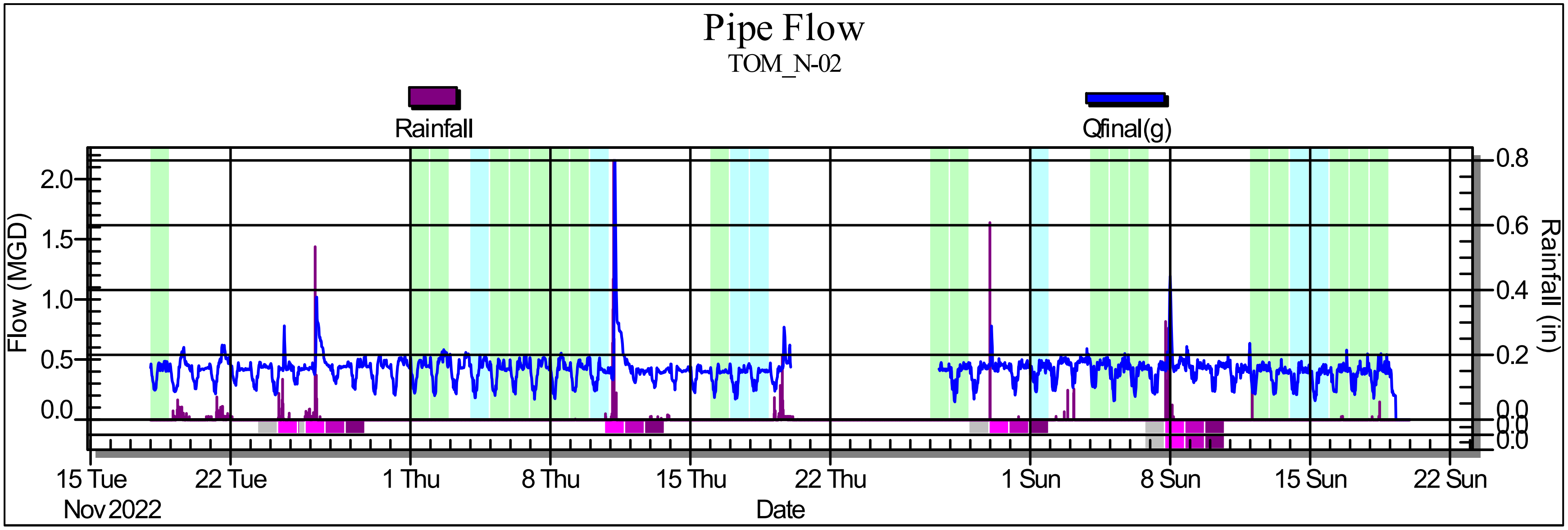

Storm Event - 11/25/2022 6:30:00 PM
TOM_N-01
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
Date
25 Fri
Nov 2022
26 Sat
27 Sun
28 Mon
29 Tue

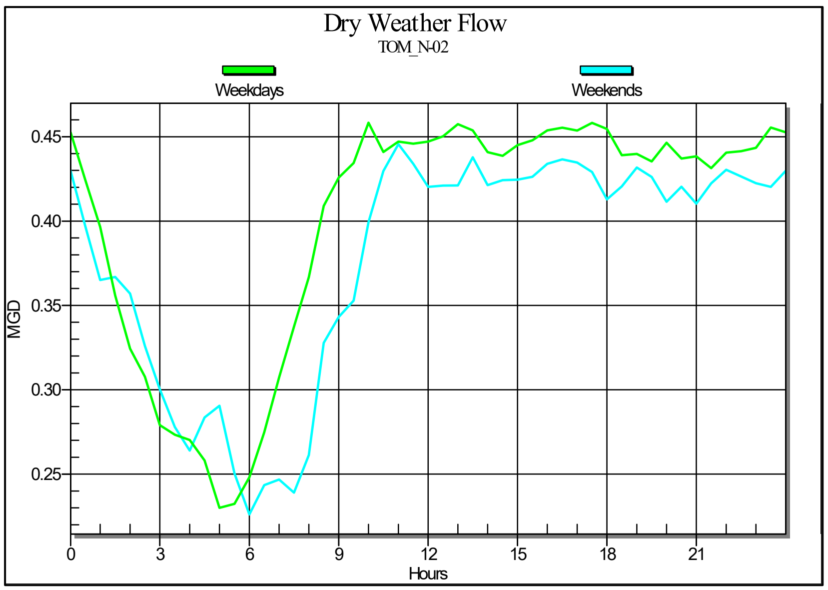

Storm Event - 12/10/2022 6:00:00 PM
TOM_N-01
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
Date
9 Fri
Dec 2022
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed

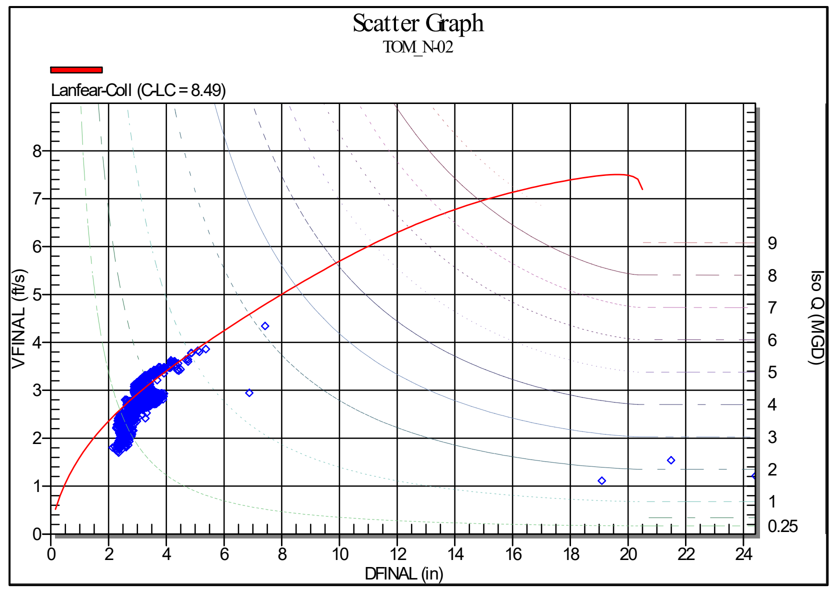

Storm Event - 12/29/2022 11:30:00 PM
TOM_N-01
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
Date
28 Wed
Dec 2022
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon

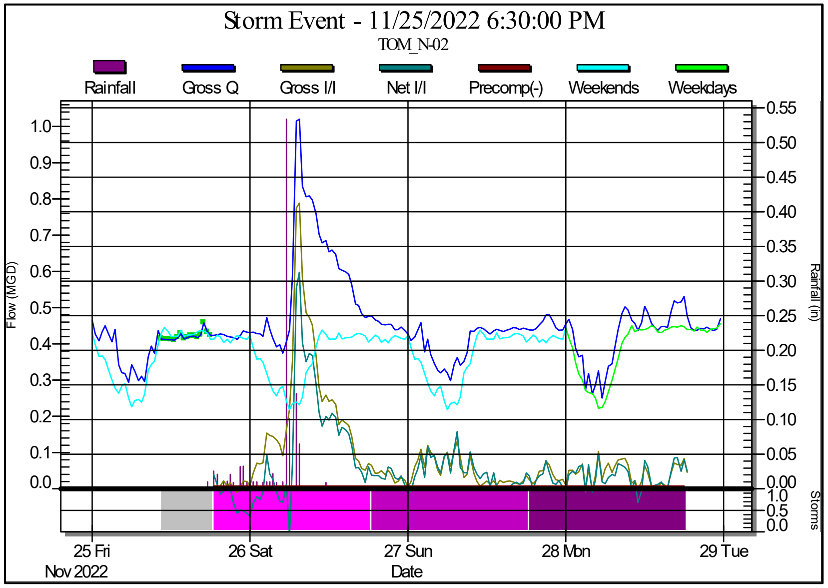

Storm Event - 1/7/2023 6:30:00 PM
TOM_N-01
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
Date
6 Fri
Jan 2023
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed

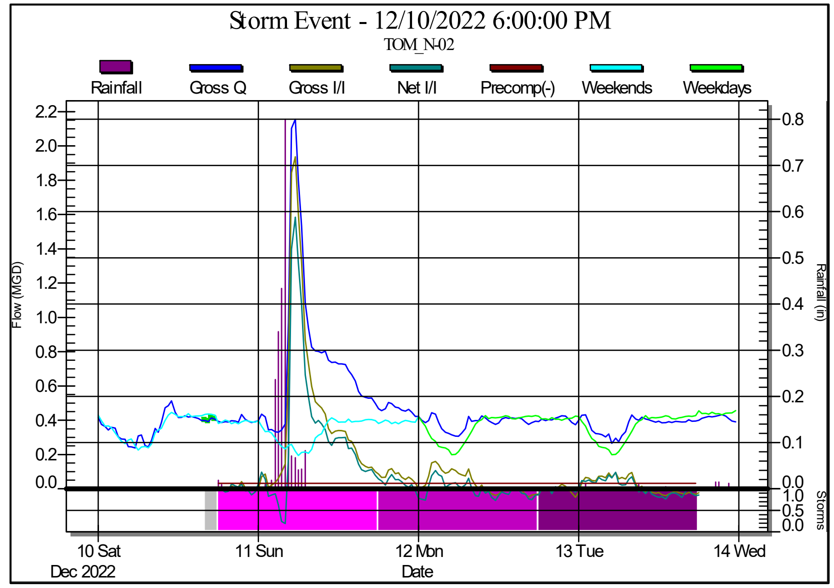

Q vs i - TOM_N-01
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0
1
2
3
4
5
6
Total Event Rainfall Depth (in)
(1/7/2023)
(12/10/2022)
(12/29/2022)
(11/26/2022)
(11/24/2022)

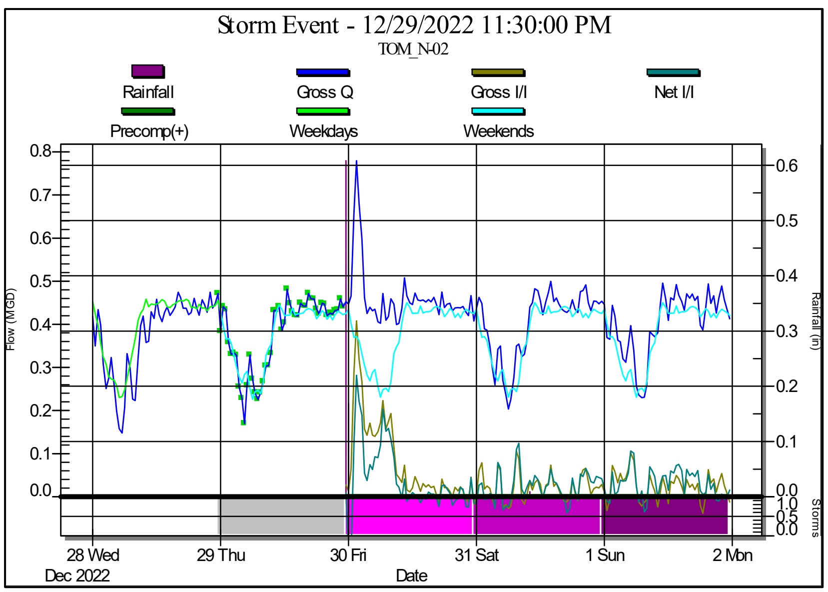

Pipe Flow
TOM_N-02
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date

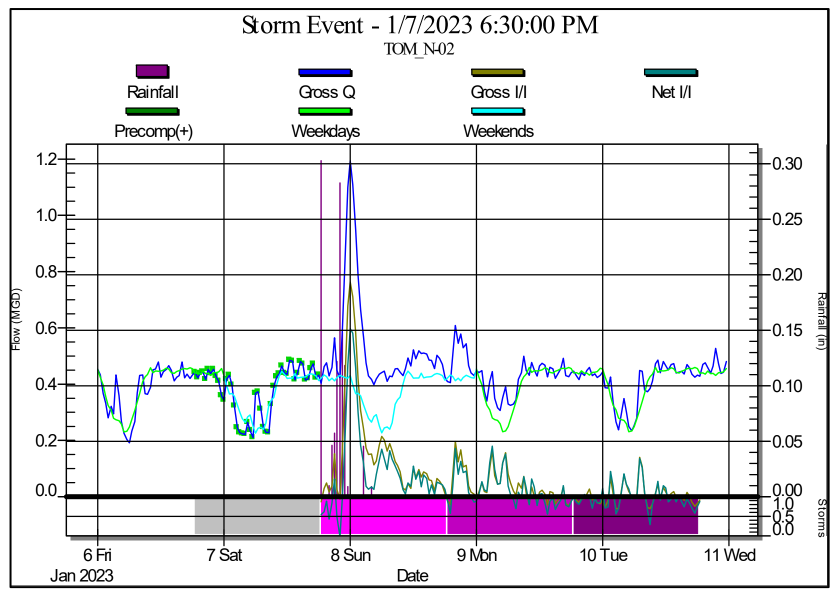

Dry Weather Flow
TOM_N-02
Weekdays
Weekends
MGD
Hours

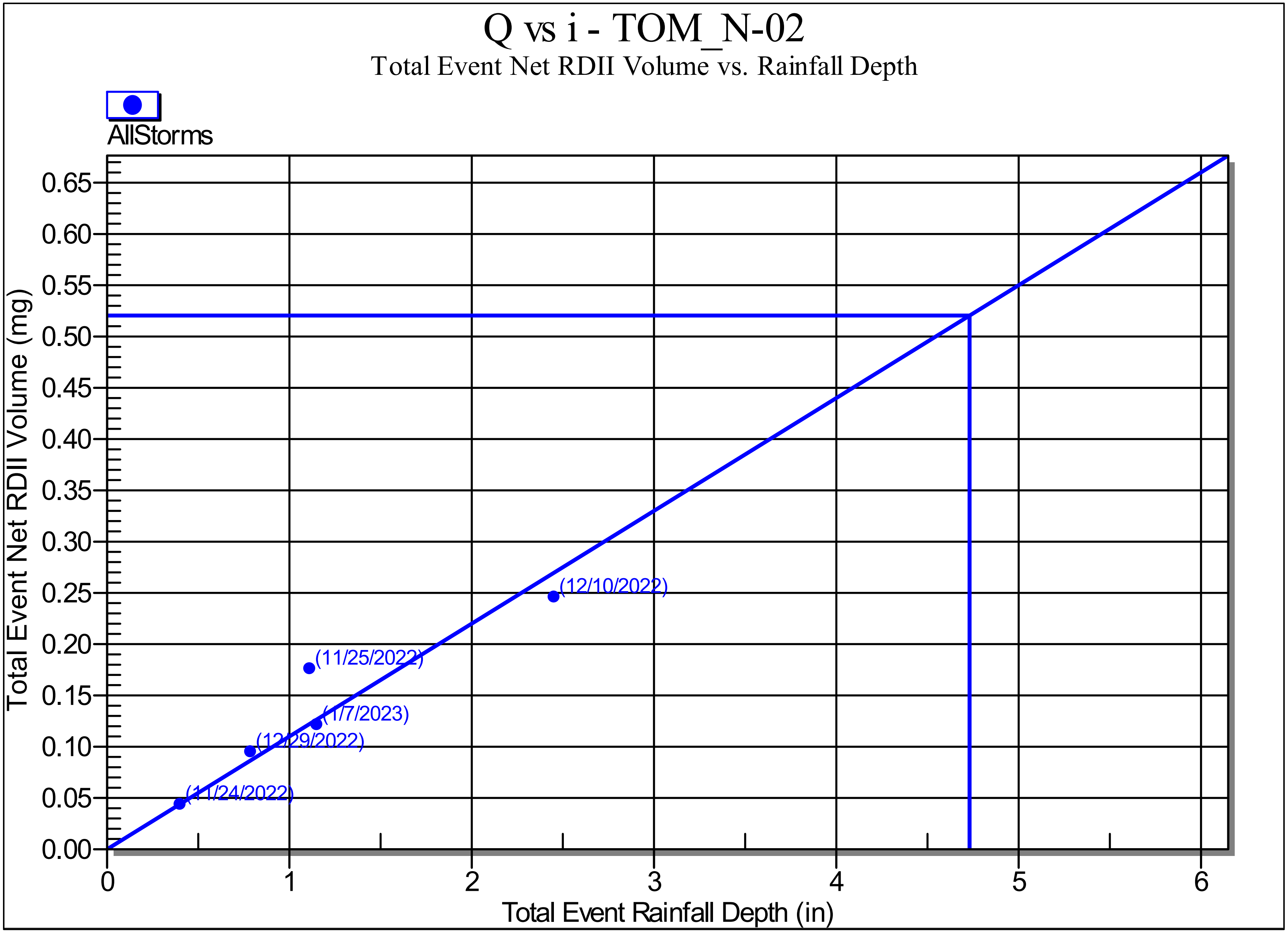

Scatter Graph
TOM_N-02
Lanfear-Coll (C-LC = 8.49)
VFINAL (ft/s)
DFINAL (in)
Iso Q (MGD)


Storm Event - 11/25/2022 6:30:00 PM
TOM_N-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(-)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
25 Fri
Nov 2022
26 Sat
27 Sun
28 Mon
29 Tue
Date

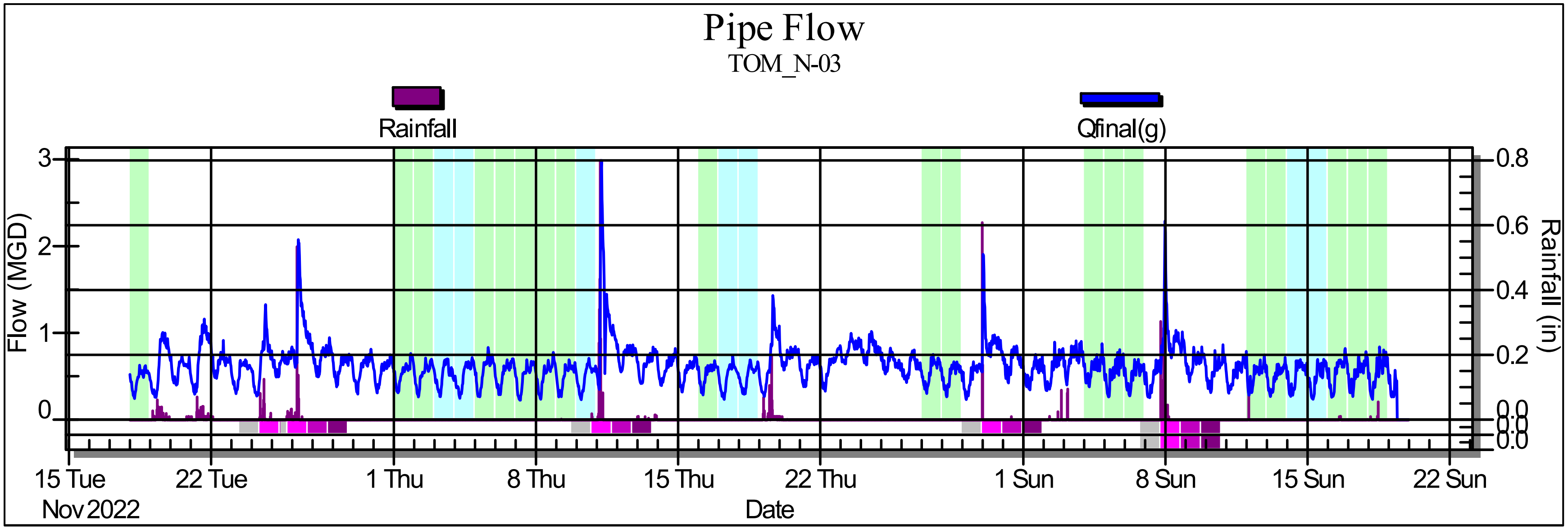

Storm Event - 12/10/2022 6:00:00 PM
TOM_N-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(-)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
10 Sat
Dec 2022
11 Sun
12 Mon
13 Tue
14 Wed
Date

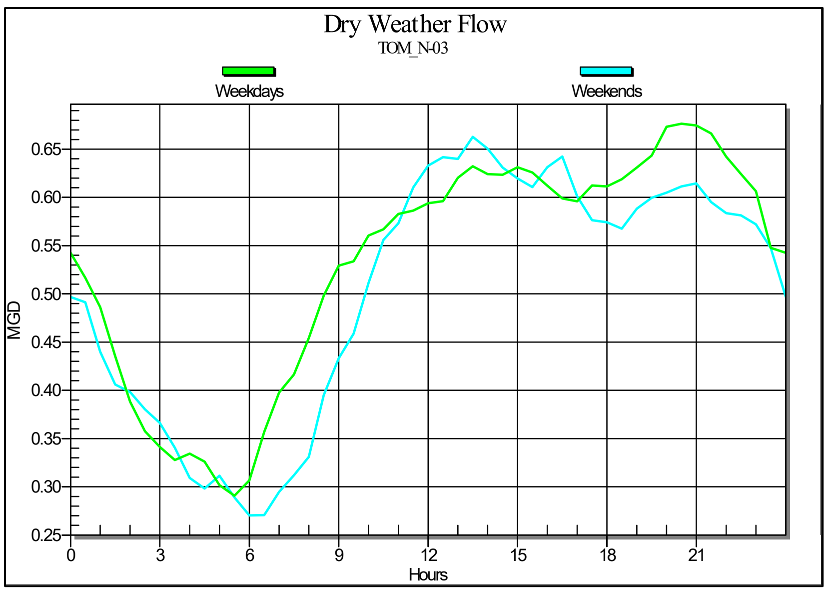

Storm Event - 12/29/2022 11:30:00 PM
TOM_N-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
Dec 2022
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Date

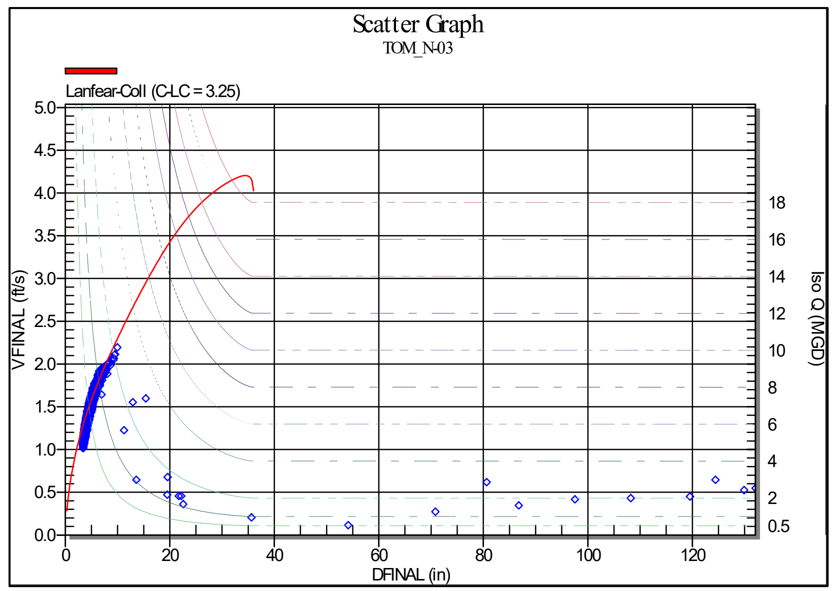

Storm Event - 1/7/2023 6:30:00 PM
TOM_N-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
Jan 2023
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Date

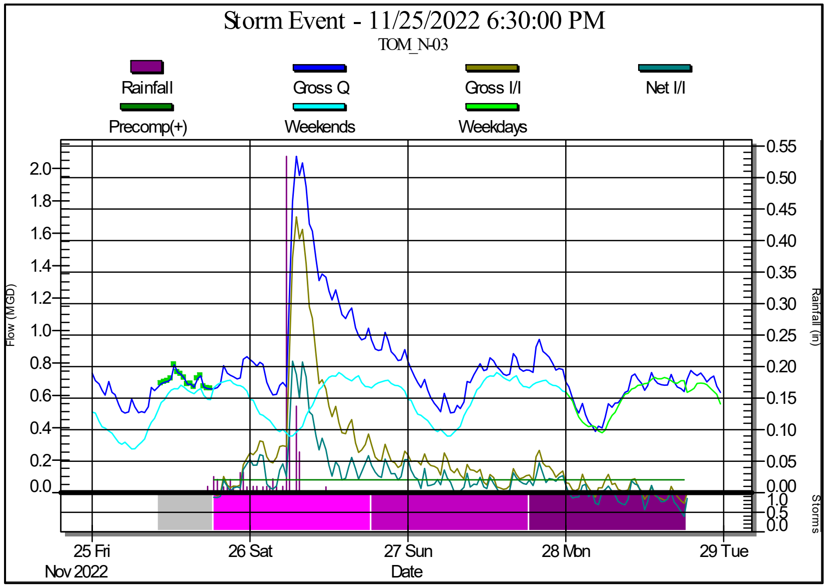


Q vs i - TOM_N-02
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
Total Event Rainfall Depth (in)
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
6
(12/10/2022)
(11/25/2022)
(1/7/2023)
(12/29/2022)
(11/24/2022)

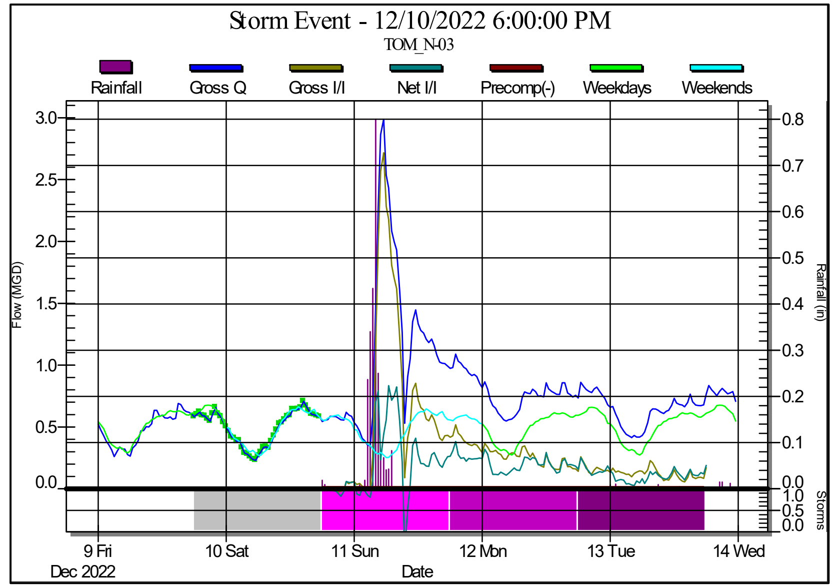

Pipe Flow
TOM_N-03
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date


Dry Weather Flow
TOM_N-03
Weekdays
Weekends
MGD
Hours

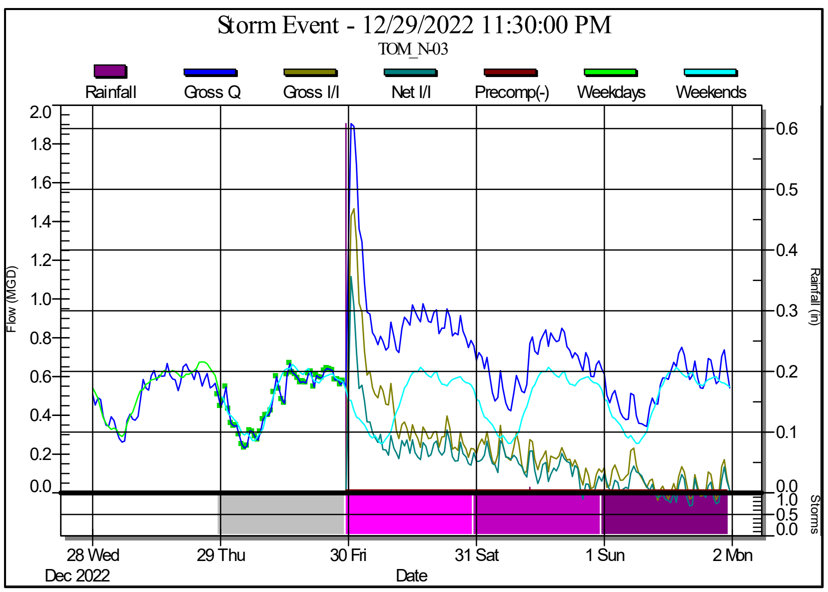

Scatter Graph
TOM_N-03
Lanfear-Coll (C-LC = 3.25)
VFINAL (ft/s)
DFINAL (in)
Iso Q (MGD)



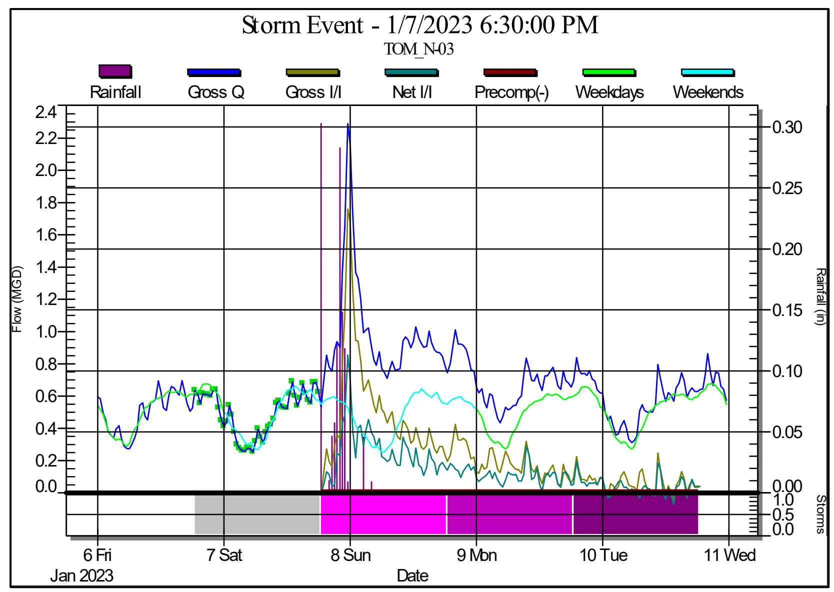
Storm Event - 11/25/2022 6:30:00 PM
TOM_N-03
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
25 Fri
Nov 2022
26 Sat
27 Sun
28 Mon
29 Tue
Date



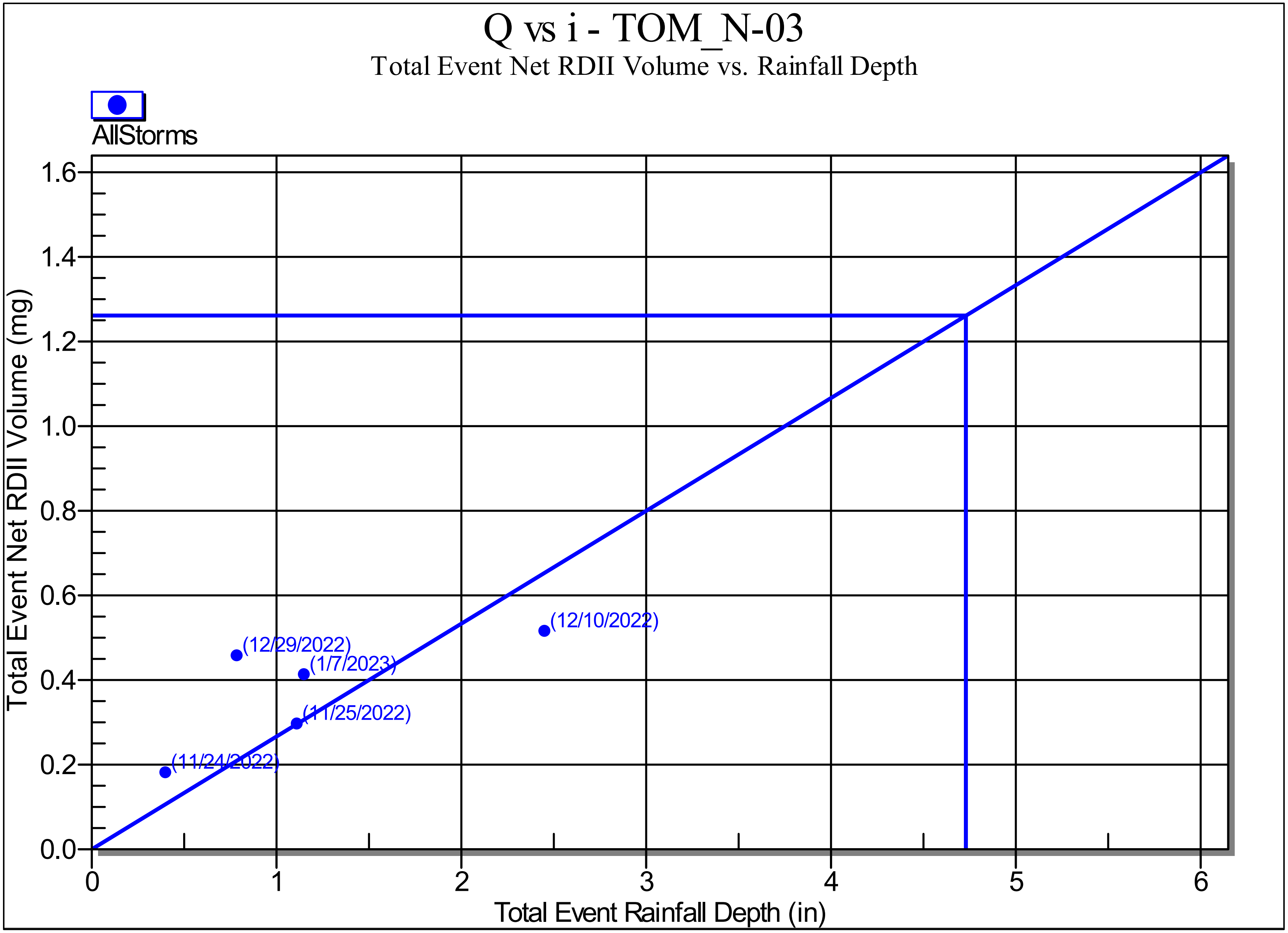
Storm Event - 12/10/2022 6:00:00 PM
TOM_N-03
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
Dec 2022
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Date



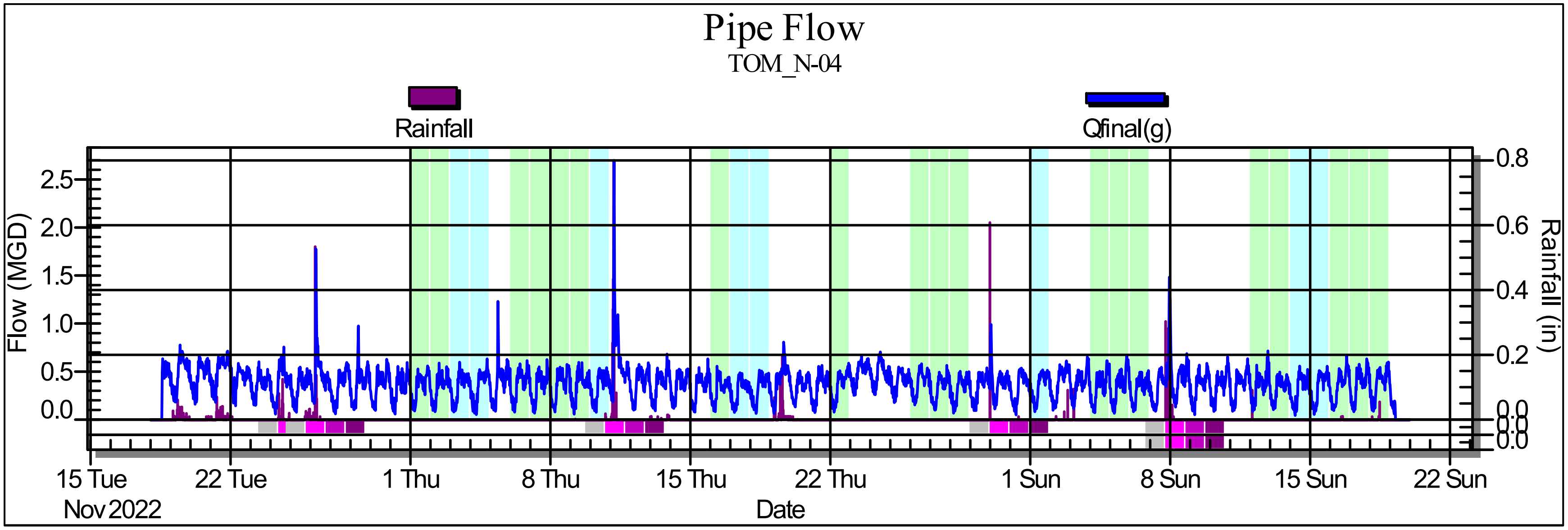
Storm Event - 12/29/2022 11:30:00 PM
TOM_N-03
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
Dec 2022
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Date



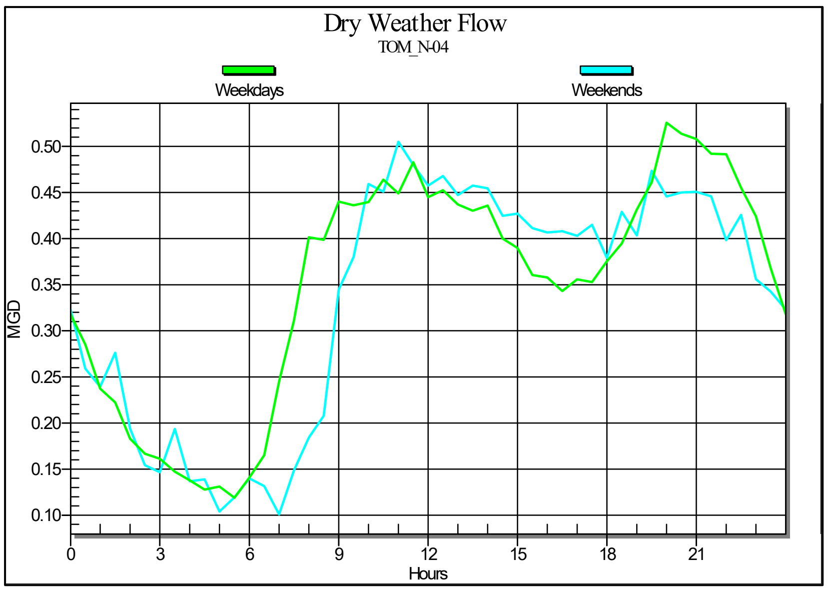
Storm Event - 1/7/2023 6:30:00 PM
TOM_N-03
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
Jan 2023
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Date



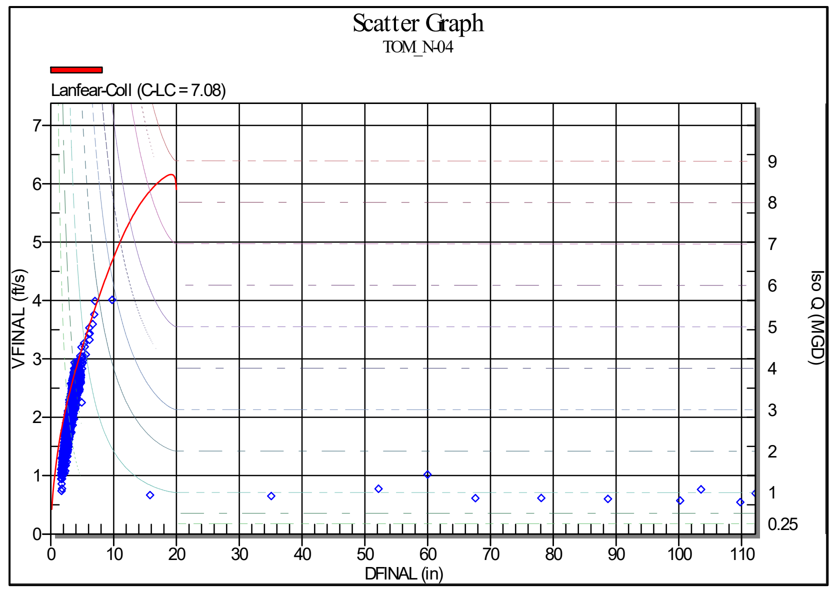
Q vs i - TOM_N-03
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
Total Event Rainfall Depth (in)
(12/10/2022)
(12/29/2022)
(1/7/2023)
(11/25/2022)
(11/24/2022)



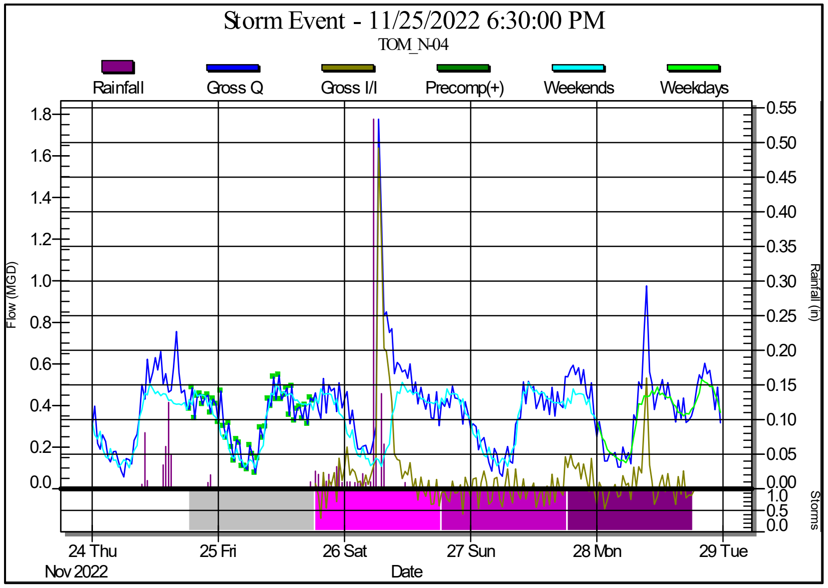
Pipe Flow
TOM_N-04
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date

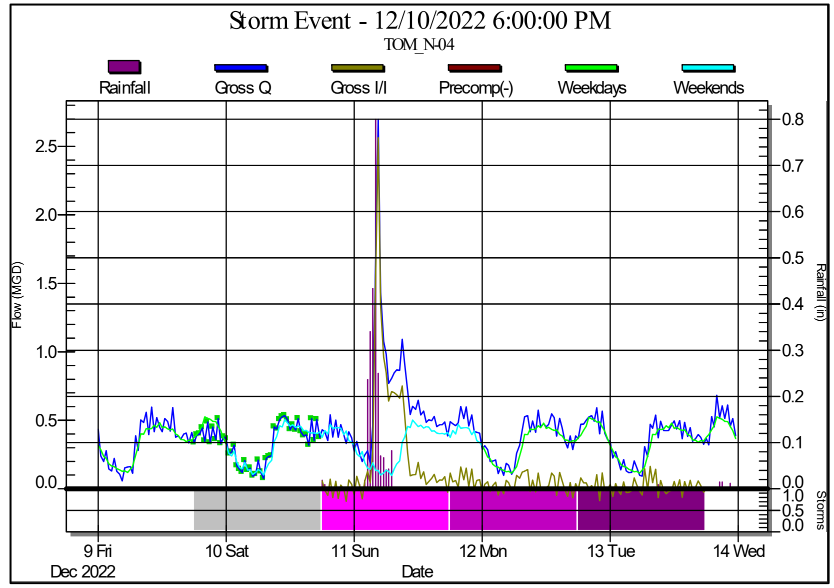


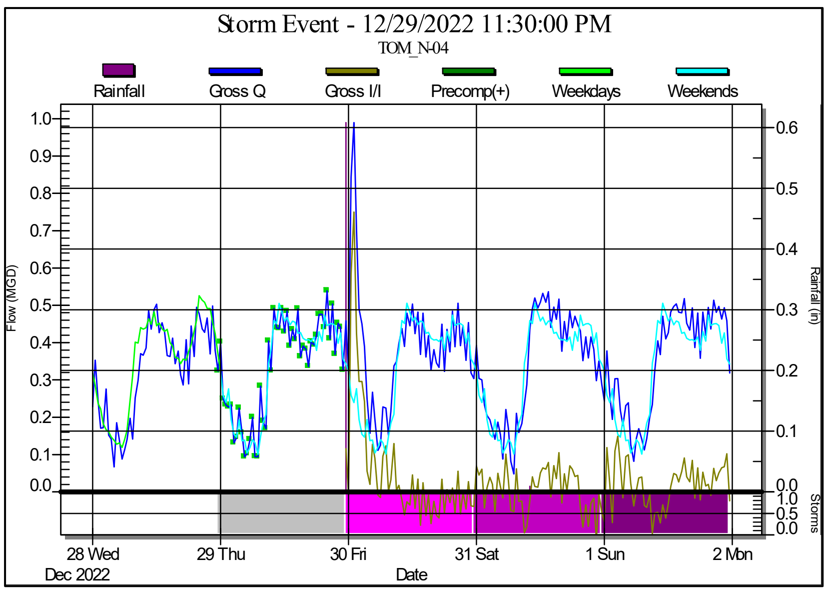
Dry Weather Flow
TOM_N-04
Weekdays
Weekends
MGD
Hours

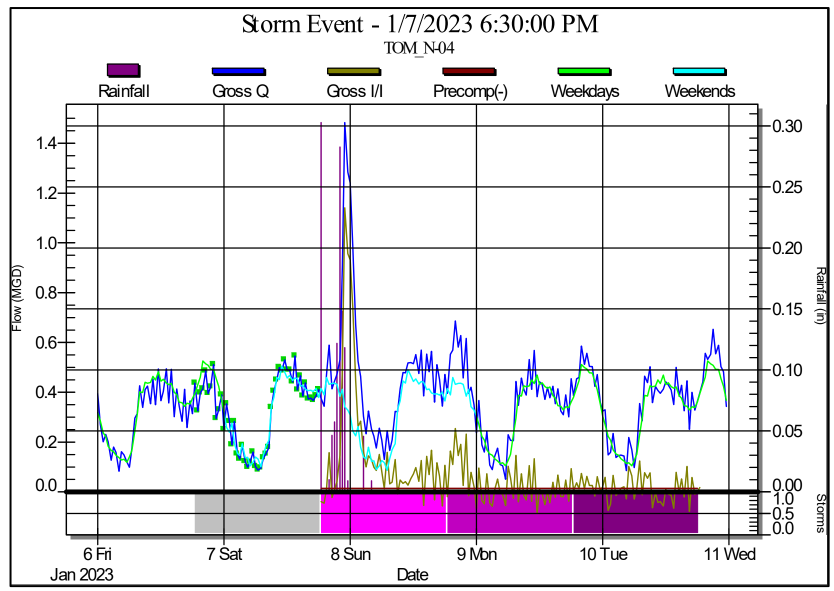


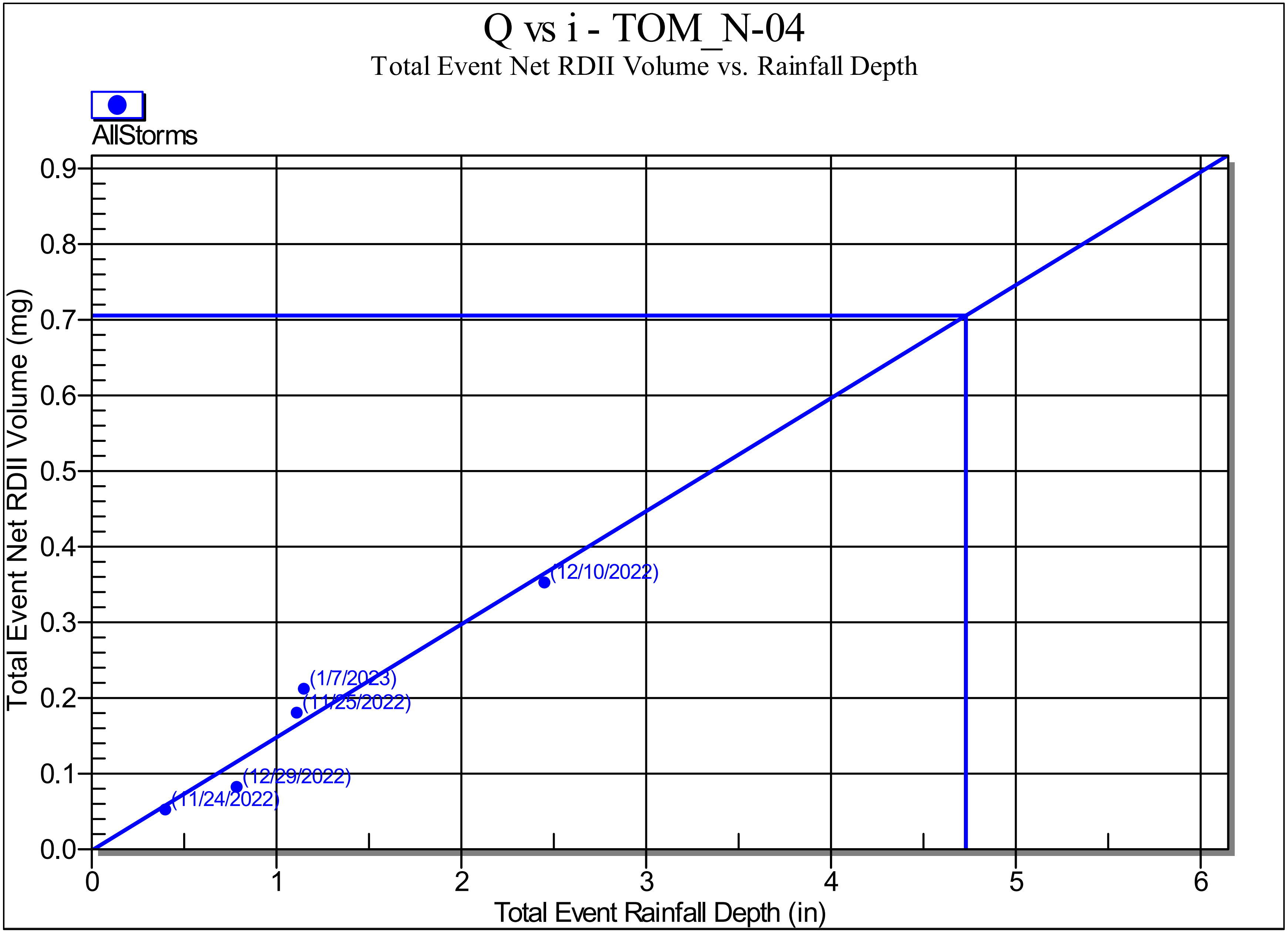
Scatter Graph
TOM_N-04
Lanfear-Coll (C-LC = 7.08)
VFINAL (ft/s)
DFINAL (in)
Iso Q (MGD)


Storm Event - 11/25/2022 6:30:00 PM
TOM_N-04
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
24 Thu
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date

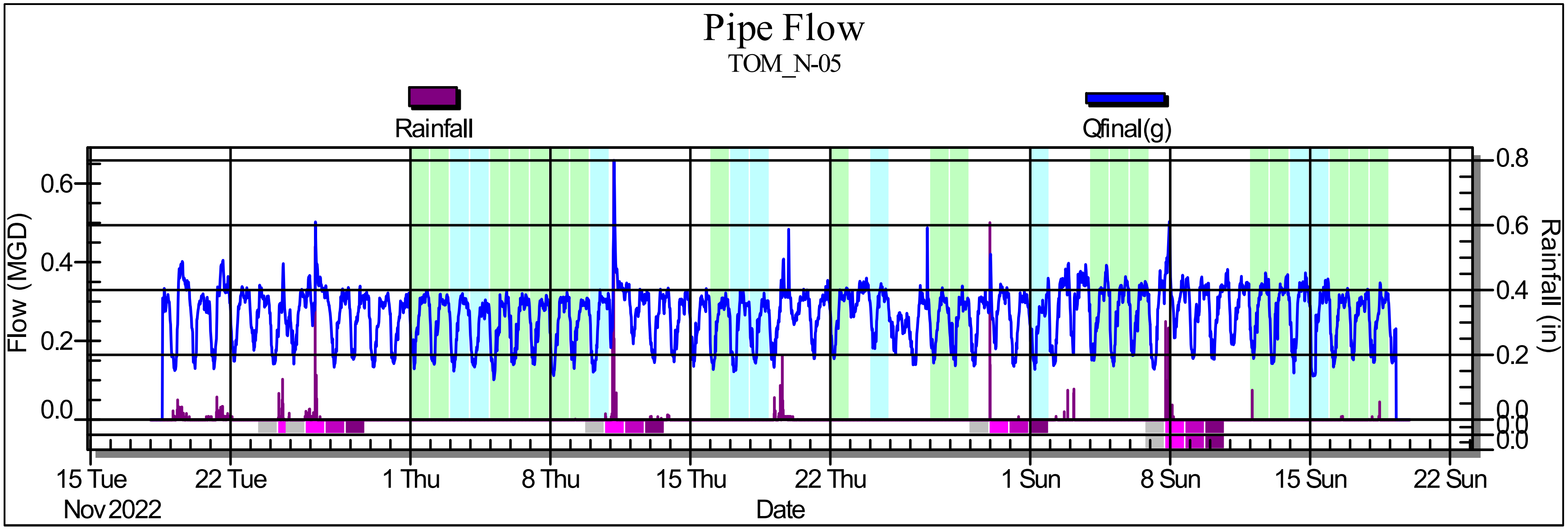

Storm Event - 12/10/2022 6:00:00 PM
TOM_N-04
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date


Storm Event - 12/29/2022 11:30:00 PM
TOM_N-04
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date

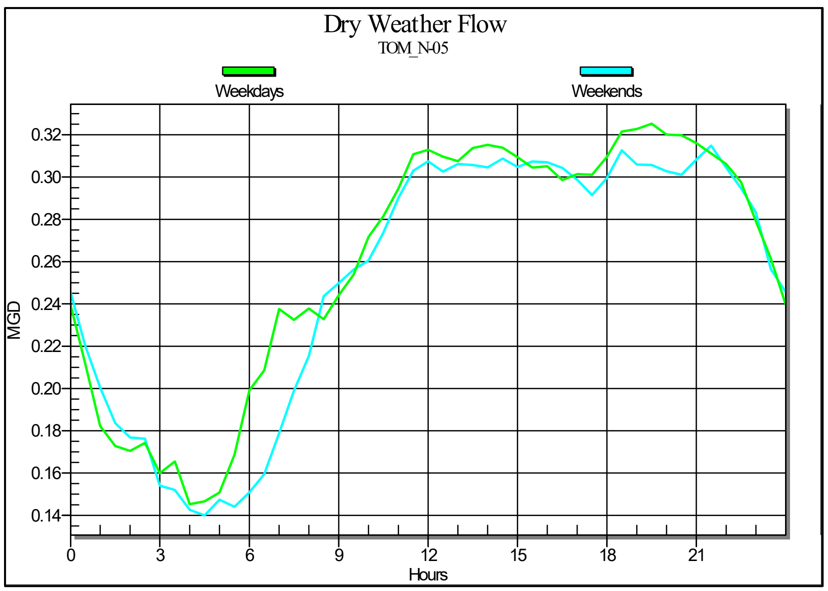

Storm Event - 1/7/2023 6:30:00 PM
TOM_N-04
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date



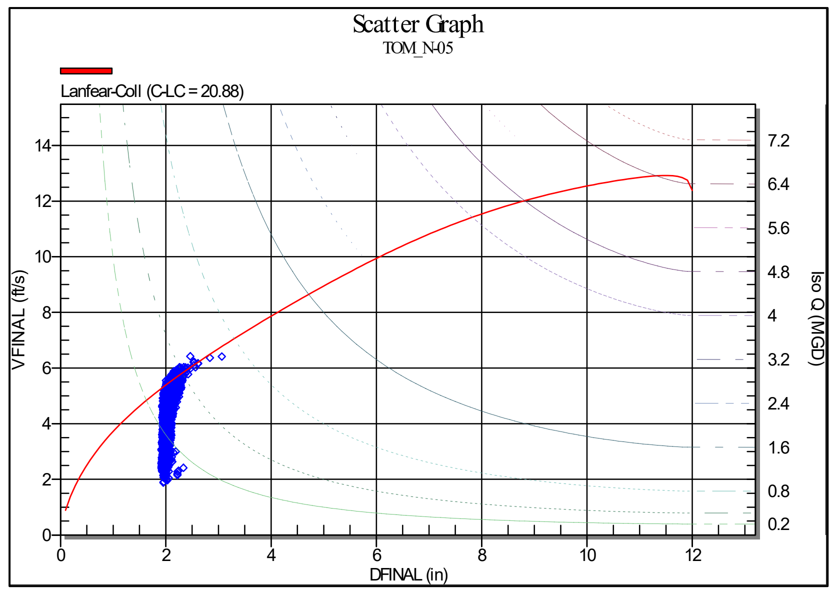
Q vs i - TOM_N-04
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
Total Event Rainfall Depth (in)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1
2
3
4
5
6
(12/10/2022)
(1/7/2023)
(11/25/2022)
(12/29/2022)
(11/24/2022)



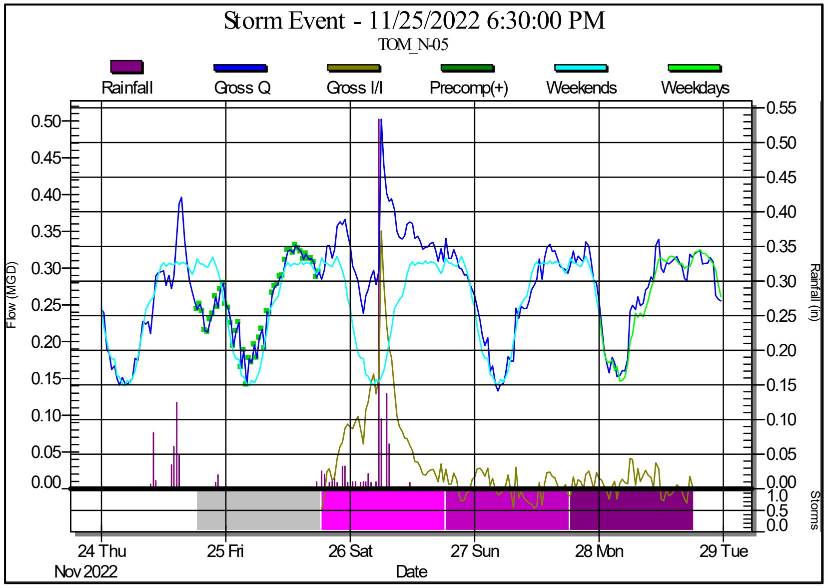
Pipe Flow
TOM_N-05
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
0.6
0.4
0.2
0.0
0.8
15 Tue
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Nov 2022
Date

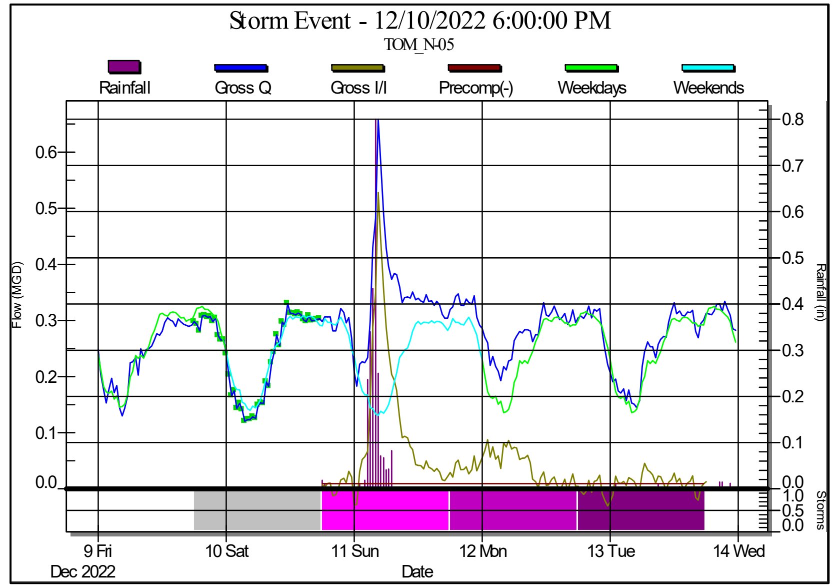


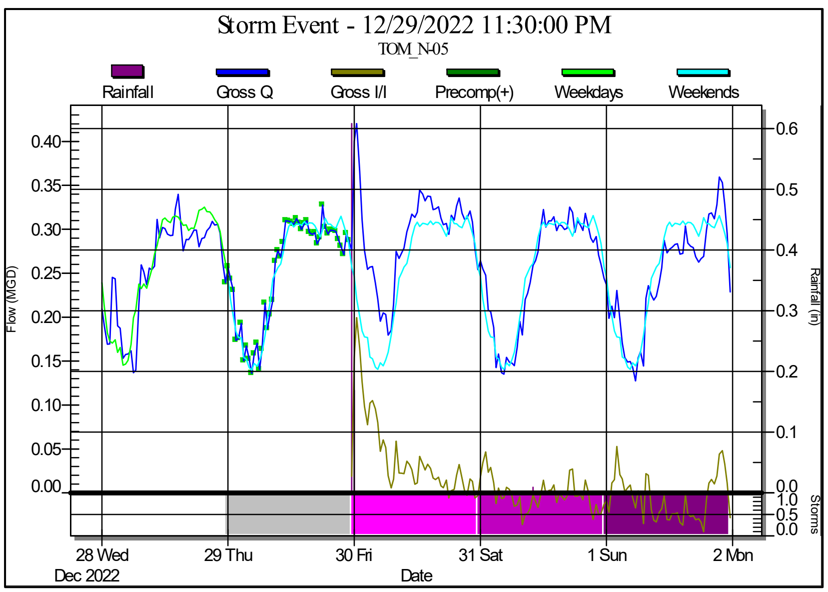
Dry Weather Flow
TOM_N-05
Weekdays
Weekends
MGD
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0
3
6
9
12
15
18
21
Hours

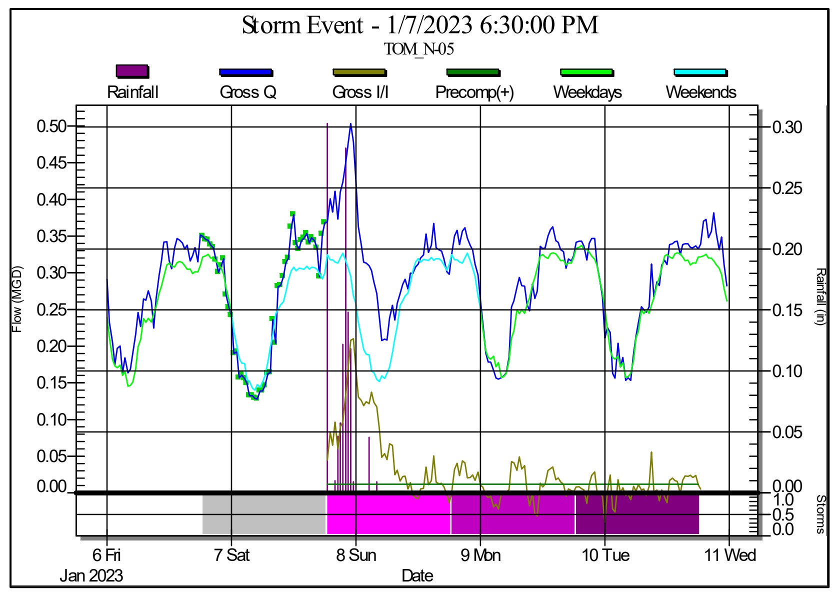


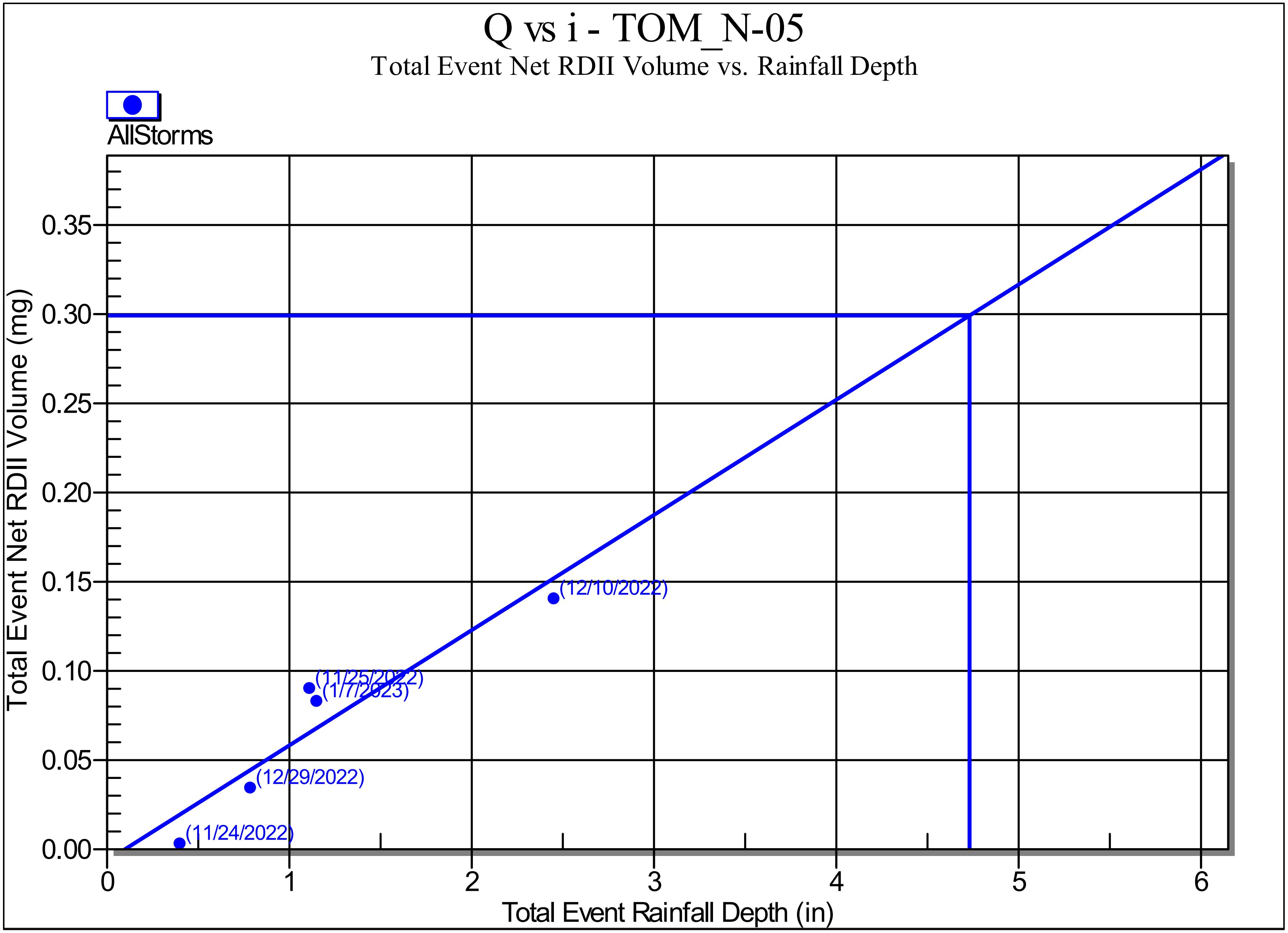
Scatter Graph
TOM_N-05
Lanfear-Coll (C-LC = 20.88)
VFINAL (ft/s)
14
12
10
8
6
4
2
0
DFINAL (in)
Iso Q (MGD)
7.2
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0.2


Storm Event - 11/25/2022 6:30:00 PM
TOM_N-05
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
24 Thu
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date

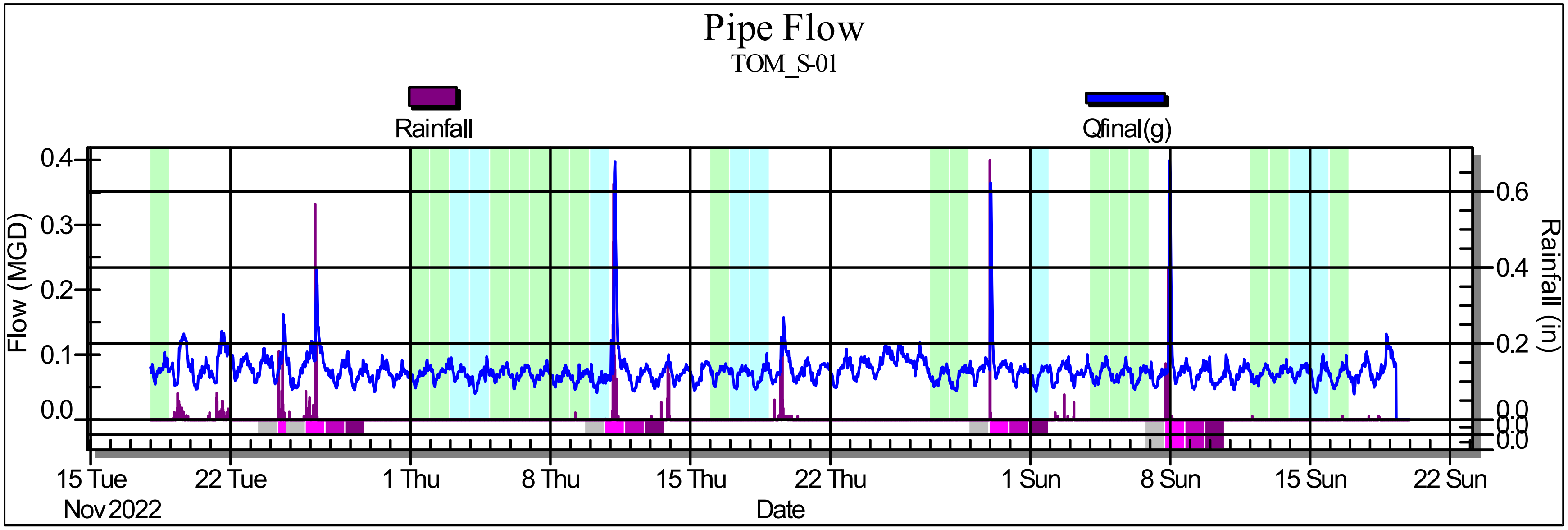

Storm Event - 12/10/2022 6:00:00 PM
TOM_N-05
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date


Storm Event - 12/29/2022 11:30:00 PM
TOM_N-05
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date

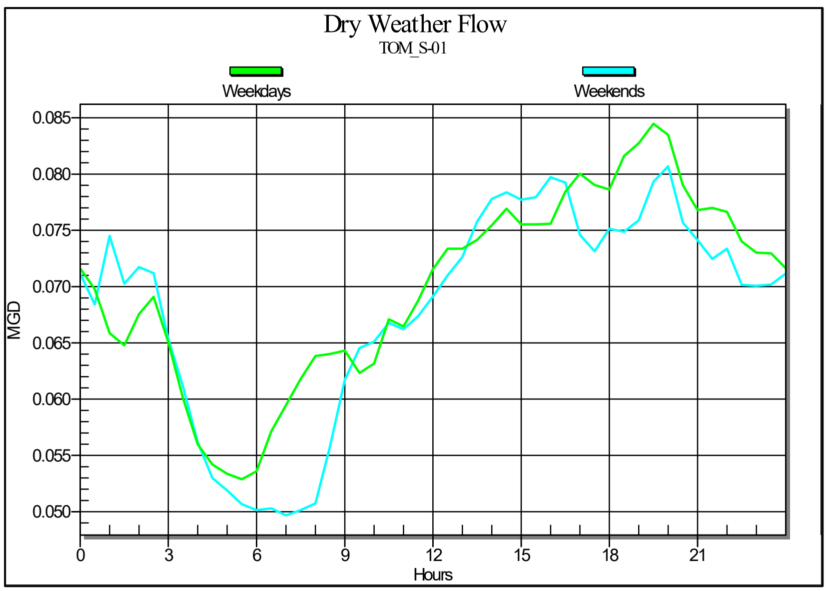

Storm Event - 1/7/2023 6:30:00 PM
TOM_N-05
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date



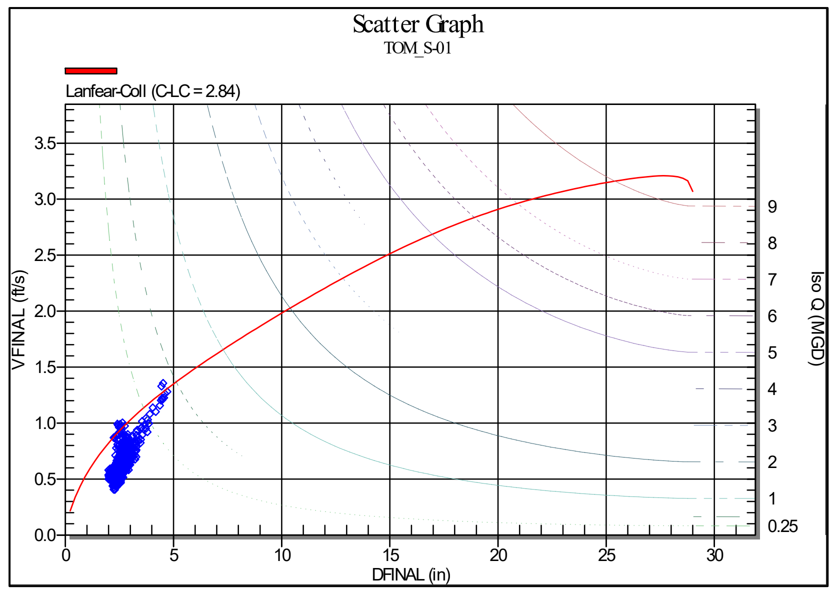
Q vs i - TOM_N-05
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Total Event Rainfall Depth (in)
0
1
2
3
4
5
6
(11/24/2022)
(12/29/2022)
(11/25/2022)
(1/7/2023)
(12/10/2022)



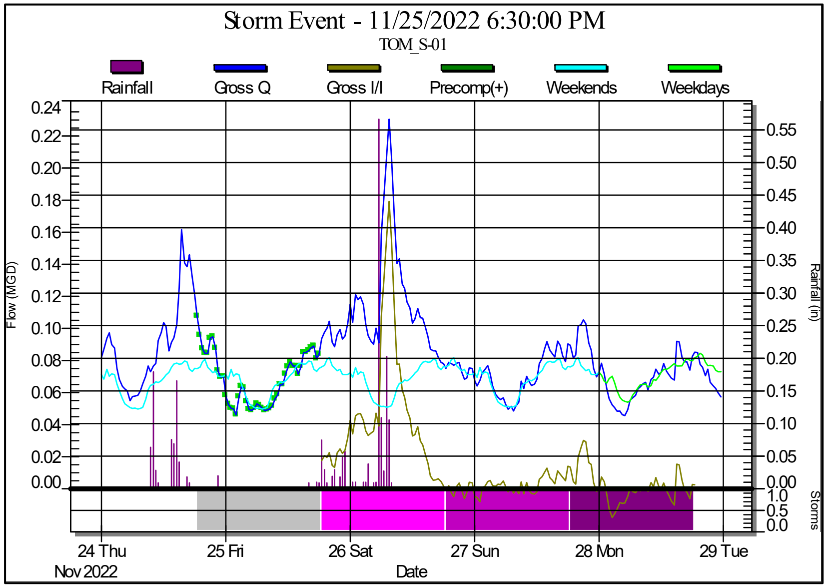
Pipe Flow
TOM_S-01
Rainfall
Qfinal(g)
Flow (MGD)
0.4
0.3
0.2
0.1
0.0
0.6
0.4
0.2
0.0
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date



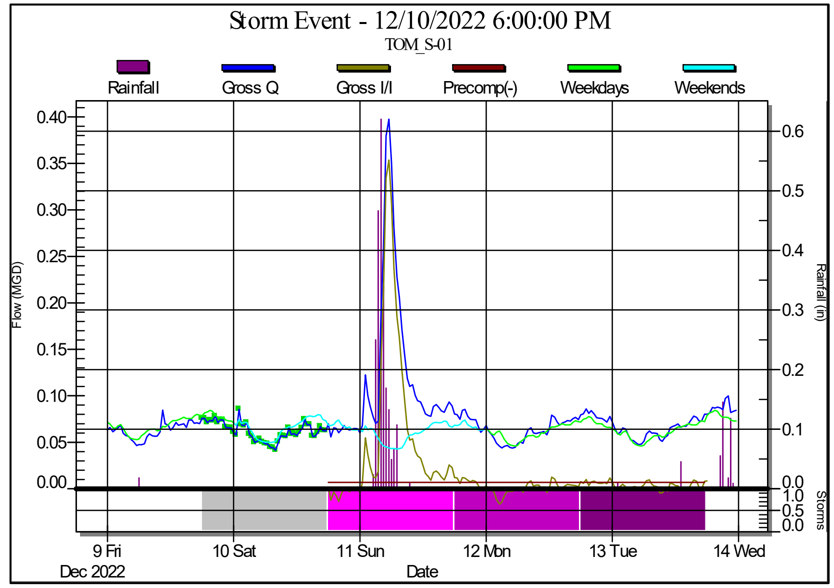
Dry Weather Flow
TOM_S-01
Weekdays
Weekends
MGD
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0
3
6
9
12
15
18
21
Hours



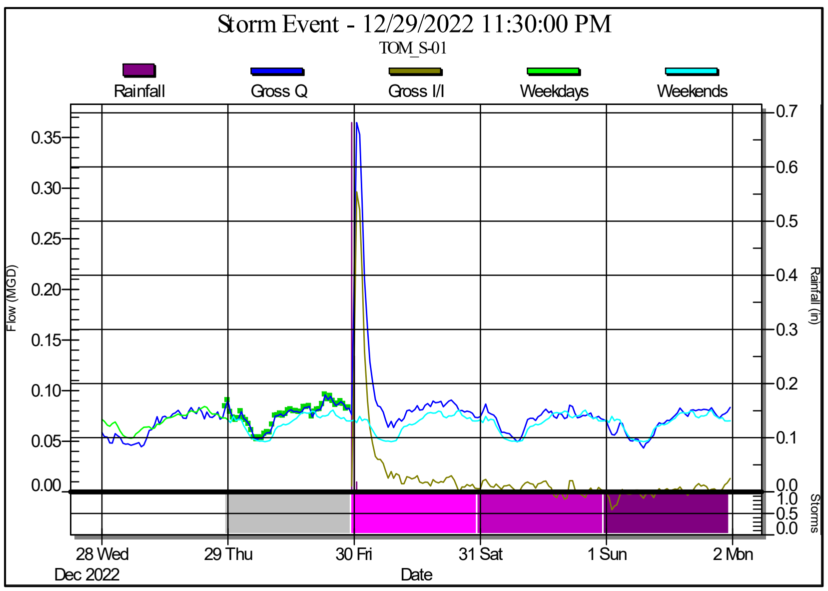
Scatter Graph
TOM_S-01
Lanfear-Coll (C-LC = 2.84)
VFINAL (ft/s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
DFINAL (in)
Iso Q (MGD)
9
8
7
6
5
4
3
2
1
0.25



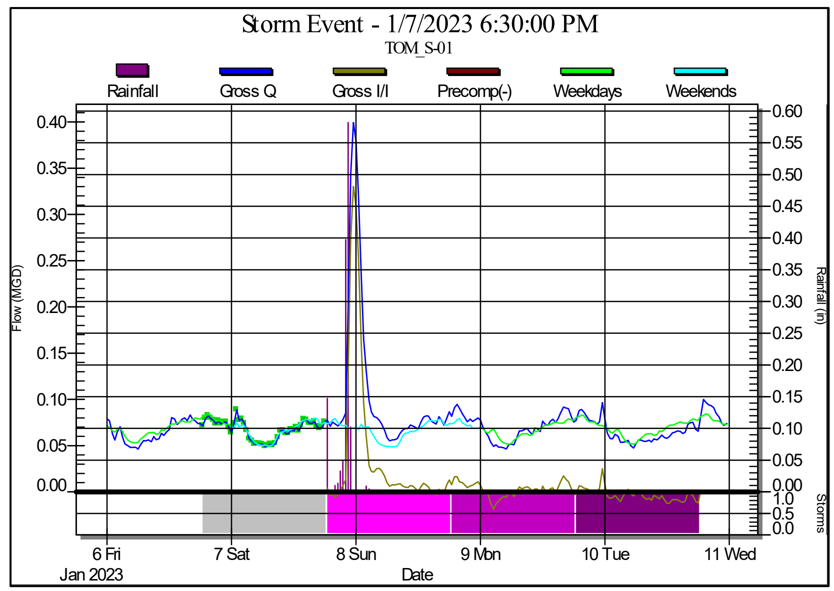
Storm Event - 11/25/2022 6:30:00 PM
TOM_S-01
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.0
0.5
0.0
24 Thu
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date



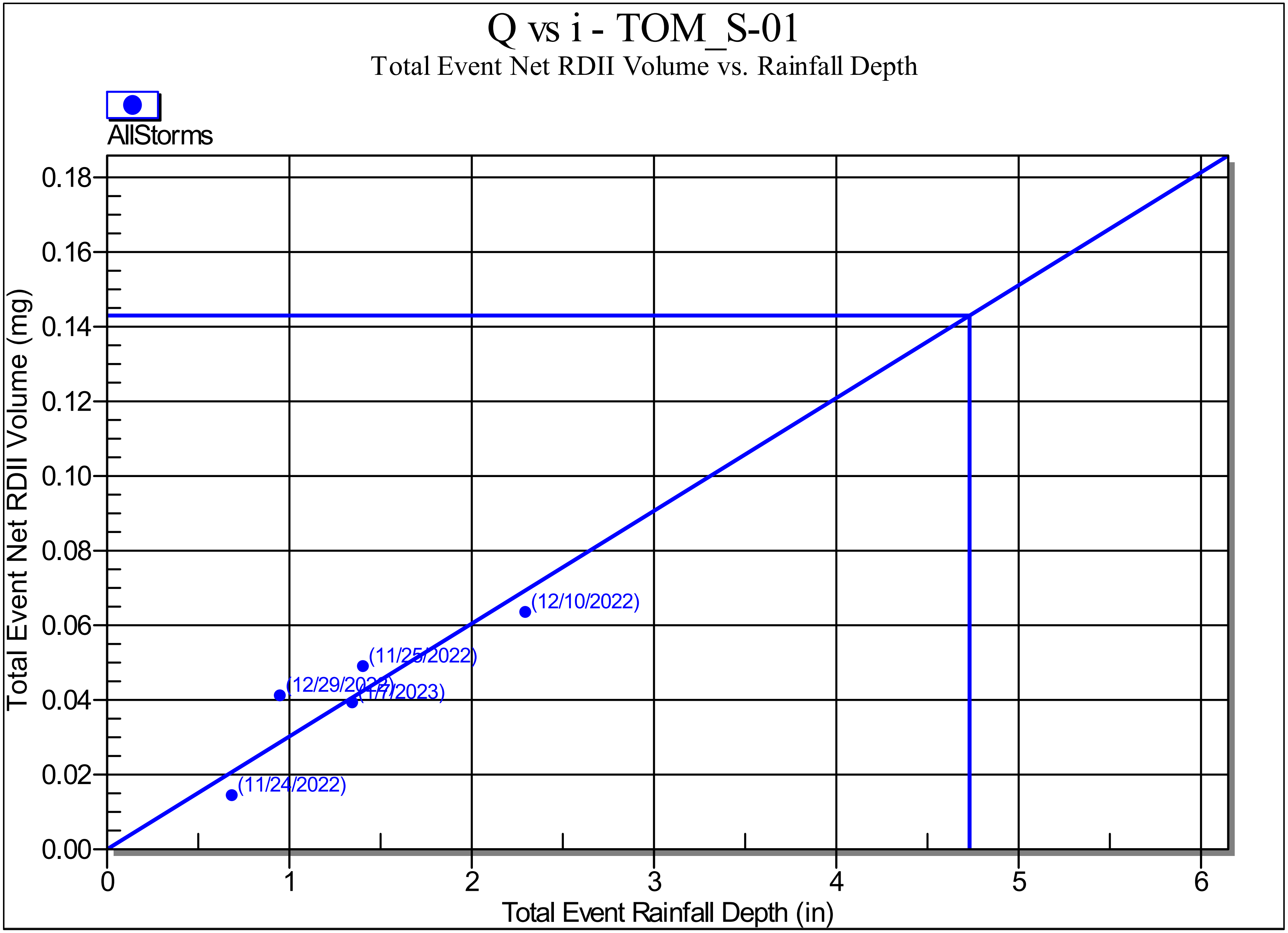
Storm Event - 12/10/2022 6:00:00 PM
TOM_S-01
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0
0.5
0.0
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date



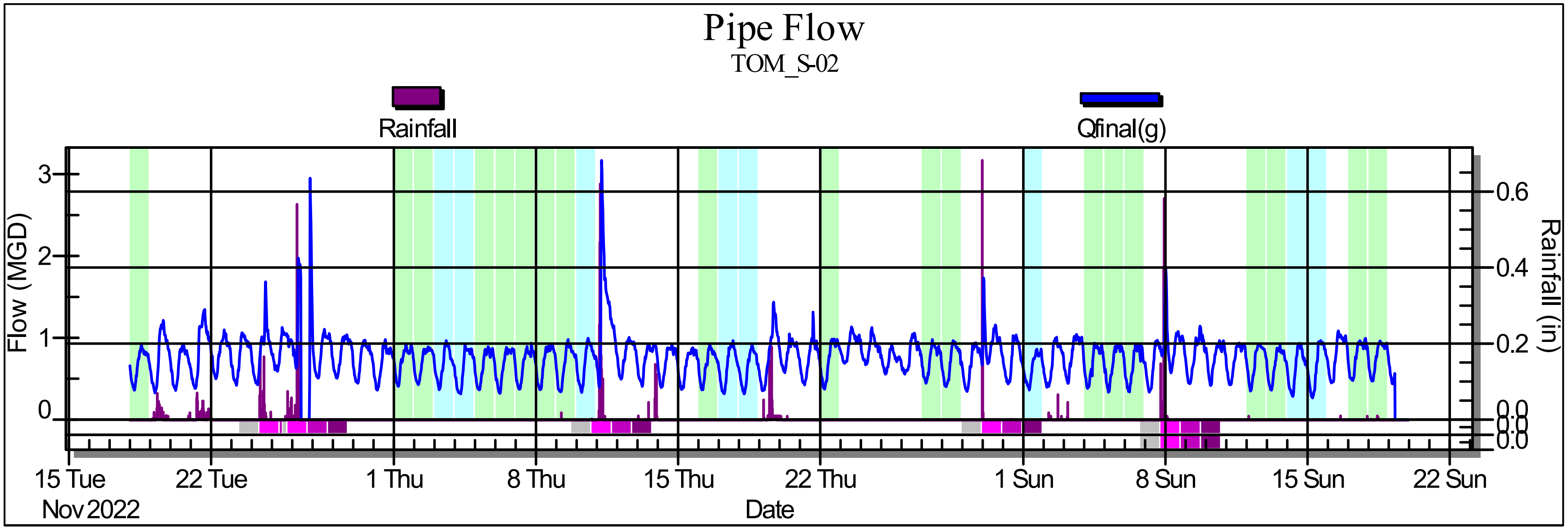
Storm Event - 12/29/2022 11:30:00 PM
TOM_S-01
Rainfall
Gross Q
Gross I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0
0.5
0.0
28 Wed
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date

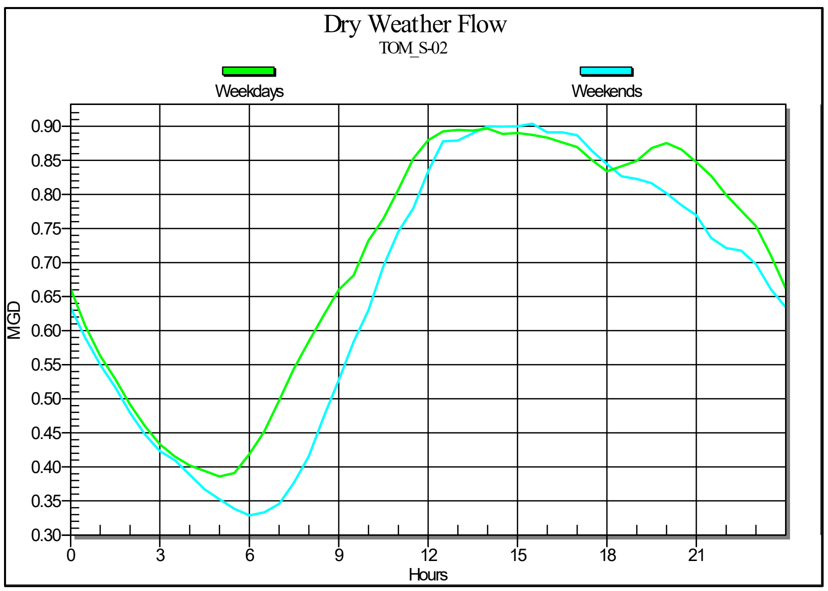


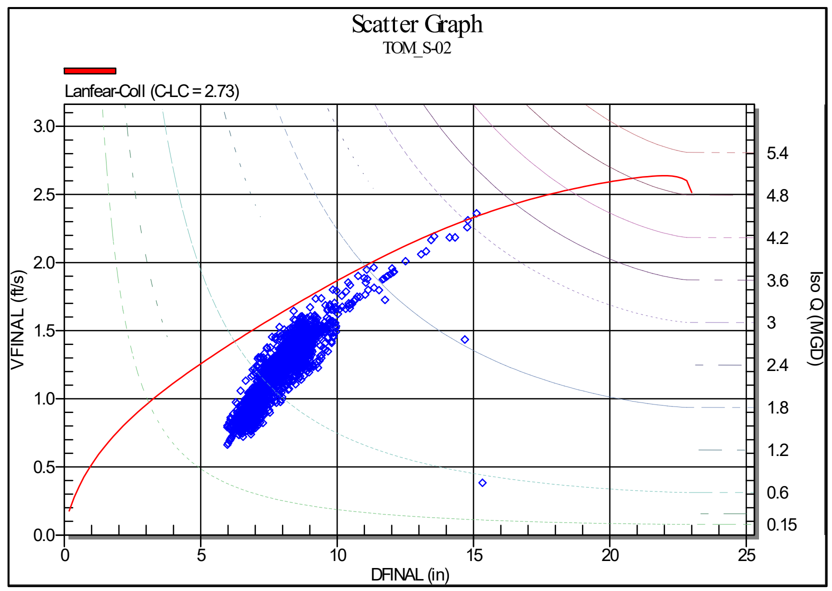
Storm Event - 1/7/2023 6:30:00 PM
TOM_S-01
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.0
0.5
0.0
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date

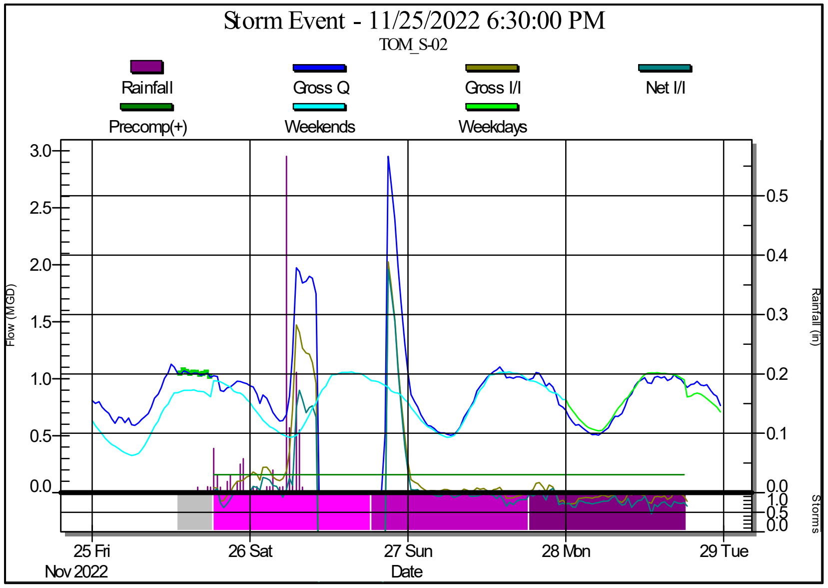


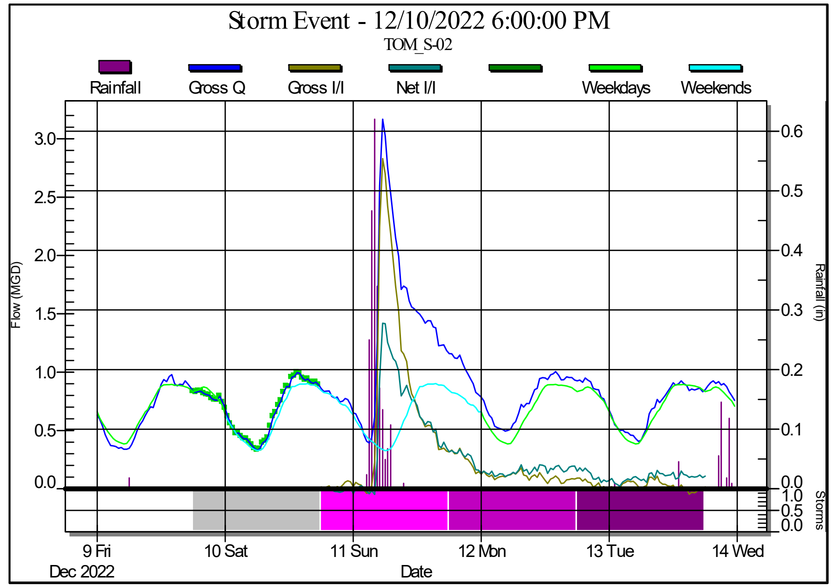
Q vs i - TOM_S-01
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
1
2
3
4
5
6
Total Event Rainfall Depth (in)
(12/10/2022)
(11/25/2022)
(12/29/2022)
(1/7/2023)
(11/24/2022)

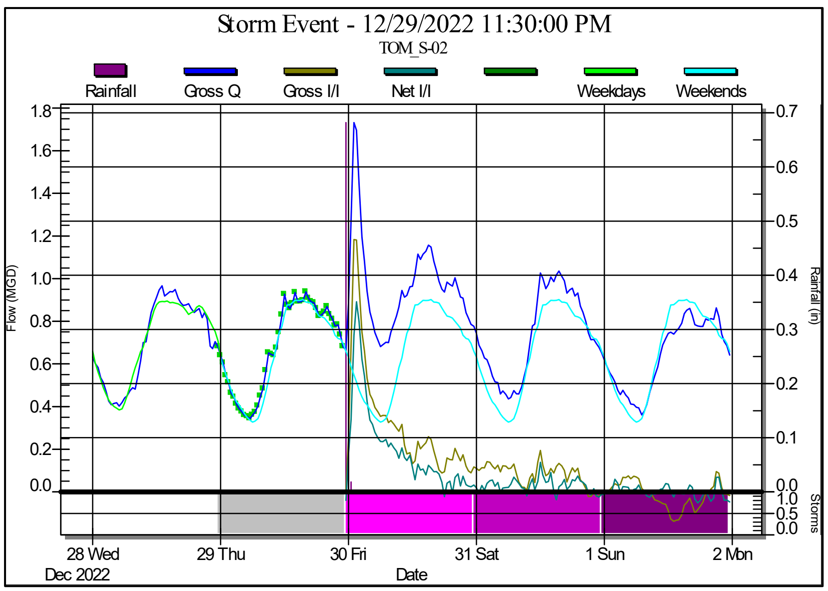

Pipe Flow
TOM_S-02
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date

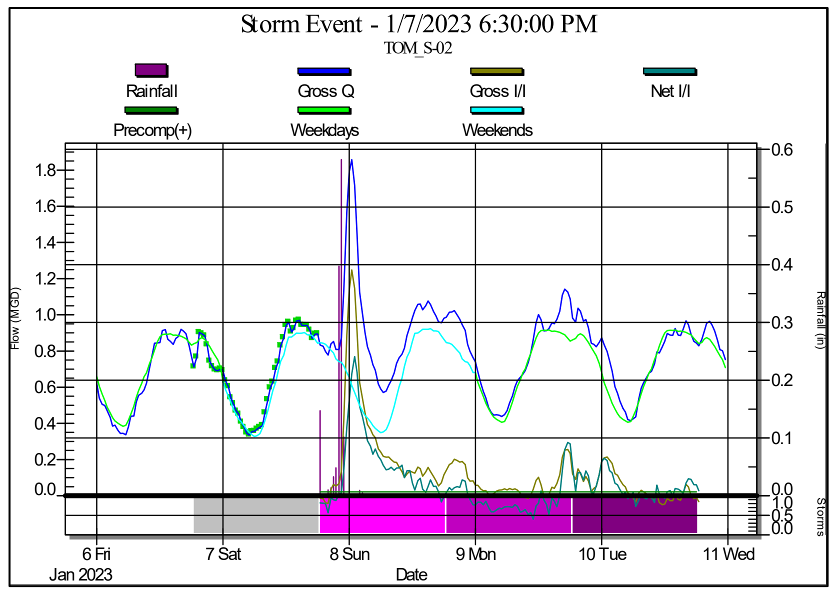

Dry Weather Flow
TOM_S-02
Weekdays
Weekends
MGD
Hours

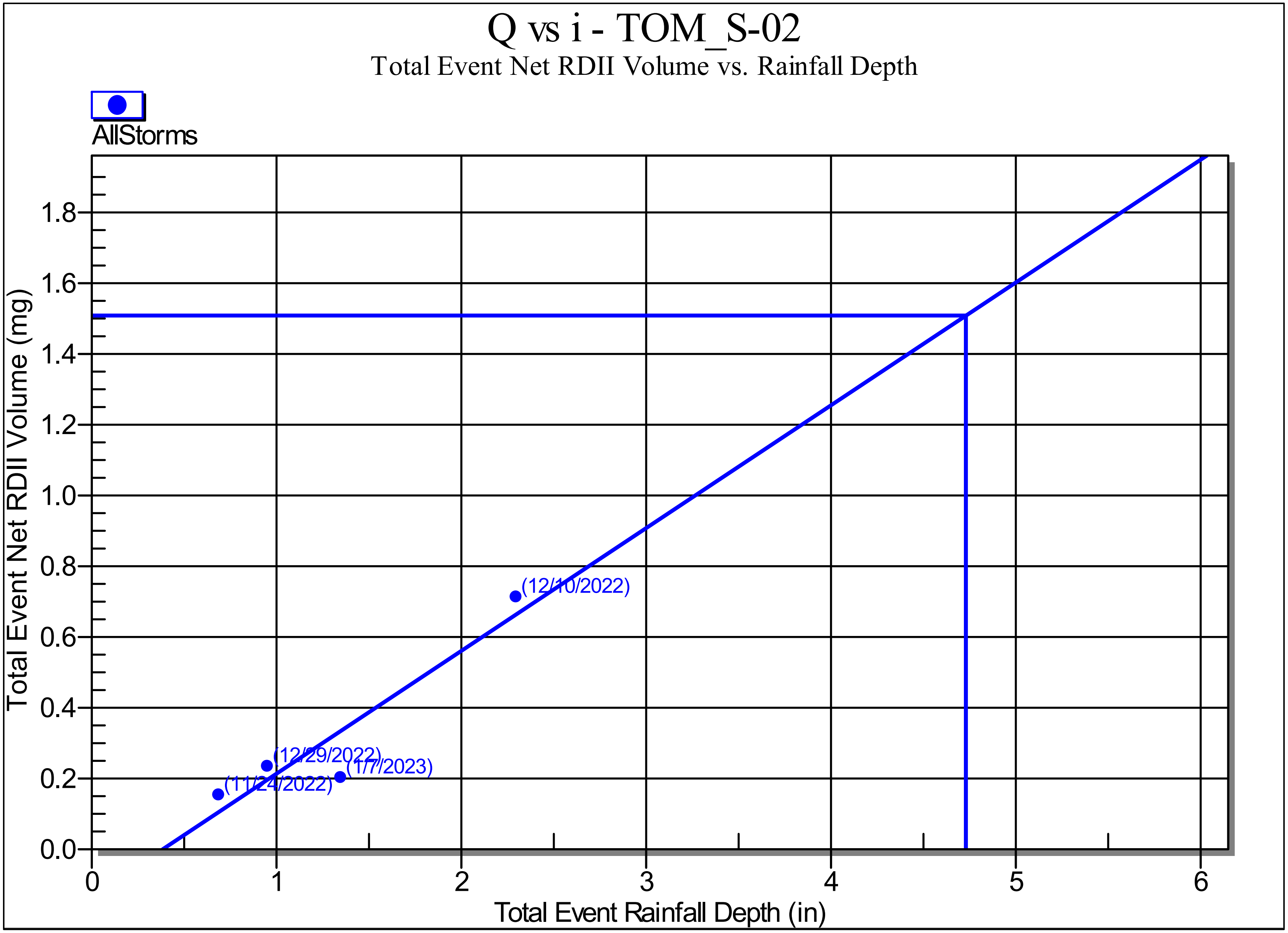

Scatter Graph
TOM_S-02
Lanfear-Coll (C-LC = 2.73)
VFINAL (ft/s)
DFINAL (in)
Iso Q (MGD)

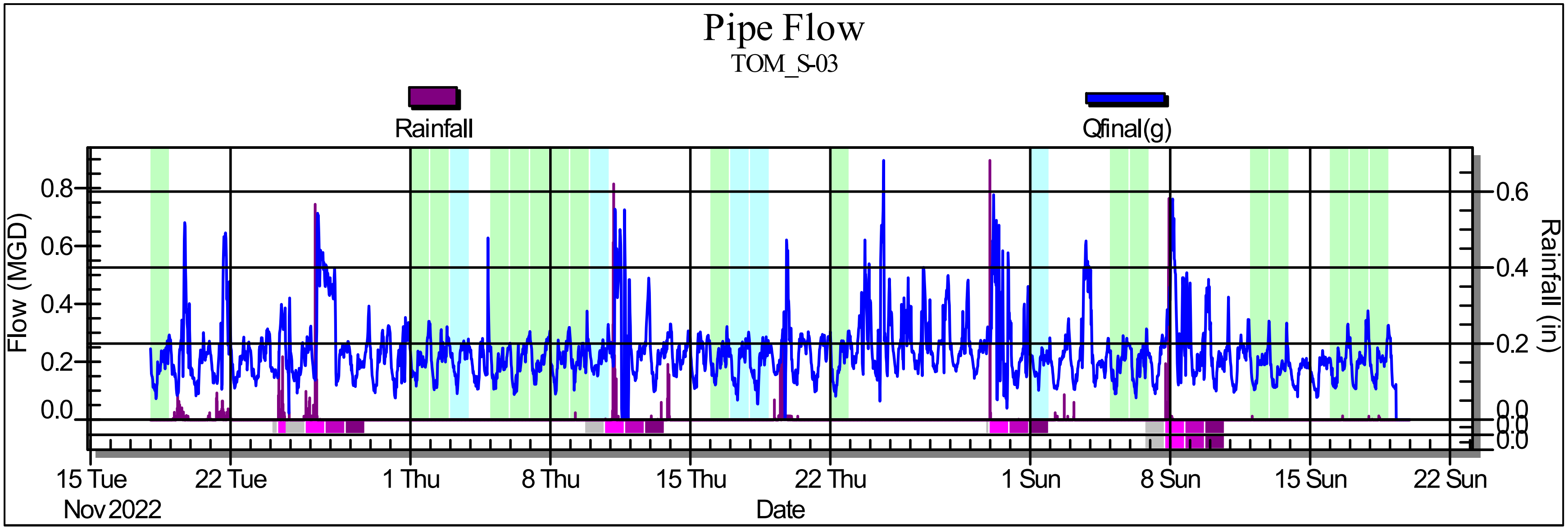

Storm Event - 11/25/2022 6:30:00 PM
TOM_S-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date


Storm Event - 12/10/2022 6:00:00 PM
TOM_S-02
Rainfall
Gross Q
Gross I/I
Net I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date

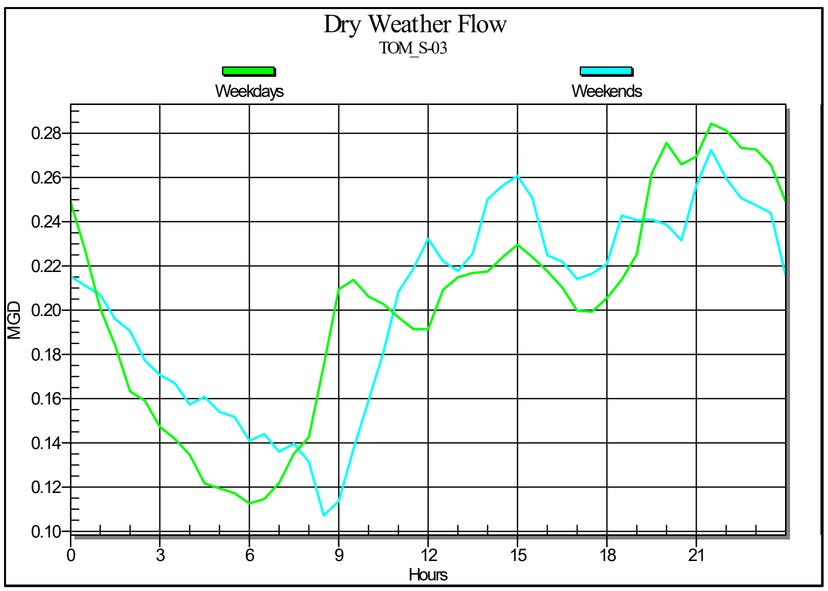

Storm Event - 12/29/2022 11:30:00 PM
TOM_S-02
Rainfall
Gross Q
Gross I/I
Net I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date


Storm Event - 1/7/2023 6:30:00 PM
TOM_S-02
Rainfall
Gross Q
Gross I/I
Net I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date

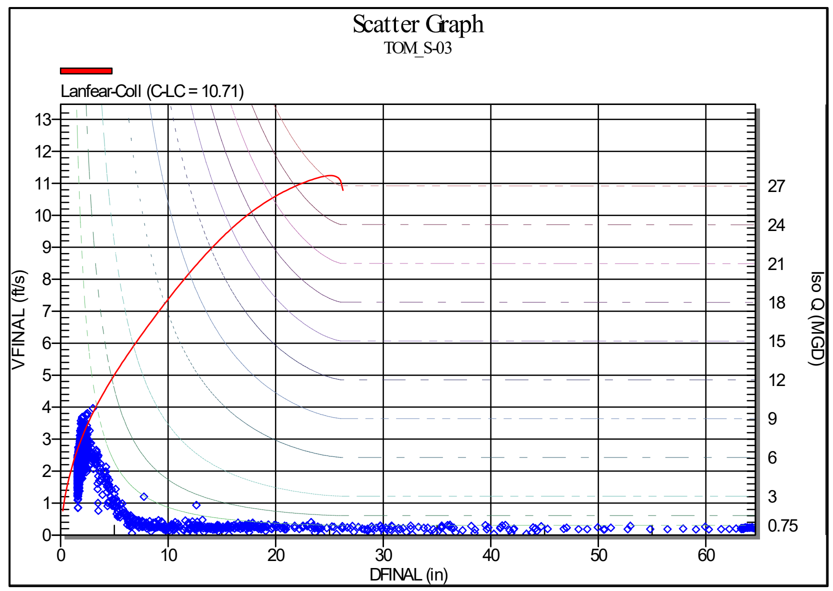

Q vs i - TOM_S-02
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
Total Event Rainfall Depth (in)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
1
2
3
4
5
6
(12/10/2022)
(12/29/2022)
(1/7/2023)
(11/24/2022)



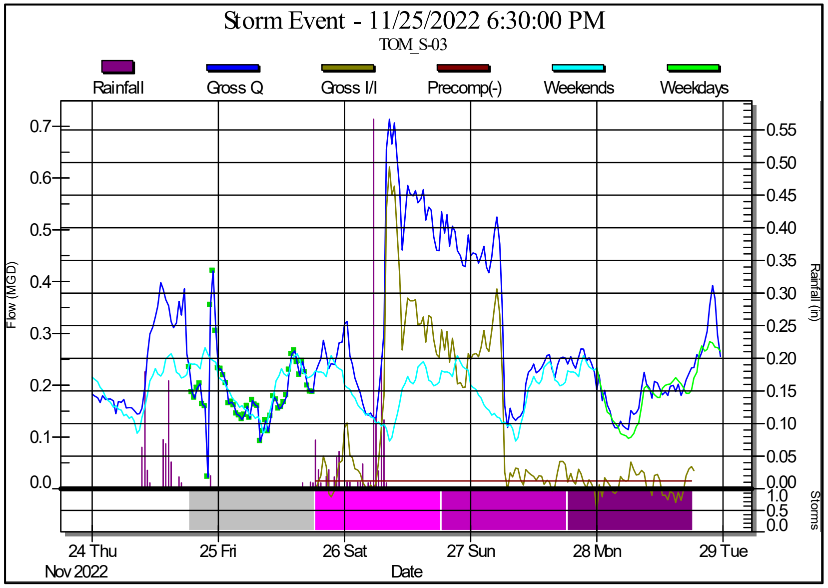
Pipe Flow
TOM_S-03
Rainfall
Qfinal(g)
Flow (MGD)
Rainfall (in)
0.0
0.2
0.4
0.6
0.8
15 Tue
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Nov 2022
Date

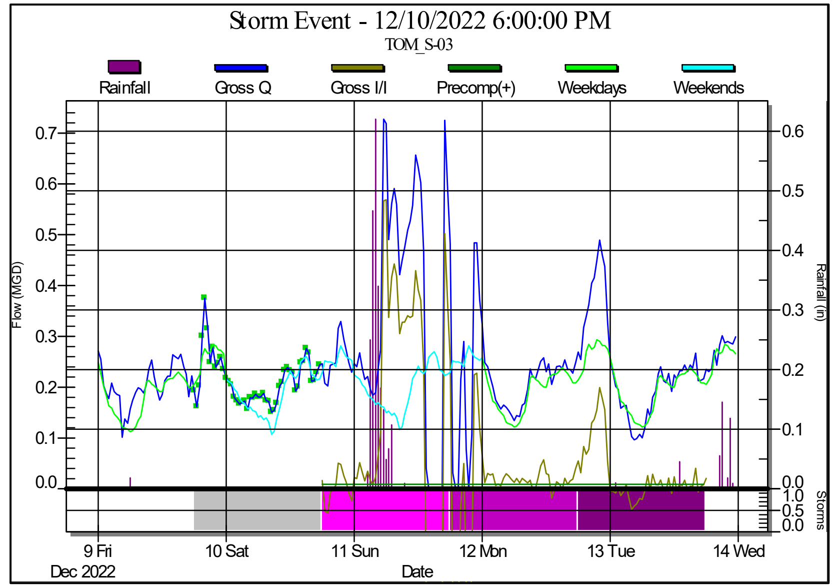


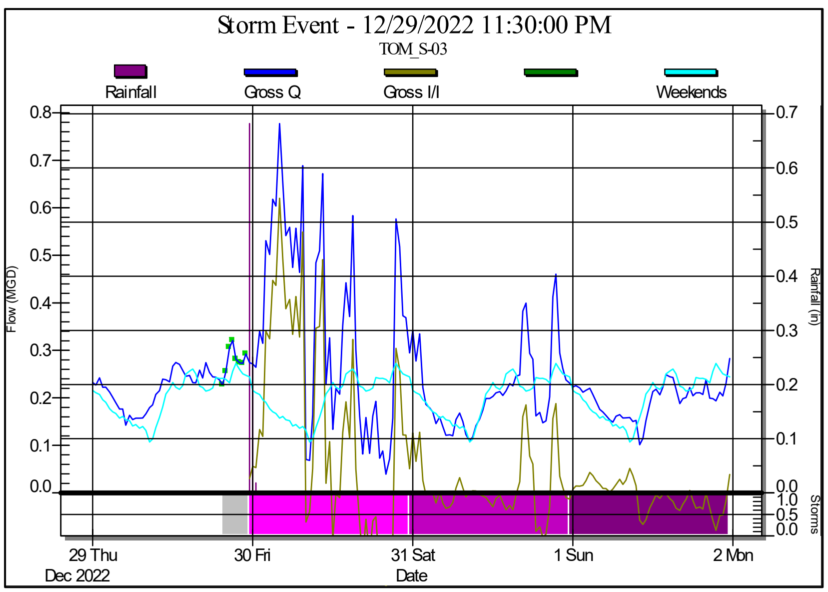
Dry Weather Flow
TOM_S-03
Weekdays
Weekends
MGD
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24
0.26
0.28
0
3
6
9
12
15
18
21
Hours

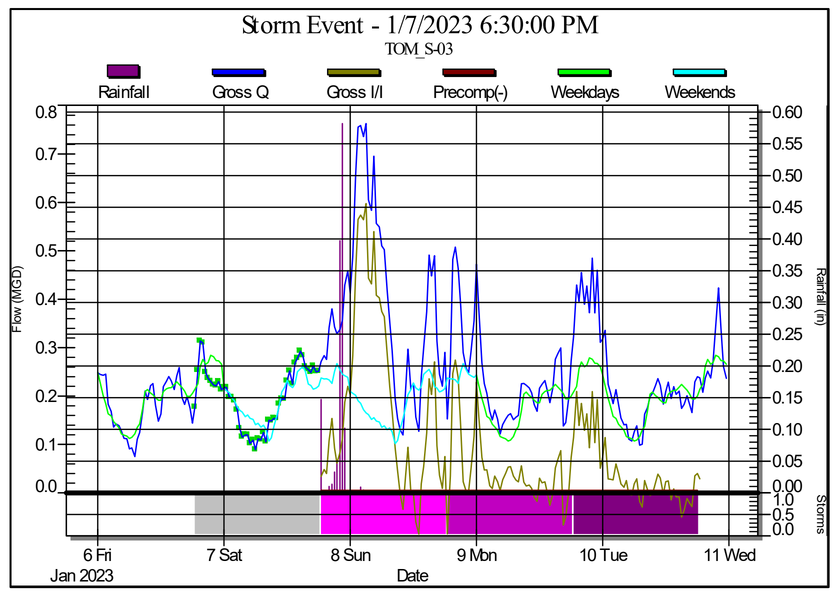


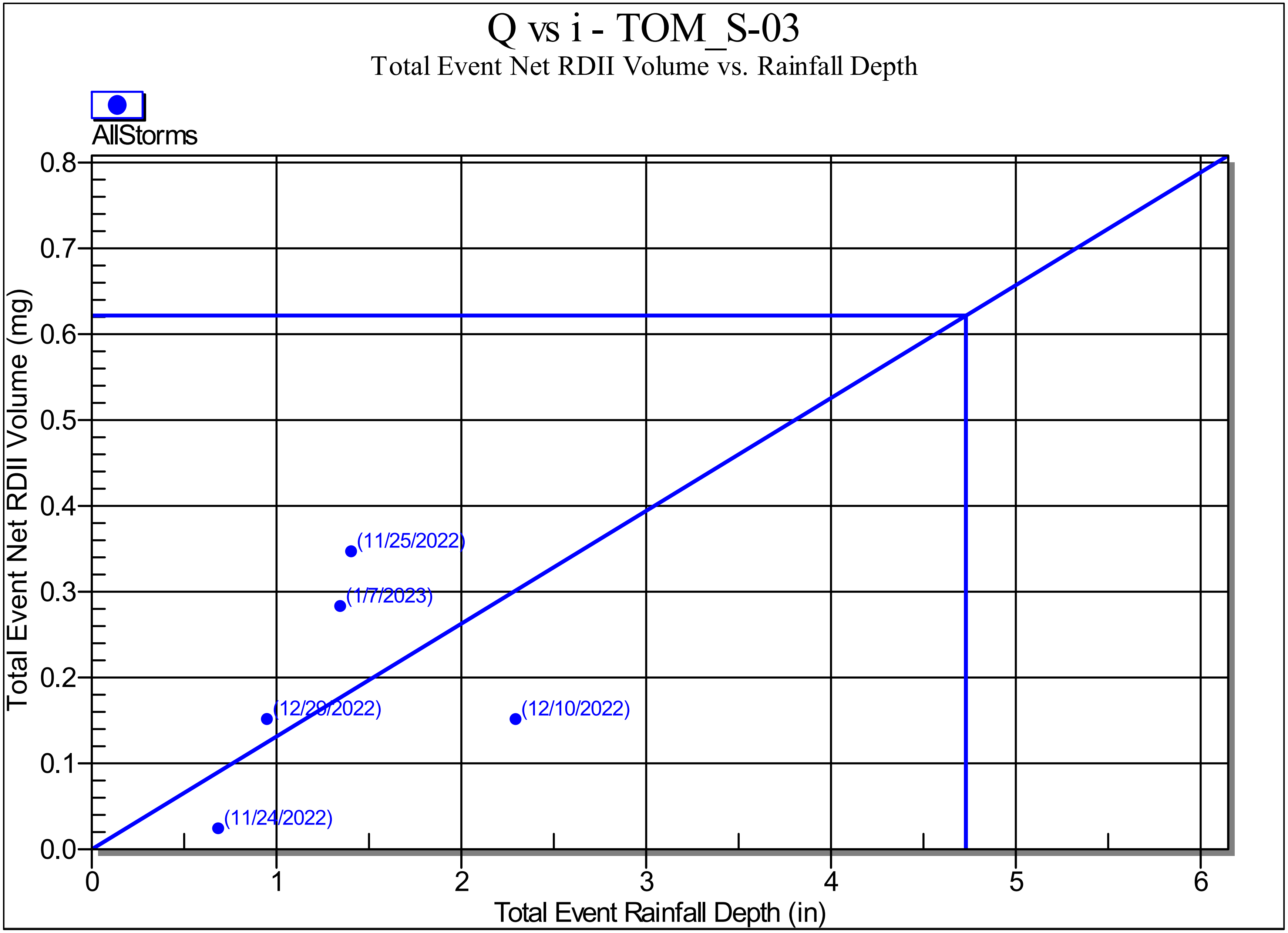
Scatter Graph
TOM_S-03
Lanfear-Coll (C-LC = 10.71)
VFINAL (ft/s)
DFINAL (in)
Iso Q (MGD)
0.75
3
6
9
12
15
18
21
24
27


Storm Event - 11/25/2022 6:30:00 PM
TOM_S-03
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
24 Thu
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date

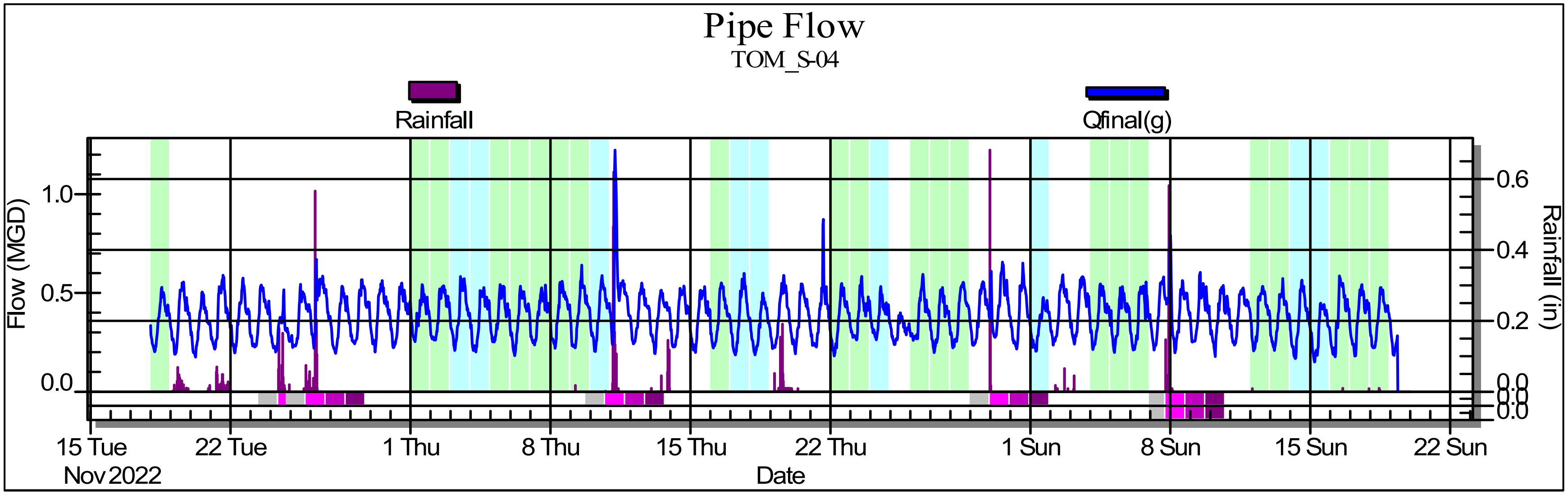

Storm Event - 12/10/2022 6:00:00 PM
TOM_S-03
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date


Storm Event - 12/29/2022 11:30:00 PM
TOM_S-03
Rainfall
Gross Q
Gross I/I
Weekends
Flow (MGD)
Rainfall (in)
Storms
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date

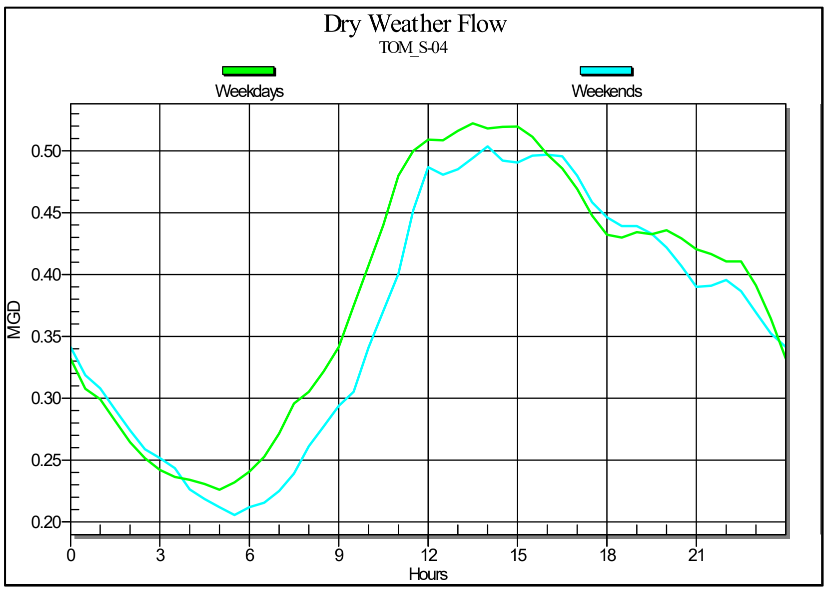

Storm Event - 1/7/2023 6:30:00 PM
TOM_S-03
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date



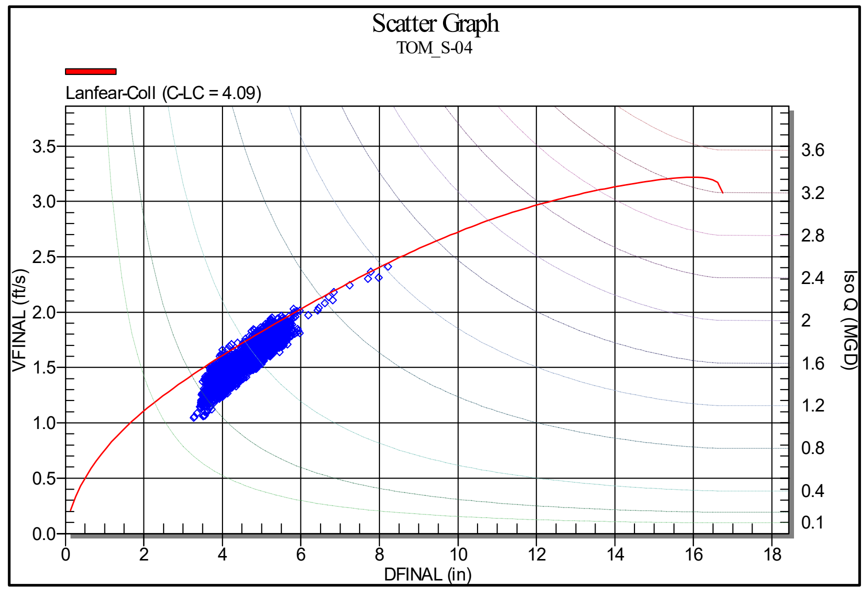
Q vs i - TOM_S-03
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
Total Event Rainfall Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
1
2
3
4
5
6
(11/25/2022)
(1/7/2023)
(12/29/2022)
(12/10/2022)
(11/24/2022)



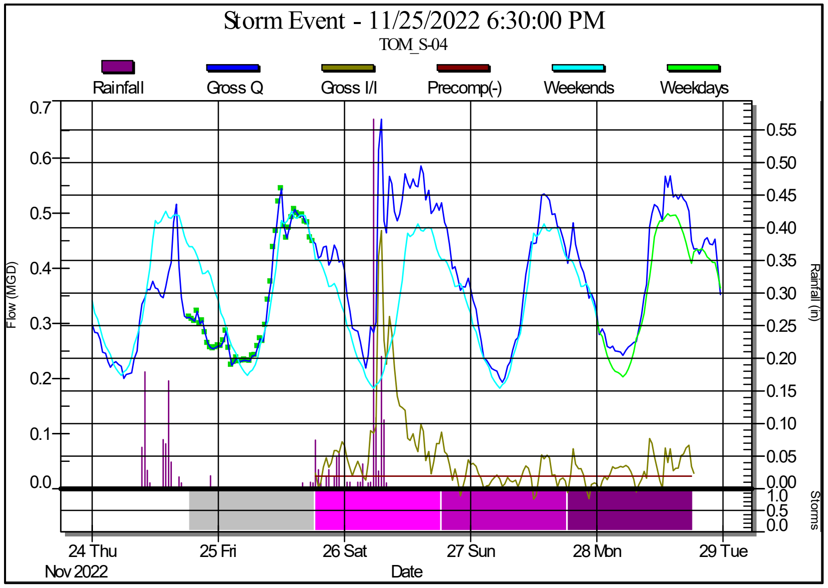
Pipe Flow
TOM_S-04
Rainfall
Qfinal(g)
Flow (MGD)
1.0
0.5
0.0
Rainfall (in)
0.6
0.4
0.2
0.0
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date



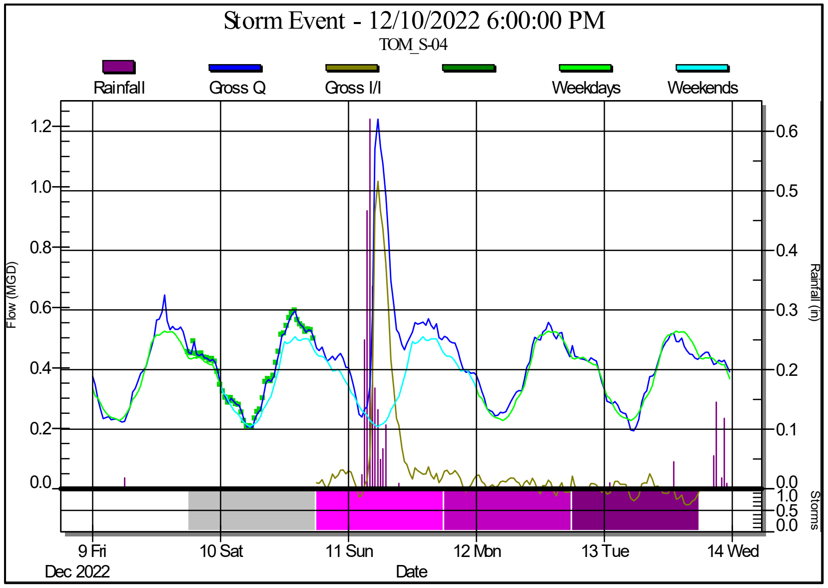
Dry Weather Flow
TOM_S-04
Weekdays
Weekends
MGD
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0
3
6
9
12
15
18
21
Hours



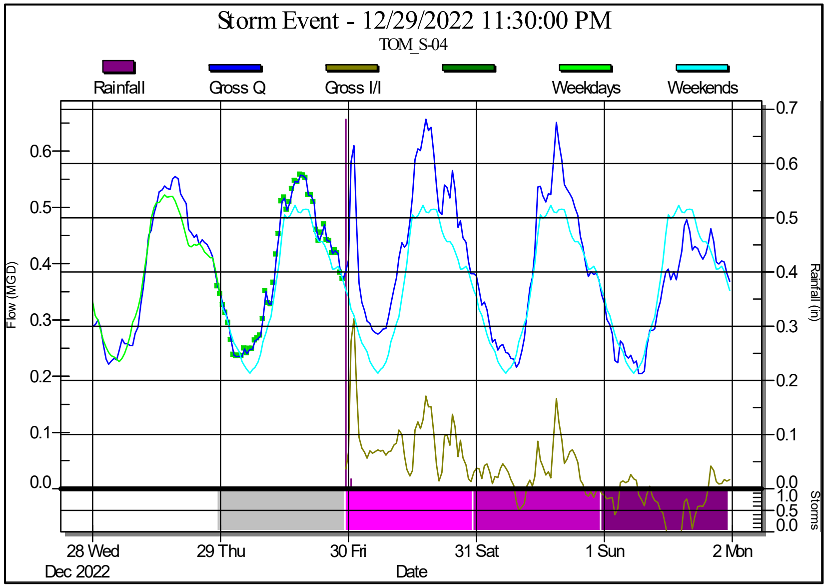
Scatter Graph
TOM_S-04
Lanfear-Coll (C-LC = 4.09)
VFINAL (ft/s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Iso Q (MGD)
3.6
3.2
2.8
2.4
2
1.6
1.2
0.8
0.4
0.1
0
2
4
6
8
10
12
14
16
18
DFINAL (in)



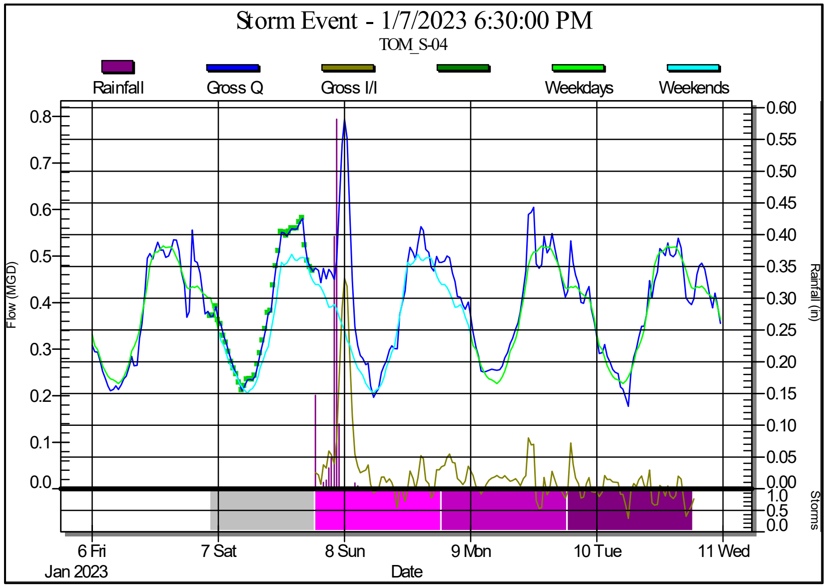
Storm Event - 11/25/2022 6:30:00 PM
TOM_S-04
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
24 Thu
25 Fri
26 Sat
27 Sun
28 Mon
29 Tue
Nov 2022
Date



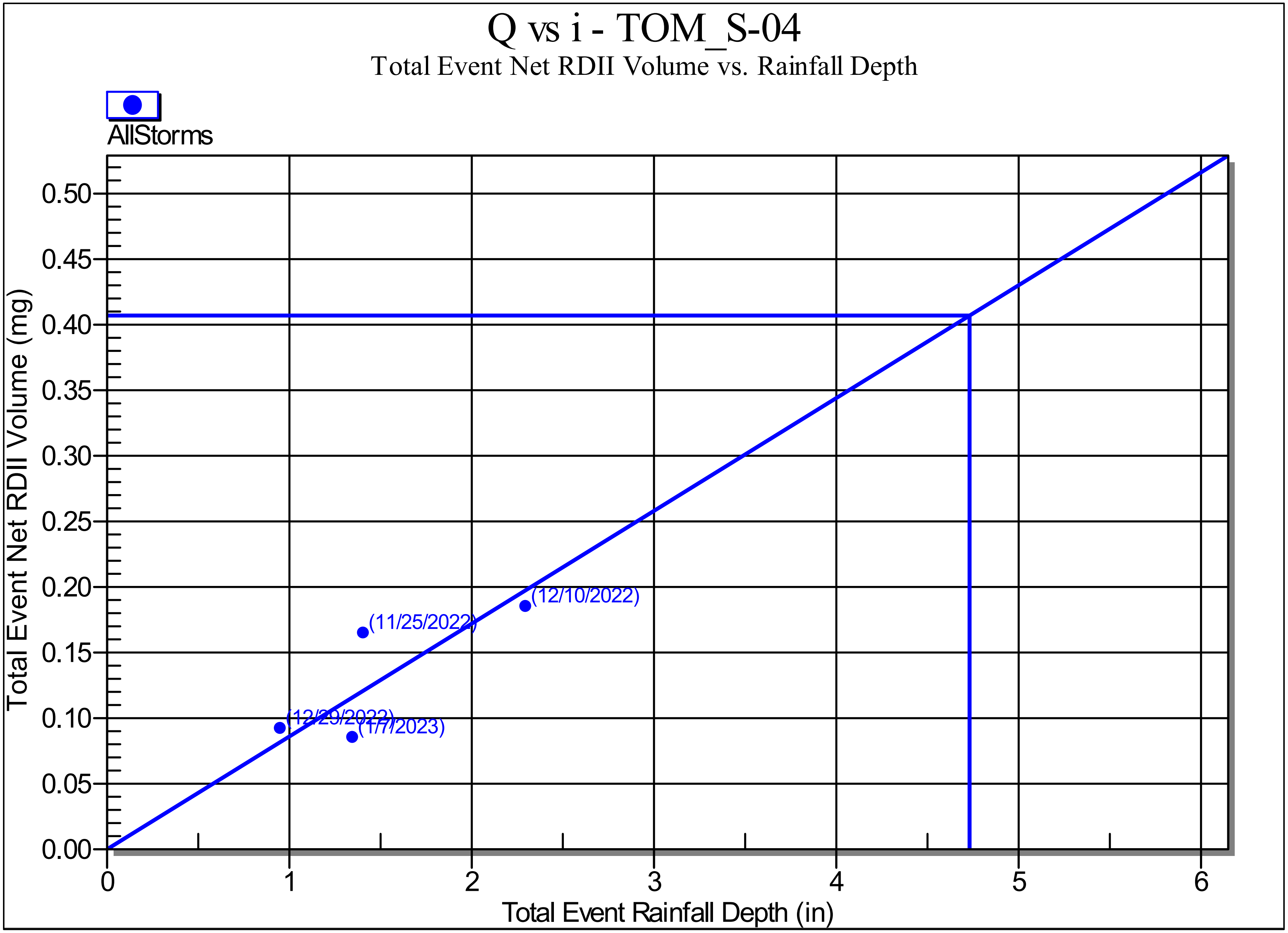
Storm Event - 12/10/2022 6:00:00 PM
TOM_S-04
Rainfall
Gross Q
Gross I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Dec 2022
Date

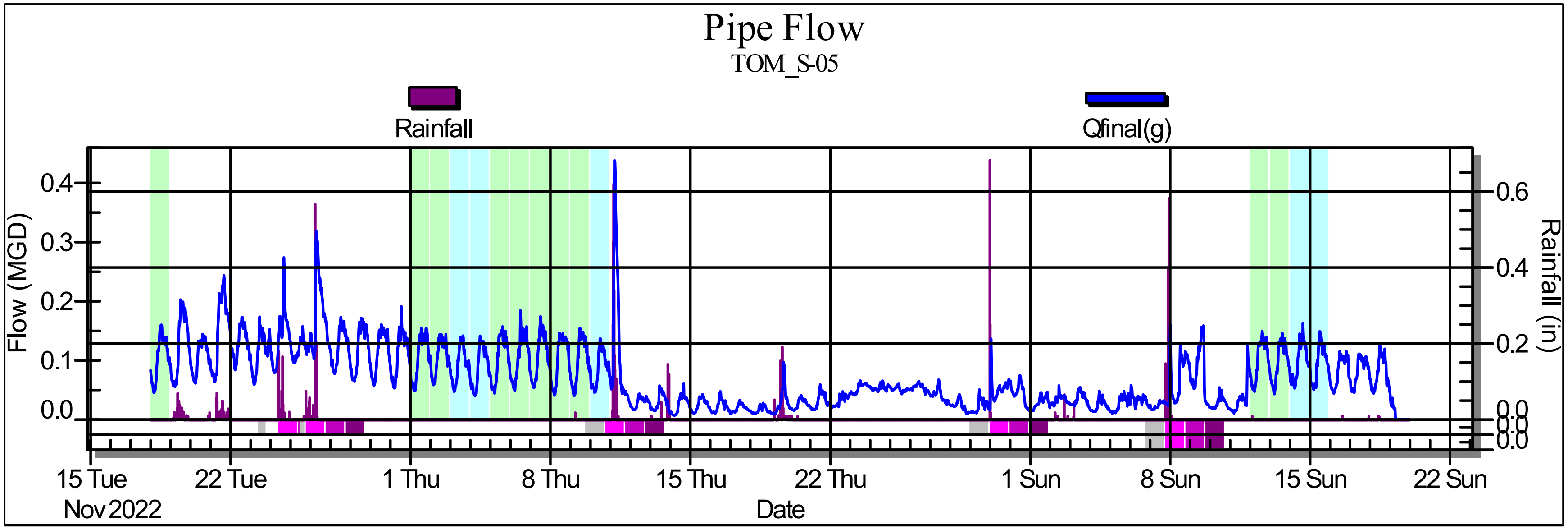


Storm Event - 12/29/2022 11:30:00 PM
TOM_S-04
Rainfall
Gross Q
Gross I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Dec 2022
Date

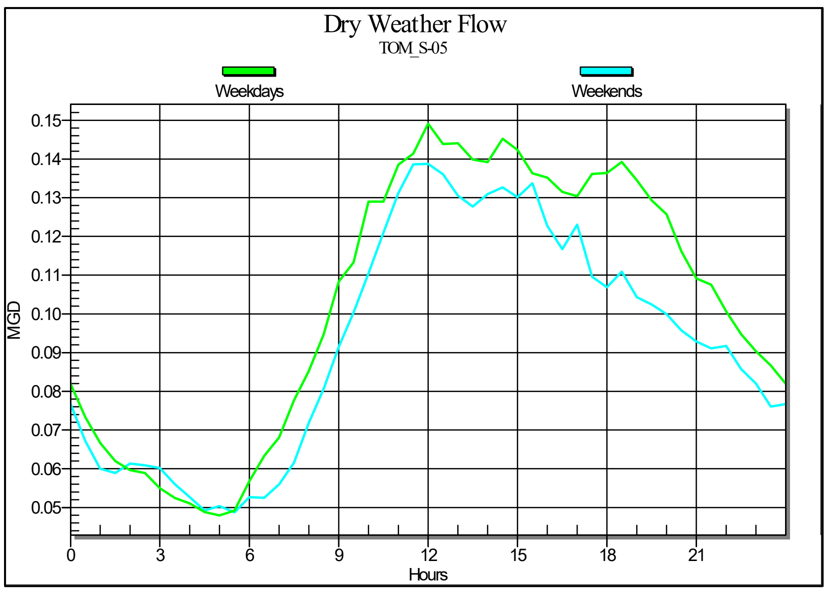


Storm Event - 1/7/2023 6:30:00 PM
TOM_S-04
Rainfall
Gross Q
Gross I/I
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Jan 2023
Date

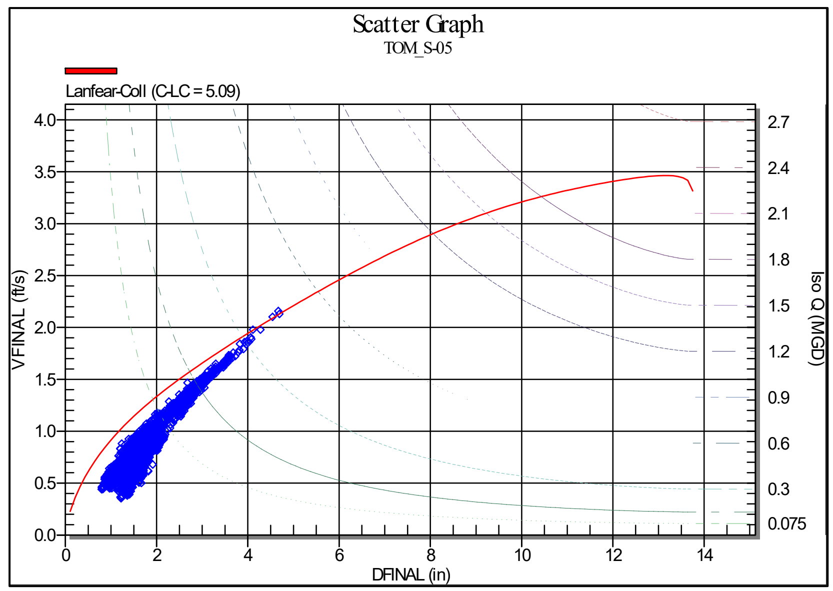

Q vs i - TOM_S-04
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0
1
2
3
4
5
6
Total Event Rainfall Depth (in)
(11/25/2022)
(12/10/2022)
(12/29/2022)
(1/7/2023)



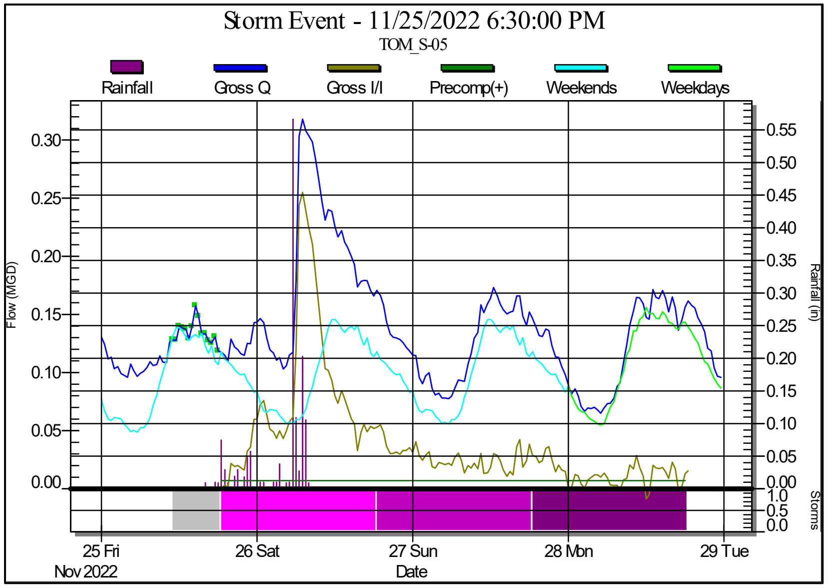
Pipe Flow
TOM_S-05
Rainfall
Qfinal(g)
Flow (MGD)
0.4
0.3
0.2
0.1
0.0
0.6
0.4
0.2
0.0
Rainfall (in)
15 Tue
Nov 2022
22 Tue
1 Thu
8 Thu
15 Thu
22 Thu
1 Sun
8 Sun
15 Sun
22 Sun
Date



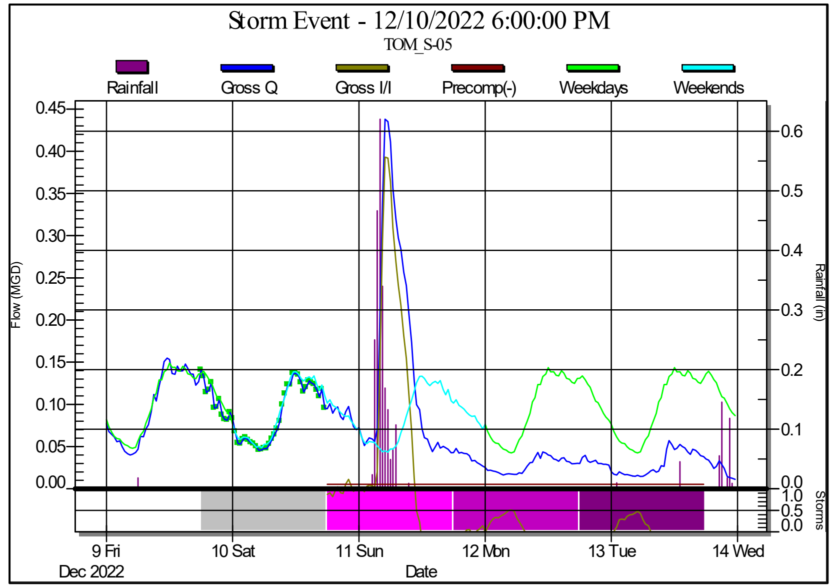
Dry Weather Flow
TOM_S-05
Weekdays
Weekends
MGD
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0
3
6
9
12
15
18
21
Hours



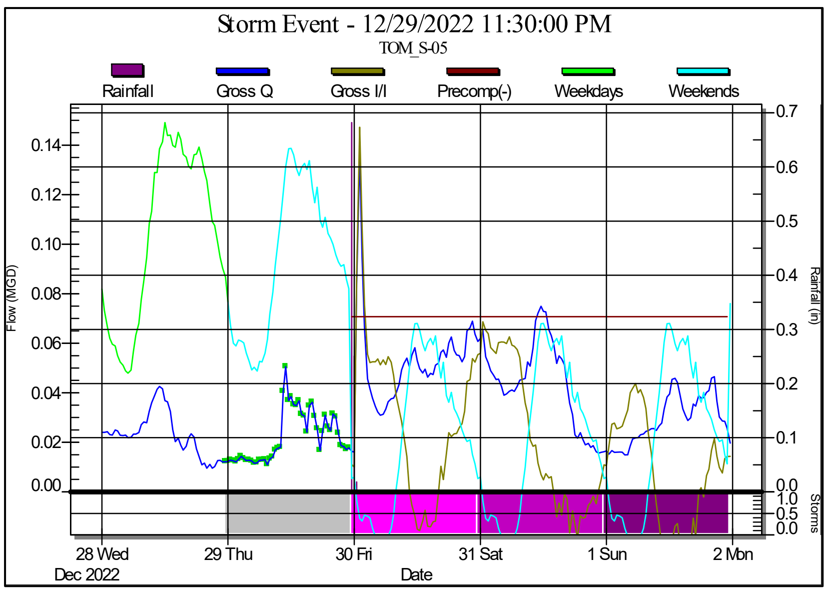
Scatter Graph
TOM_S-05
Lanfear-Coll (C-LC = 5.09)
VFINAL (ft/s)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
DFINAL (in)
Iso Q (MGD)
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.075



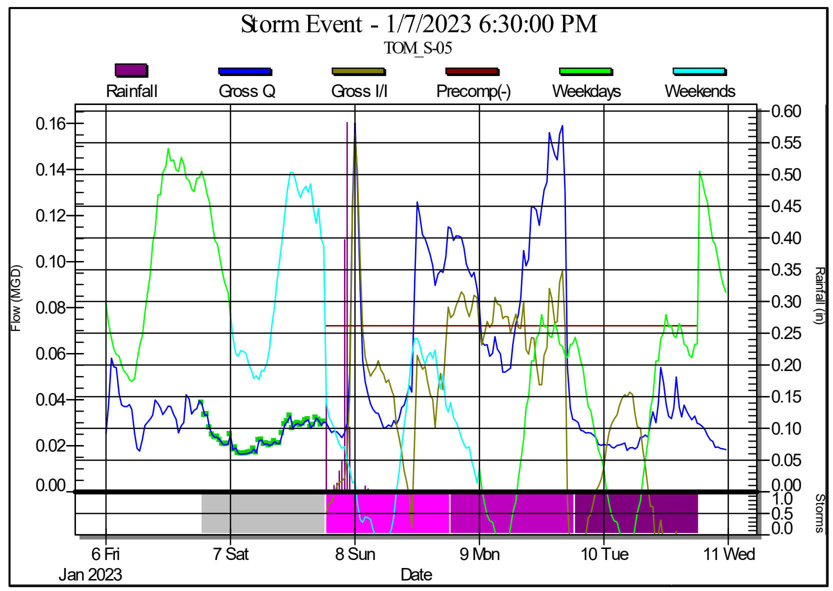
Storm Event - 11/25/2022 6:30:00 PM
TOM_S-05
Rainfall
Gross Q
Gross I/I
Precomp(+)
Weekends
Weekdays
Flow (MGD)
Rainfall (in)
Storms
25 Fri
Nov 2022
26 Sat
27 Sun
28 Mon
29 Tue
Date



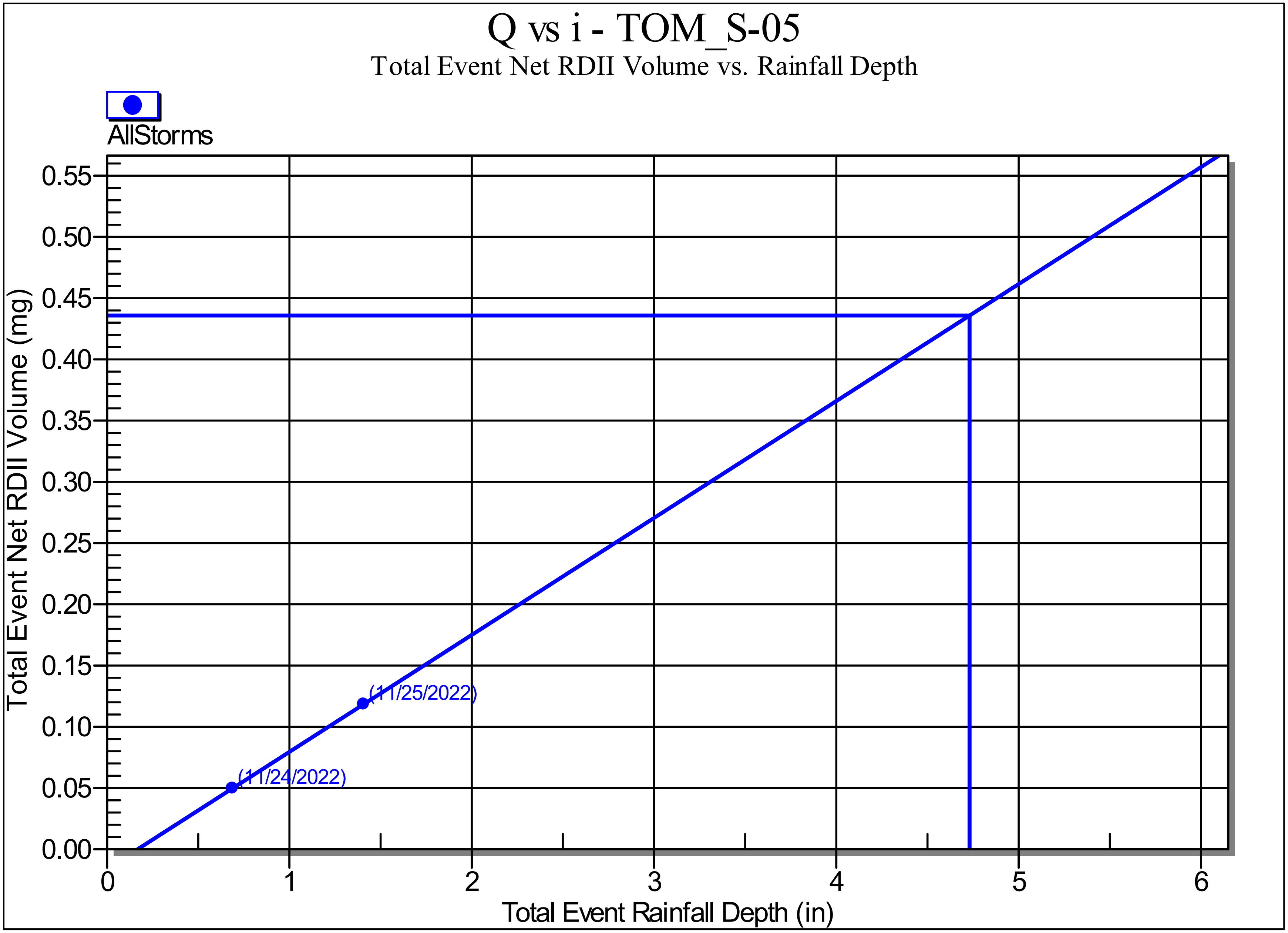
Storm Event - 12/10/2022 6:00:00 PM
TOM_S-05
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
9 Fri
Dec 2022
10 Sat
11 Sun
12 Mon
13 Tue
14 Wed
Date



Storm Event - 12/29/2022 11:30:00 PM
TOM_S-05
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
28 Wed
Dec 2022
29 Thu
30 Fri
31 Sat
1 Sun
2 Mon
Date



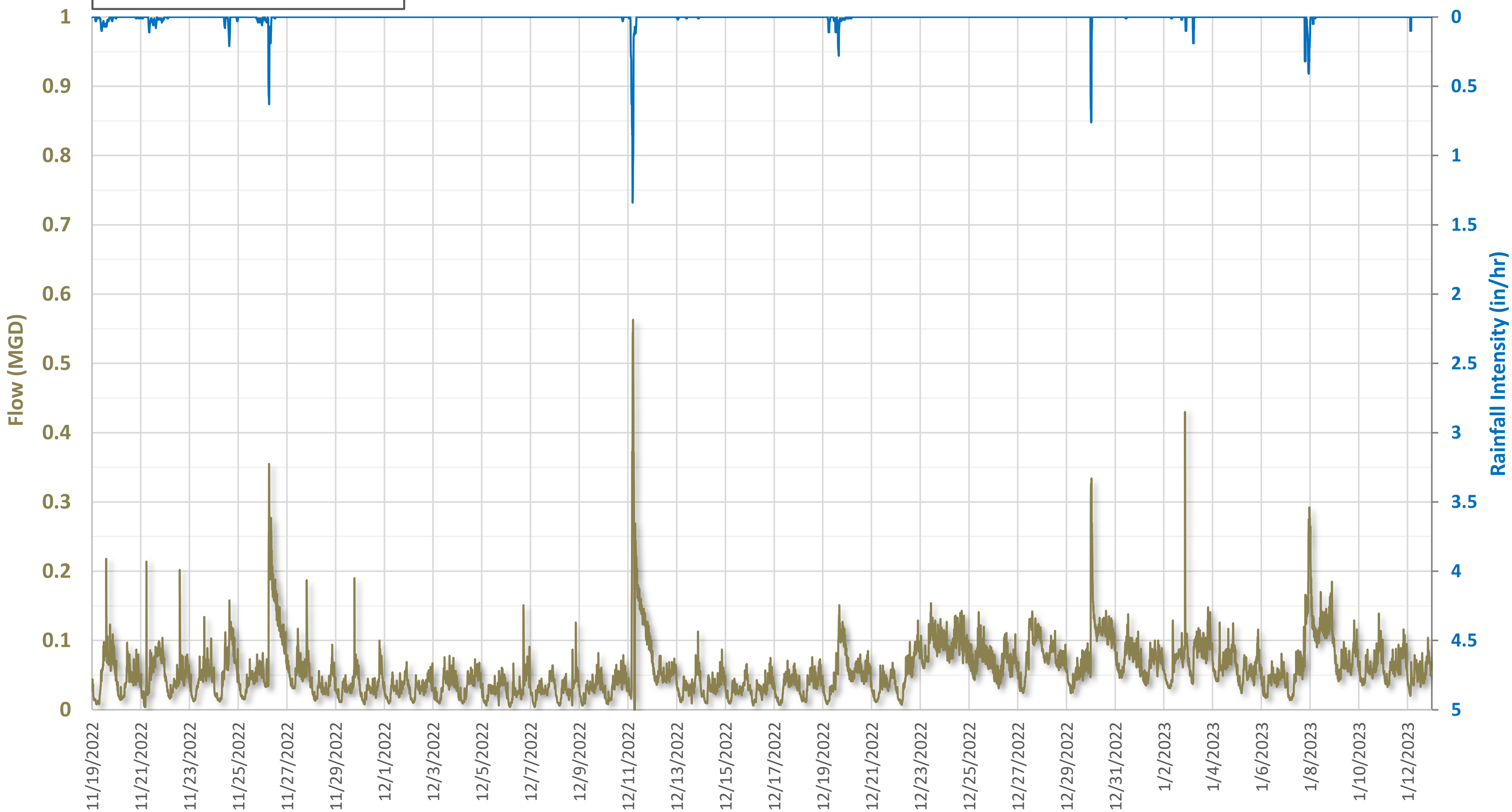
Storm Event - 1/7/2023 6:30:00 PM
TOM_S-05
Rainfall
Gross Q
Gross I/I
Precomp(-)
Weekdays
Weekends
Flow (MGD)
Rainfall (in)
Storms
6 Fri
Jan 2023
7 Sat
8 Sun
9 Mon
10 Tue
11 Wed
Date

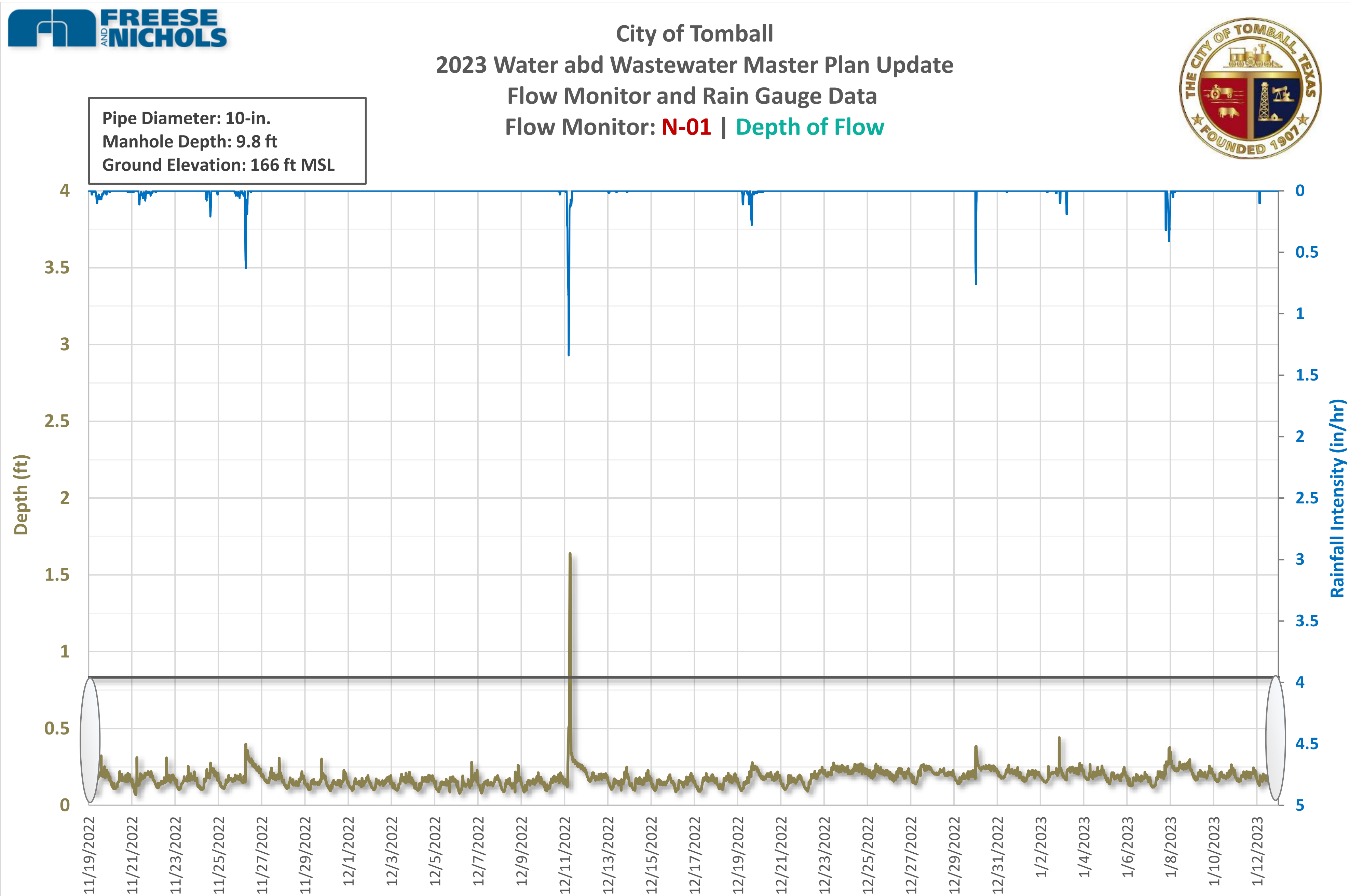

Q vs i - TOM_S-05
Total Event Net RDII Volume vs. Rainfall Depth
AllStorms
Total Event Net RDII Volume (mg)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
6
(11/25/2022)
(11/24/2022)
Total Event Rainfall Depth (in)

APPENDIX H
Hydrographs and Flow Depth Plots for Wastewater Flow Meters

City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-01 | Flow Rate

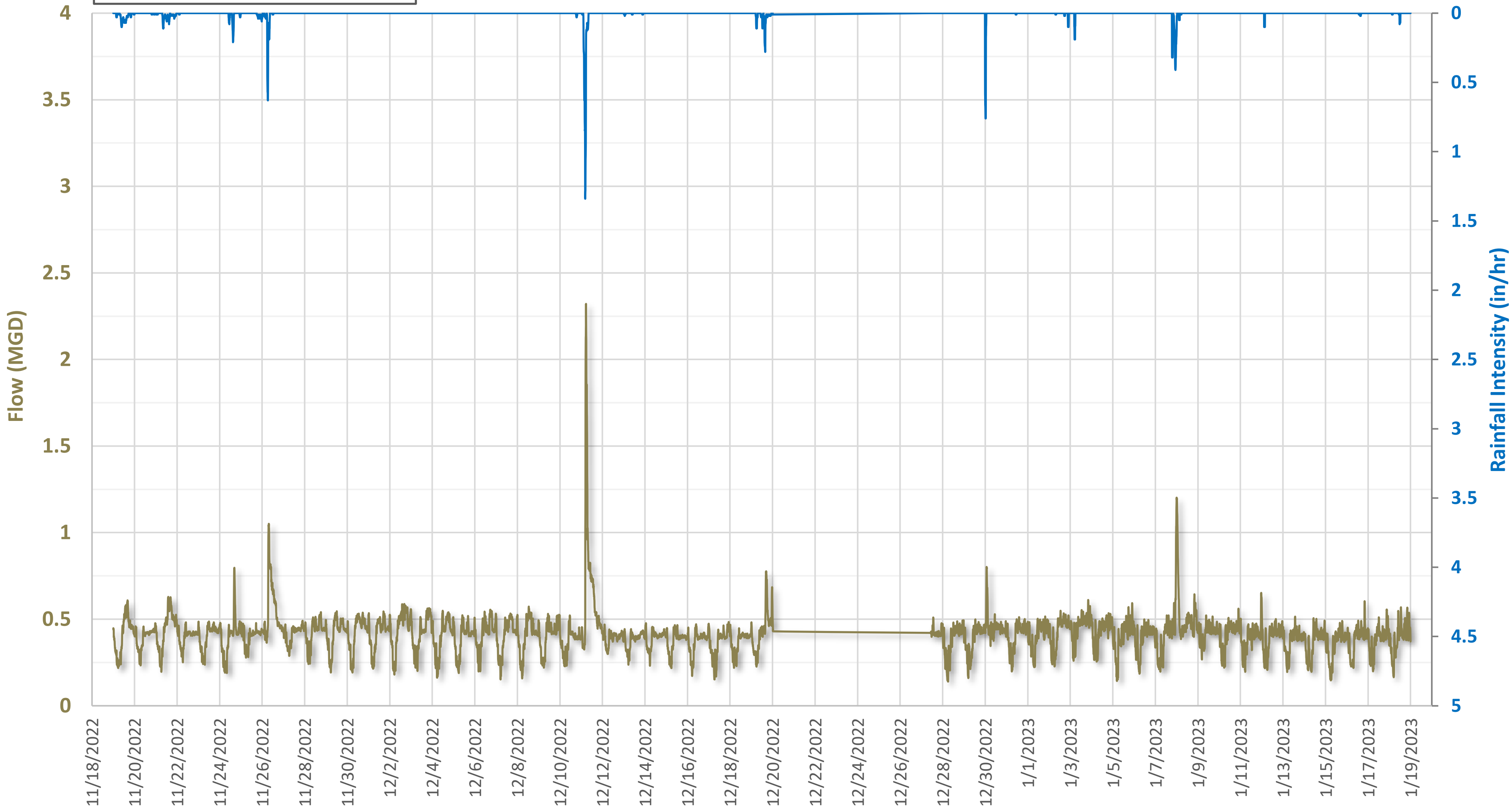
Pipe Diameter: 10-in.
Manhole Depth: 9.8 ft
Ground Elevation: 166 ft MSL




City of Tomball
2023 Water abd Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-01 | Depth of Flow
Pipe Diameter: 10-in.
Manhole Depth: 9.8 ft
Ground Elevation: 166 ft MSL
Depth (ft)
Rainfall Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/19/2022
11/21/2022
11/23/2022
11/25/2022
11/27/2022
11/29/2022
12/1/2022
12/3/2022
12/5/2022
12/7/2022
12/9/2022
12/11/2022
12/13/2022
12/15/2022
12/17/2022
12/19/2022
12/21/2022
12/23/2022
12/25/2022
12/27/2022
12/29/2022
12/31/2022
1/2/2023
1/4/2023
1/6/2023
1/8/2023
1/10/2023
1/12/2023

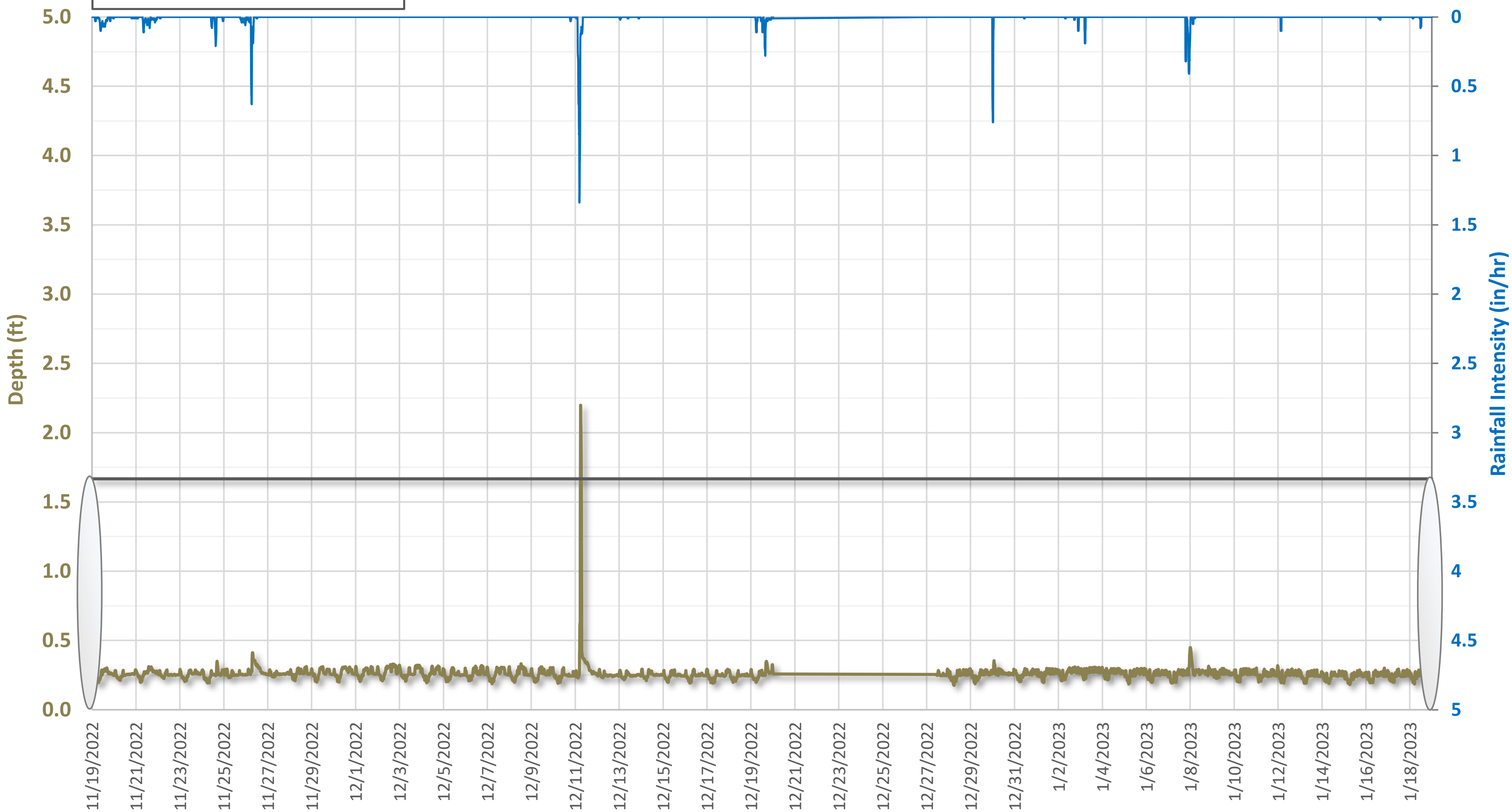
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-02 | Flow Rate

Pipe Diameter: 20 in.
Manhole Depth: 9.8 ft.
Ground Elevation: 168 ft. MSL



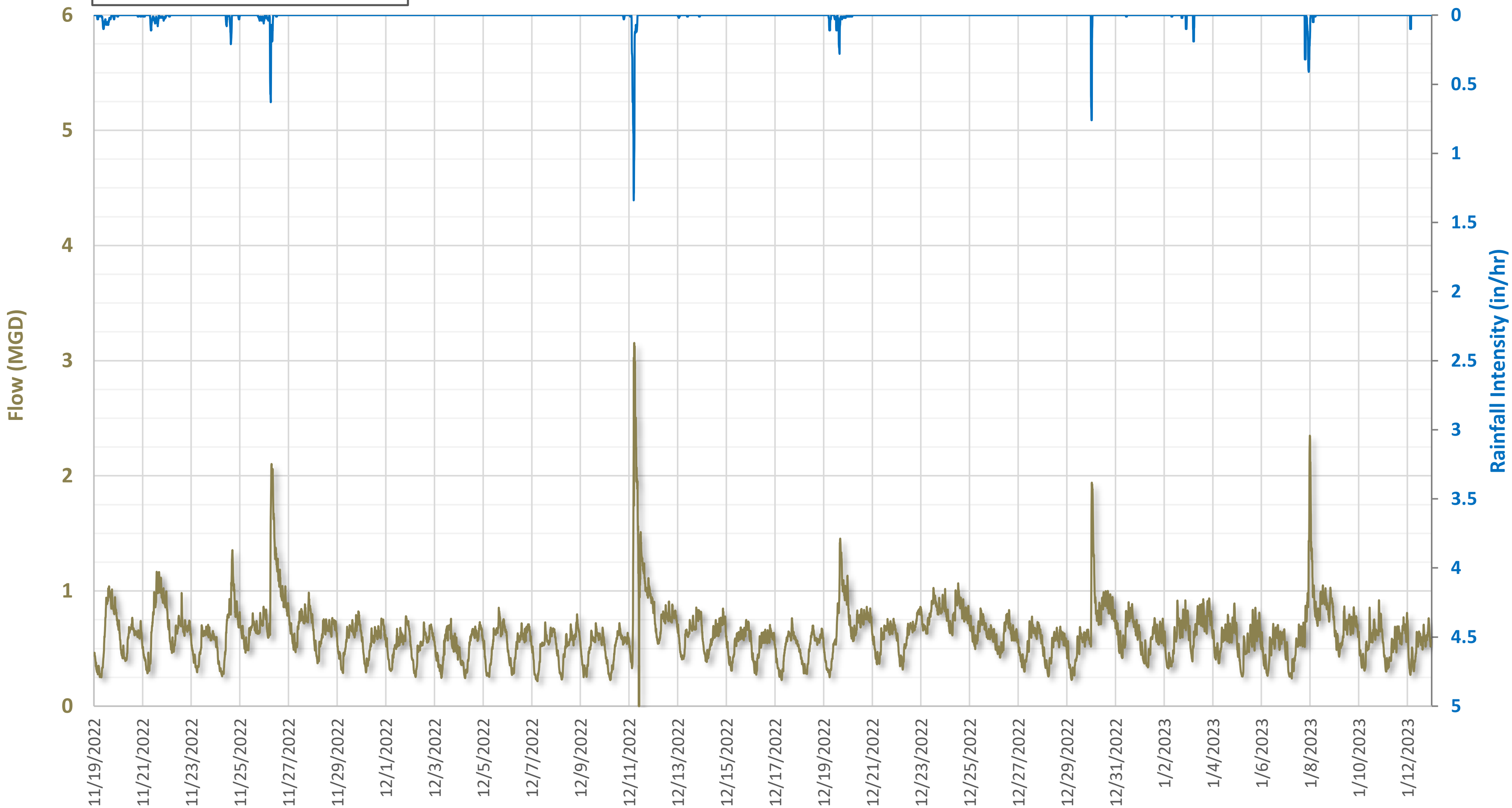
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-02 | Depth of Flow

Pipe Diameter: 20-in.
Manhole Depth: 9.8 ft
Ground Elevation: 168 ft MSL

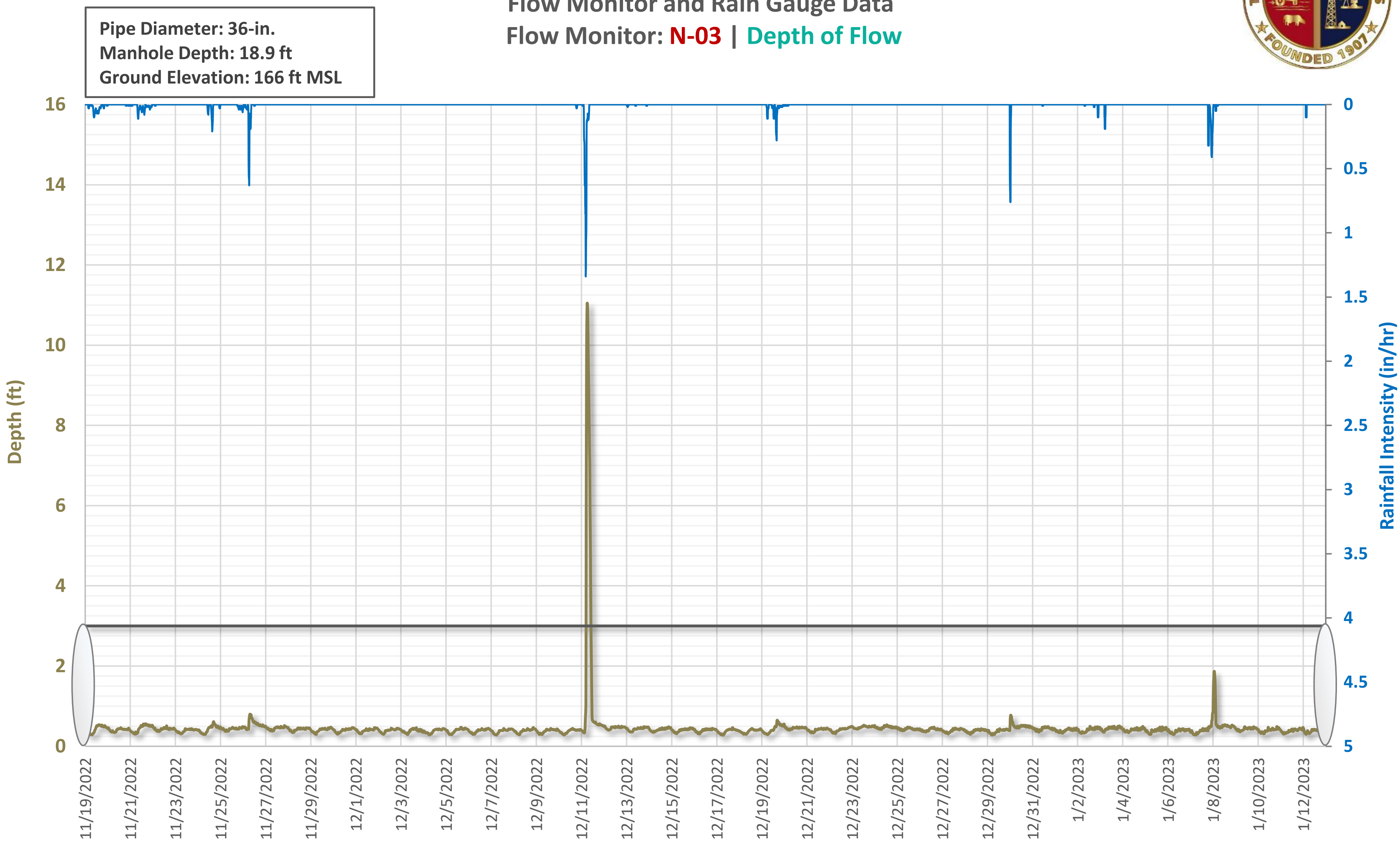


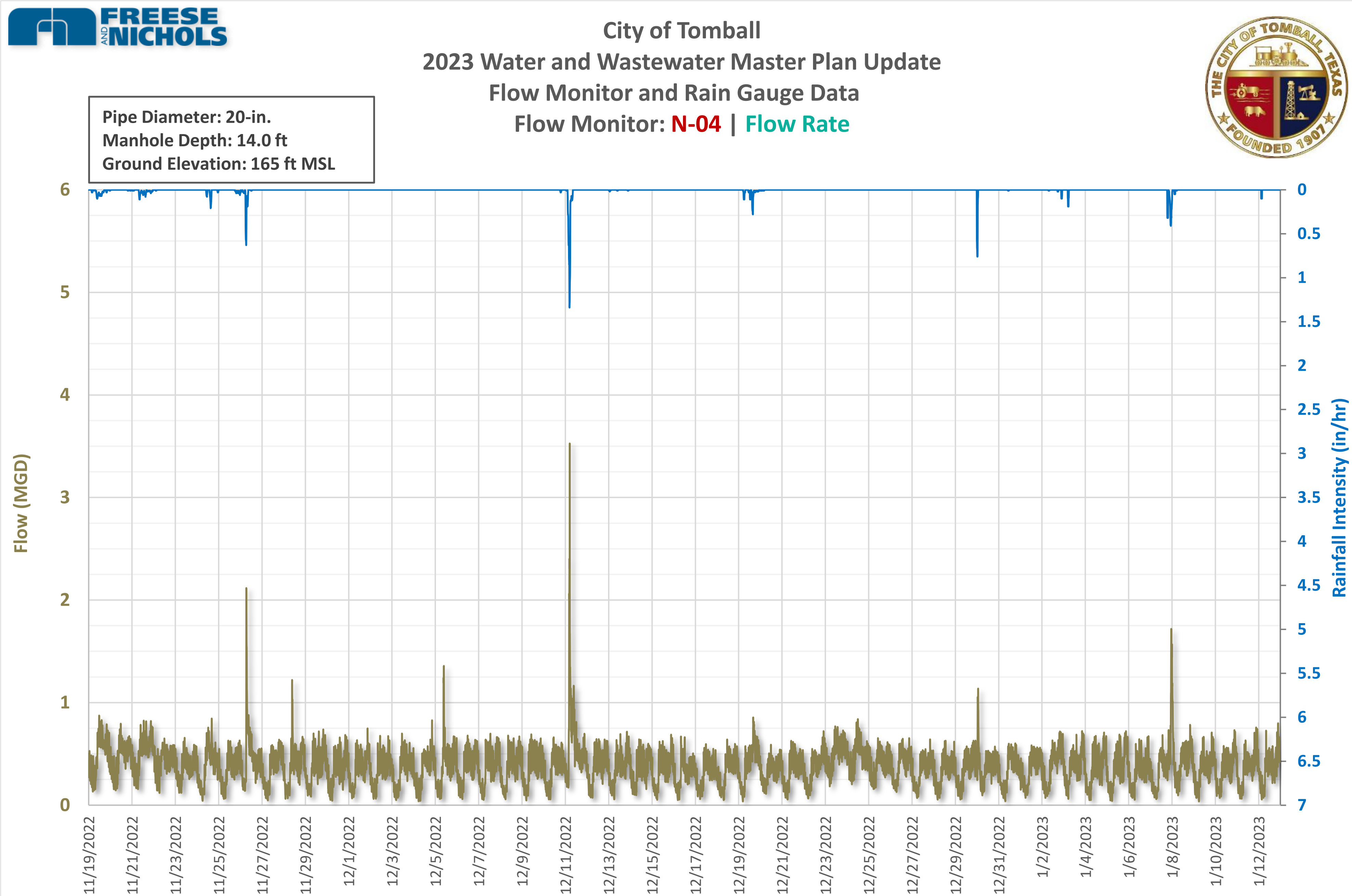
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-03 | Flow Rate

Pipe Diameter: 36-in.
Manhole Depth: 18.9 ft
Ground Elevation: 166 ft MSL



City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-03 | Depth of Flow

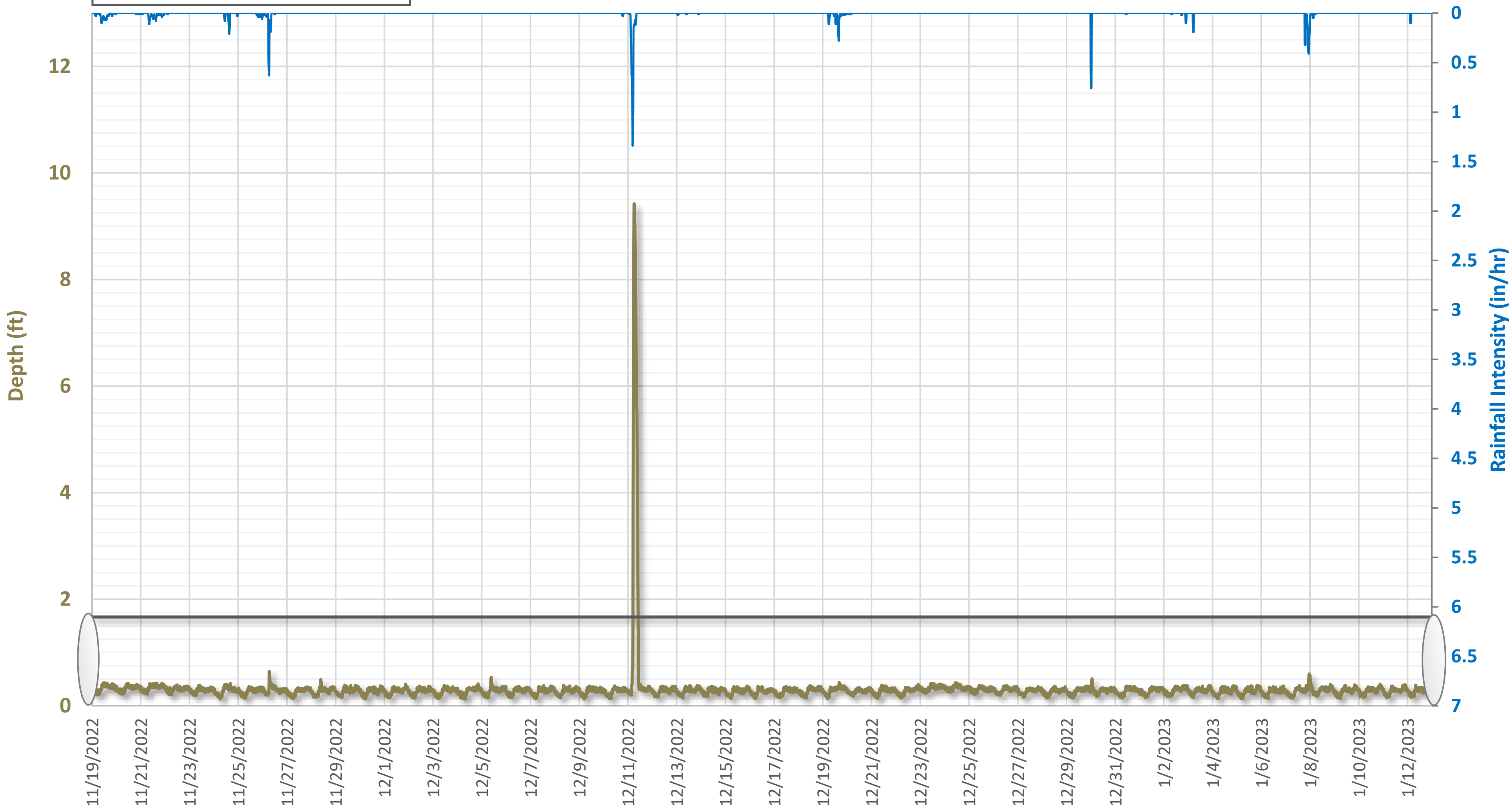


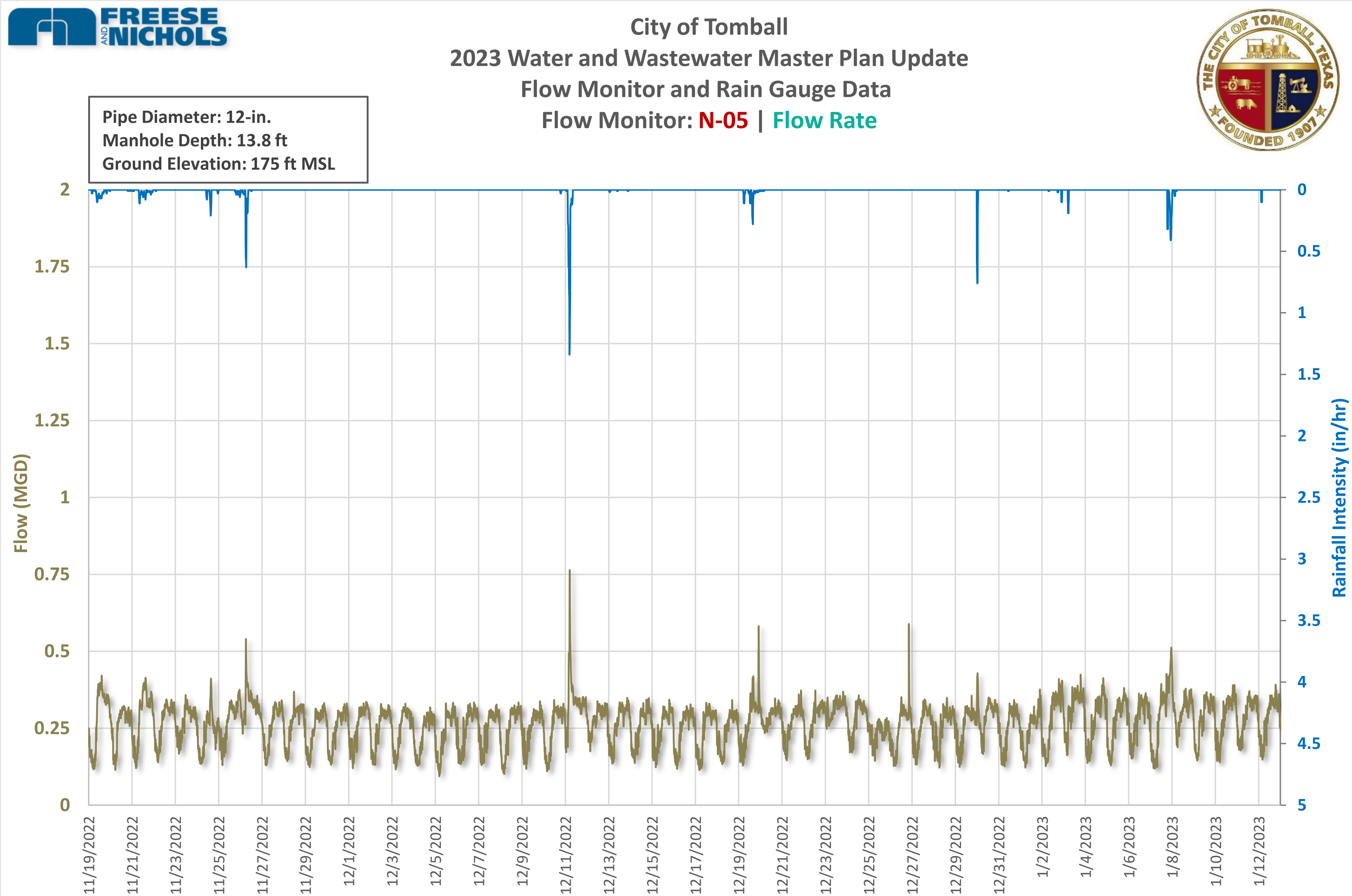


FREESE AND NICHOLS
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-04 | Flow Rate
THE CITY OF TOMBALL, TEXAS
FOUNDED 1907
Pipe Diameter: 20-in.
Manhole Depth: 14.0 ft
Ground Elevation: 165 ft MSL
Flow (MGD)
Rainfall Intensity (in/hr)
0
1
2
3
4
5
6
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7
11/19/2022
11/21/2022
11/23/2022
11/25/2022
11/27/2022
11/29/2022
12/1/2022
12/3/2022
12/5/2022
12/7/2022
12/9/2022
12/11/2022
12/13/2022
12/15/2022
12/17/2022
12/19/2022
12/21/2022
12/23/2022
12/25/2022
12/27/2022
12/29/2022
12/31/2022
1/2/2023
1/4/2023
1/6/2023
1/8/2023
1/10/2023
1/12/2023

City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-04 | Depth of Flow

Pipe Diameter: 20-in.
Manhole Depth: 14.0 ft
Ground Elevation: 165 ft MSL

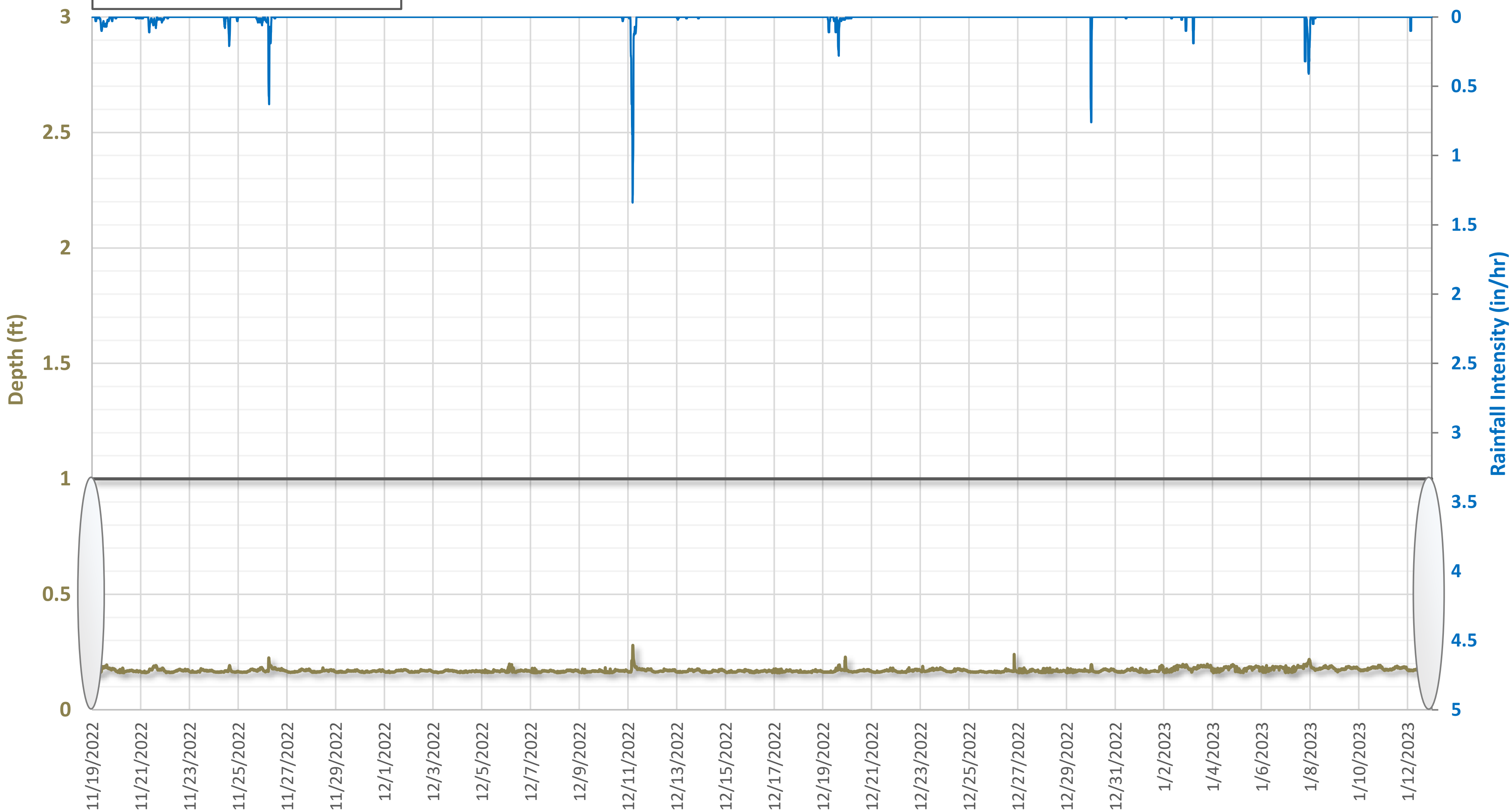




FREESE AND NICHOLS
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-05 | Flow Rate
THE CITY OF TOMBALL, TEXAS
FOUNDED 1907
Pipe Diameter: 12-in.
Manhole Depth: 13.8 ft
Ground Elevation: 175 ft MSL
Flow (MGD)
Rainfall Intensity (in/hr)
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/19/2022
11/21/2022
11/23/2022
11/25/2022
11/27/2022
11/29/2022
12/1/2022
12/3/2022
12/5/2022
12/7/2022
12/9/2022
12/11/2022
12/13/2022
12/15/2022
12/17/2022
12/19/2022
12/21/2022
12/23/2022
12/25/2022
12/27/2022
12/29/2022
12/31/2022
1/2/2023
1/4/2023
1/6/2023
1/8/2023
1/10/2023
1/12/2023

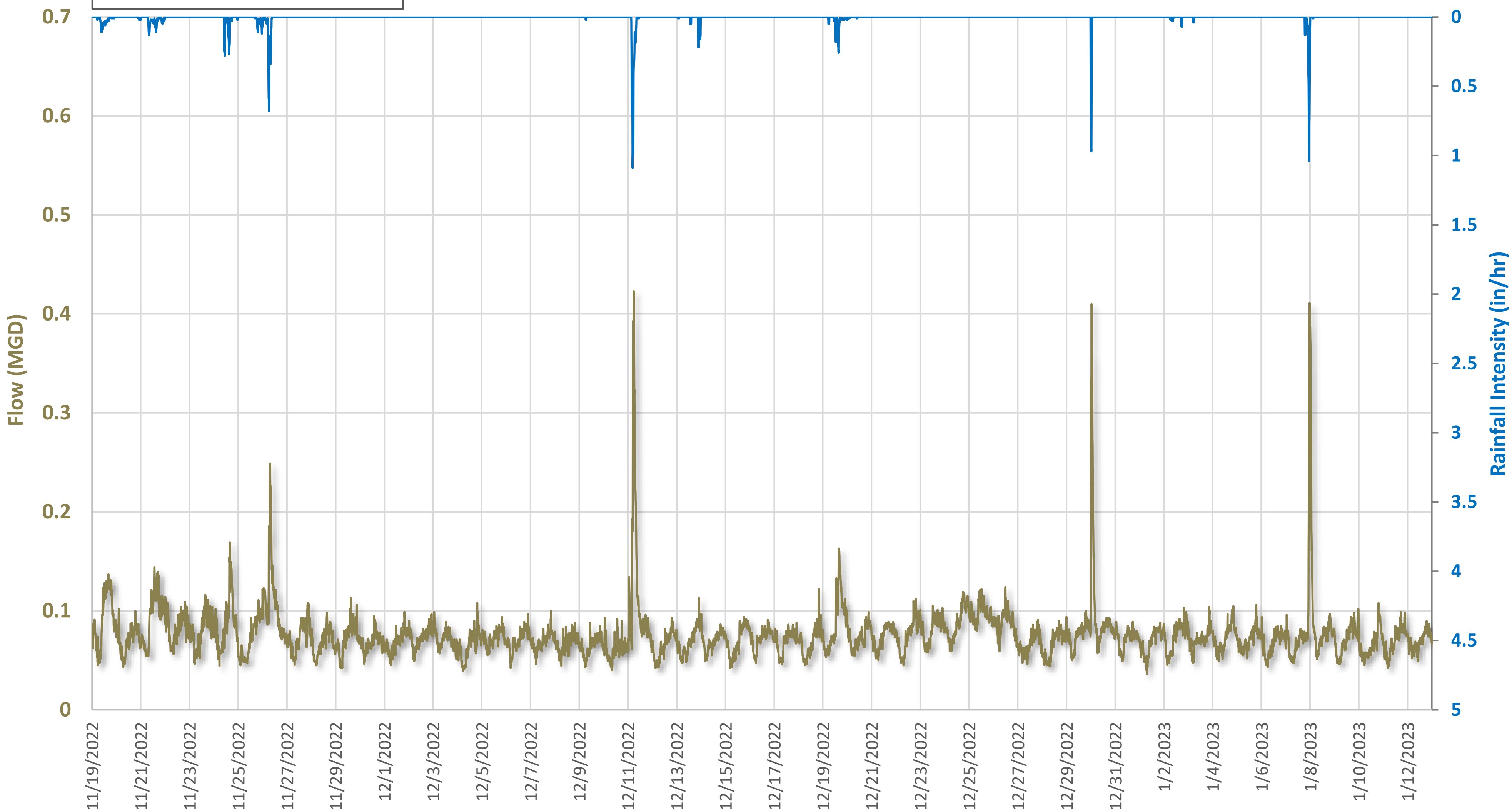
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: N-05 | Depth of Flow

Pipe Diameter: 12-in.
Manhole Depth: 13.8 ft
Ground Elevation: 175 ft MSL



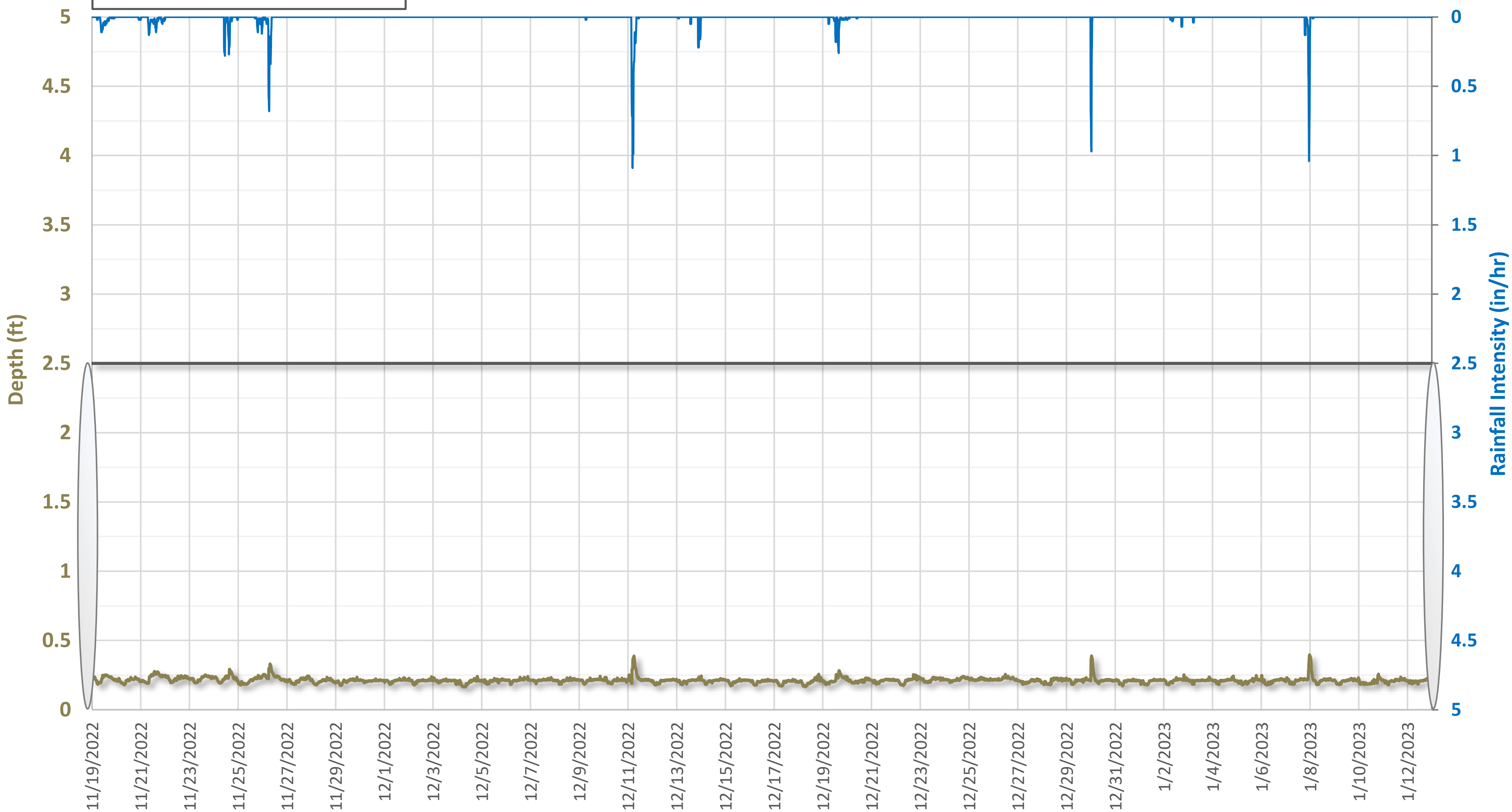
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-01 | Flow Rate

Pipe Diameter: 30-in.
Manhole Depth: 9.9 ft
Ground Elevation: 152 ft MSL



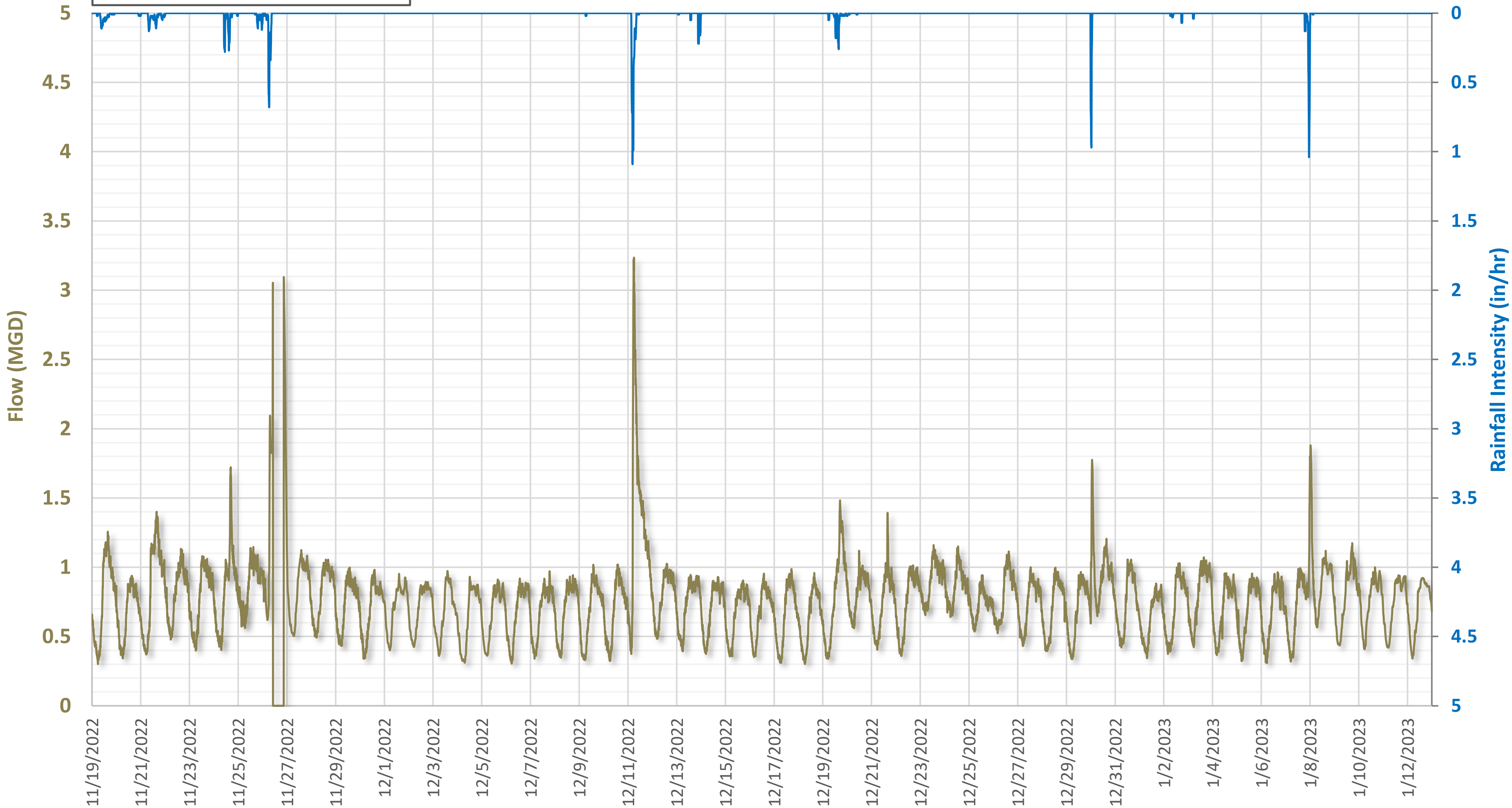
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-01 | Depth of Flow

Pipe Diameter: 30-in.
Manhole Depth: 9.9 ft
Ground Elevation: 152 ft MSL



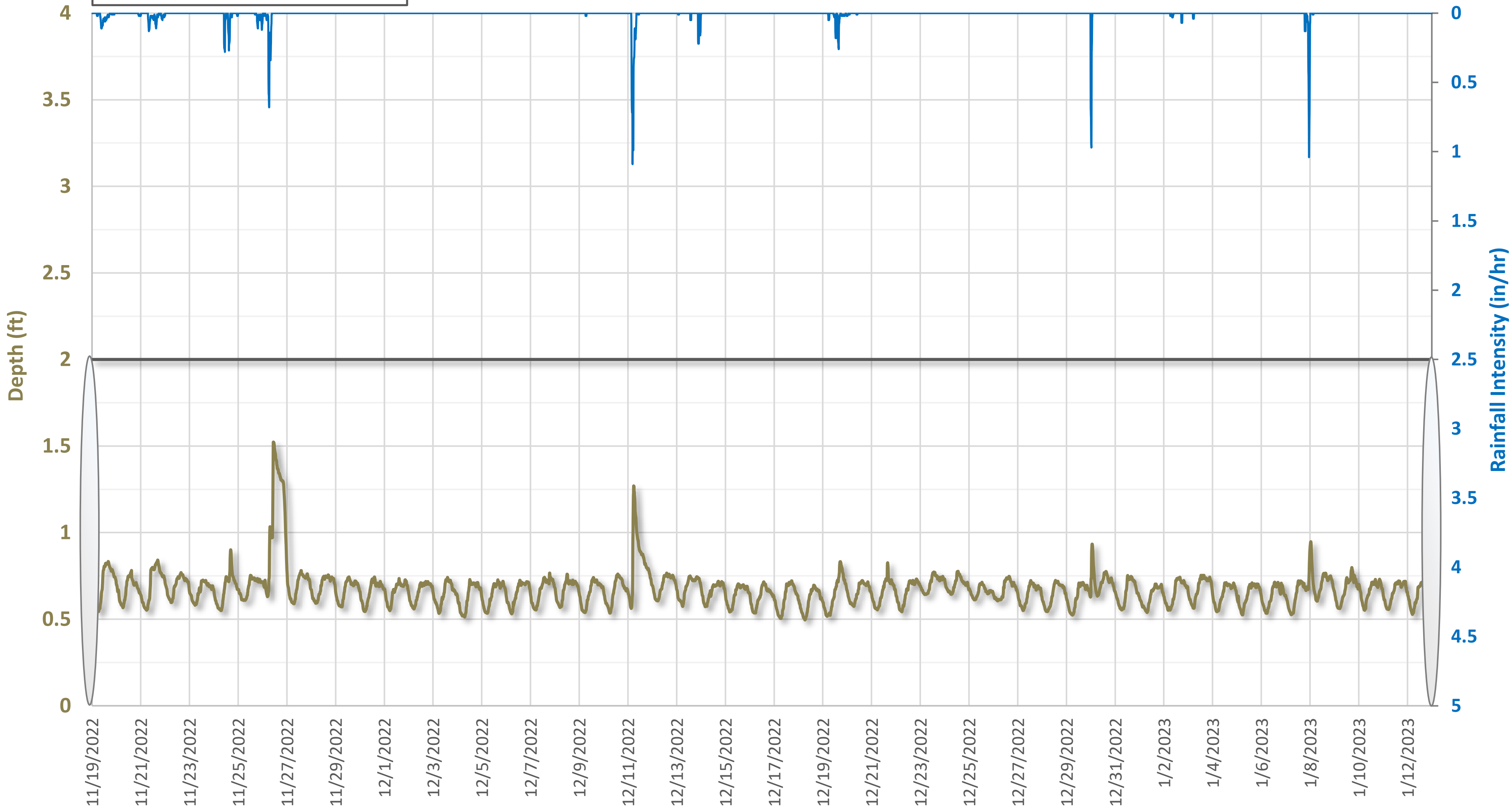
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-02 | Flow Rate

Pipe Diameter: 24-in.
Manhole Depth: 13.75 ft
Ground Elevation: 153 ft MSL



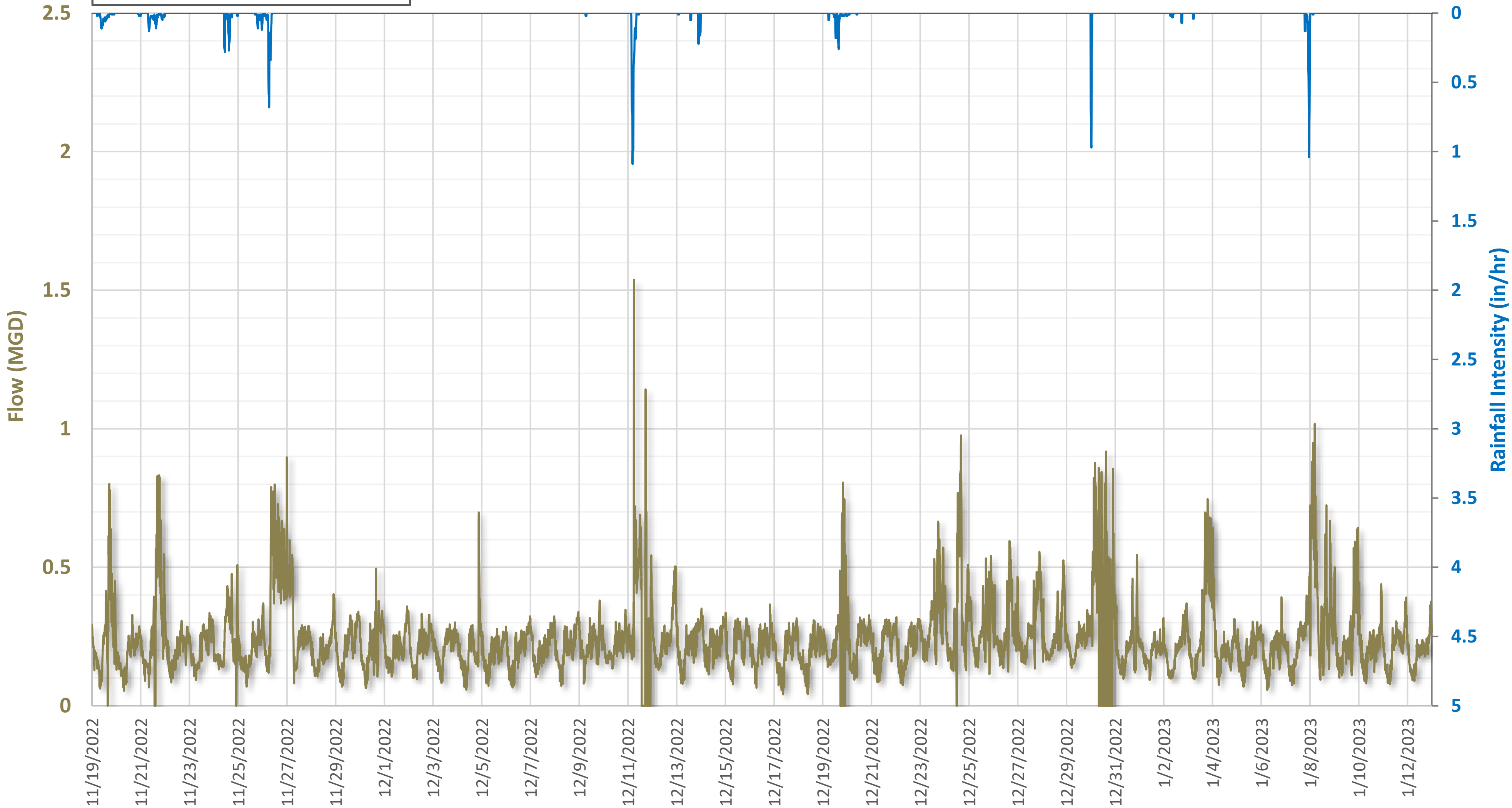
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-02 | Depth of Flow

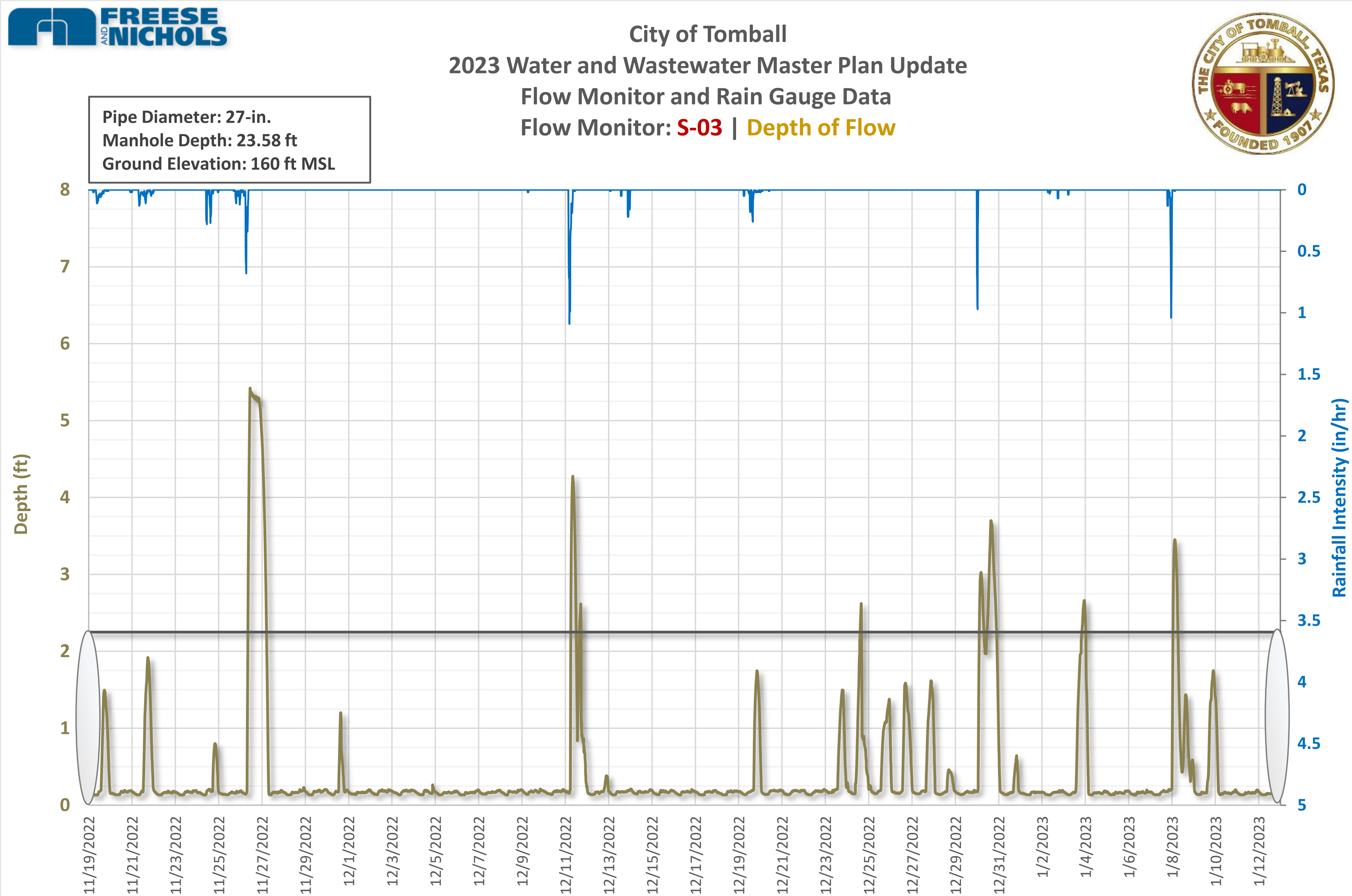
Pipe Diameter: 24-in.
Manhole Depth: 13.75 ft
Ground Elevation: 153 ft MSL



City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-03 | Flow Rate

Pipe Diameter: 27-in.
Manhole Depth: 23.58 ft
Ground Elevation: 160 ft MSL

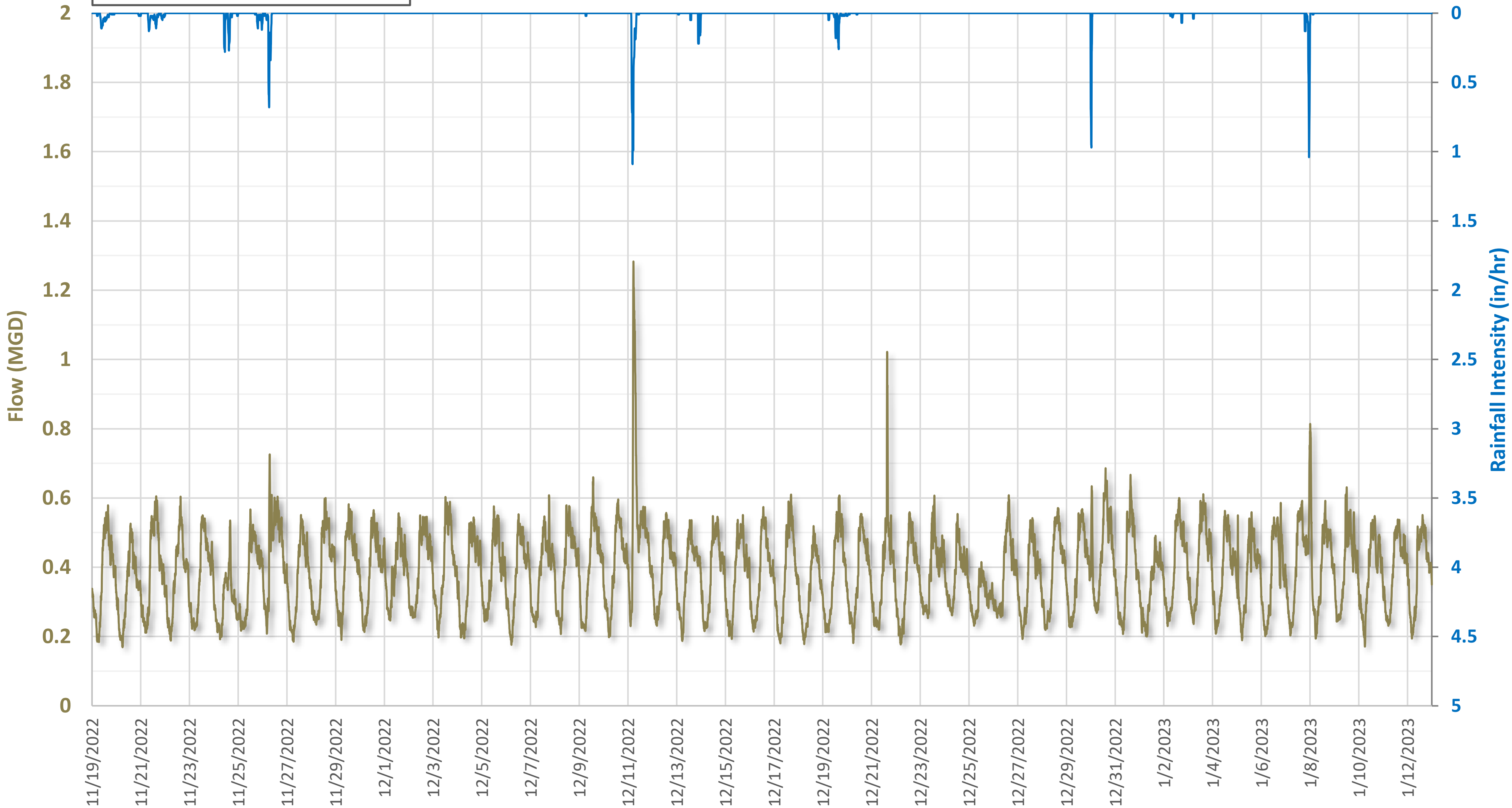




FREESE AND NICHOLS
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-03 | Depth of Flow
THE CITY OF TOMBALL, TEXAS
FOUNDED 1907
Pipe Diameter: 27-in.
Manhole Depth: 23.58 ft
Ground Elevation: 160 ft MSL
Depth (ft)
Rainfall Intensity (in/hr)
0
1
2
3
4
5
6
7
8
0.5
1.5
2.5
3.5
4.5
11/19/2022
11/21/2022
11/23/2022
11/25/2022
11/27/2022
11/29/2022
12/1/2022
12/3/2022
12/5/2022
12/7/2022
12/9/2022
12/11/2022
12/13/2022
12/15/2022
12/17/2022
12/19/2022
12/21/2022
12/23/2022
12/25/2022
12/27/2022
12/29/2022
12/31/2022
1/2/2023
1/4/2023
1/6/2023
1/8/2023
1/10/2023
1/12/2023

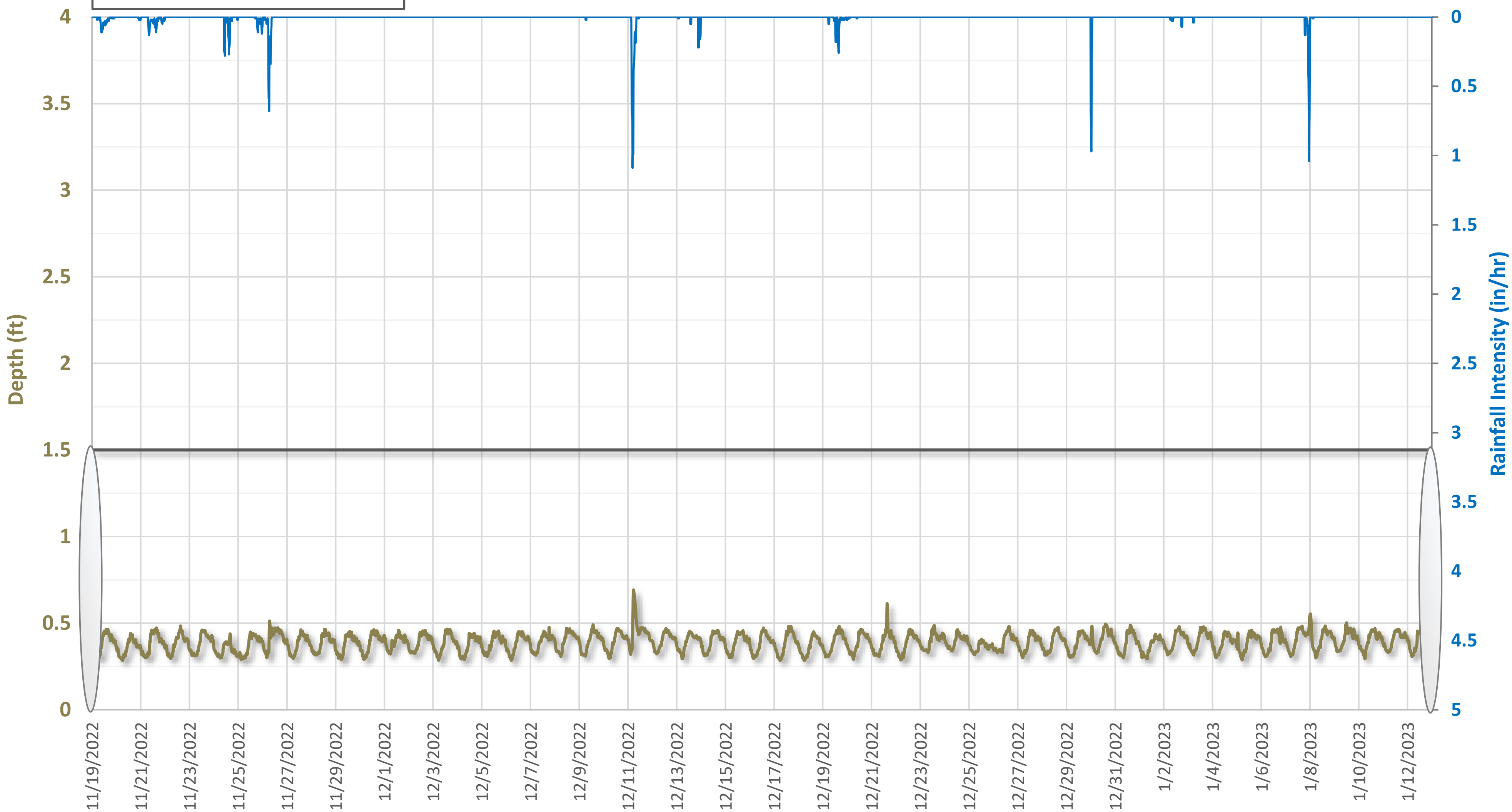
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-04 | Flow Rate

Pipe Diameter: 18-in.
Manhole Depth: 9.91 ft
Ground Elevation: 165 ft MSL



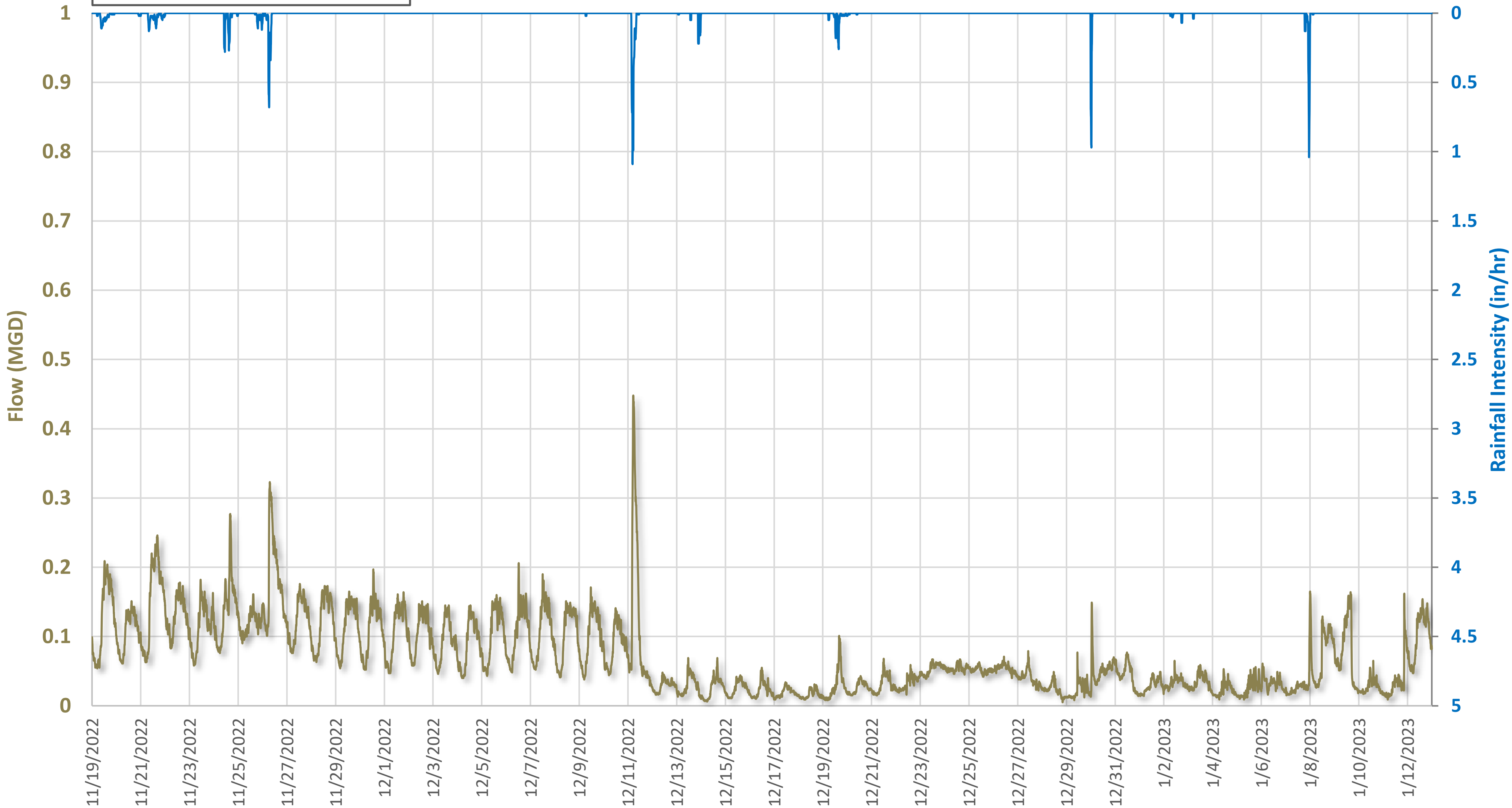
City of Tomball
Wastewater Master Plan
Flow Monitor and Rain Gauge Data
Flow Monitor: S-04 | Depth of Flow

Pipe Diameter: 18-in.
Manhole Depth: 9.91 ft
Ground Elevation: 165 ft MSL



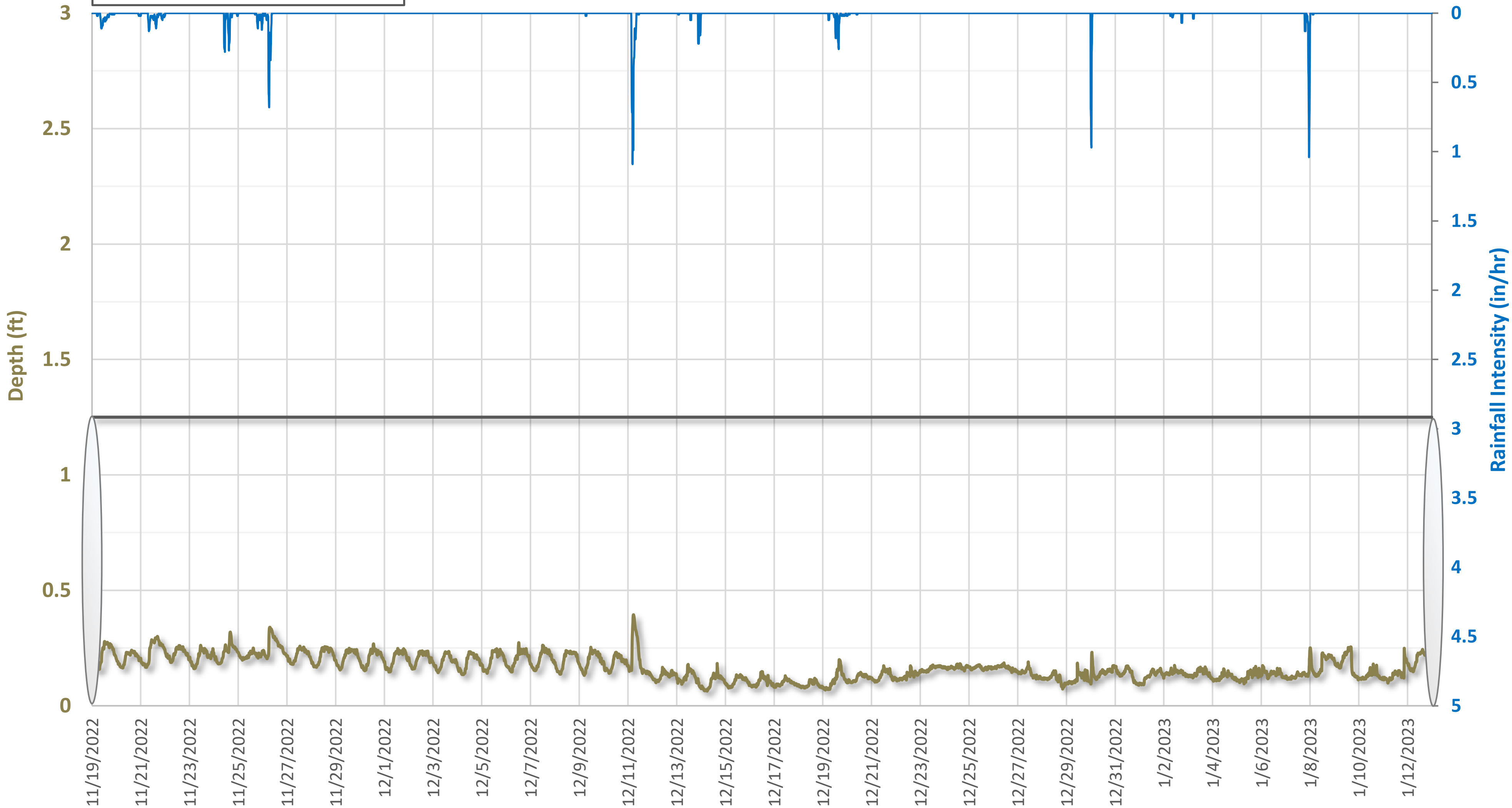
City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-05 | Flow Rate

Pipe Diameter: 15-in.
Manhole Depth: 9.9 ft
Ground Elevation: 175 ft MSL



City of Tomball
2023 Water and Wastewater Master Plan Update
Flow Monitor and Rain Gauge Data
Flow Monitor: S-05 | Depth of Flow

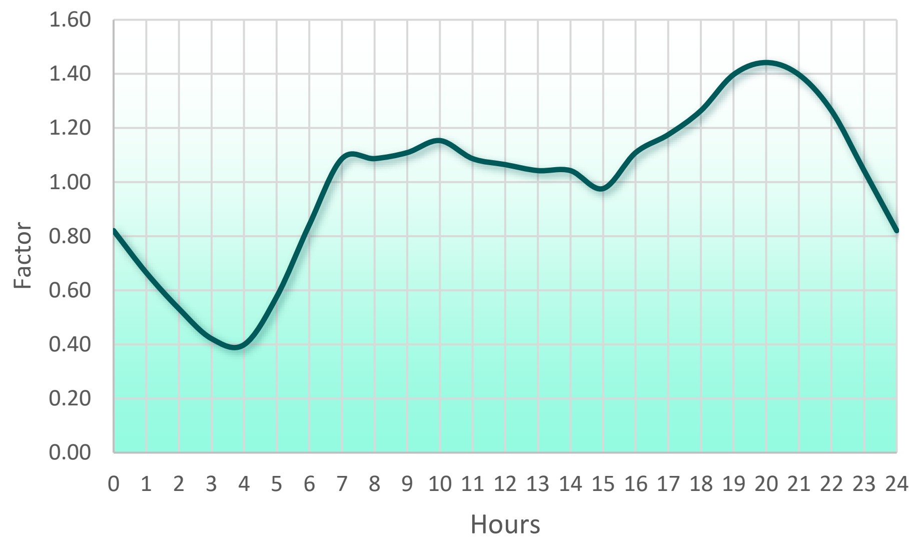
Pipe Diameter: 15-in.
Manhole Depth: 9.9 ft
Ground Elevation: 175 ft MSL



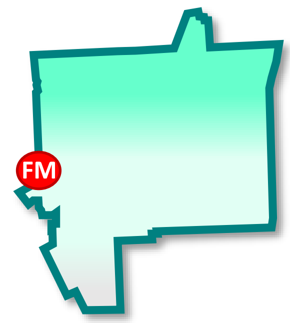
APPENDIX I
Wastewater Diurnal Patterns

City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns

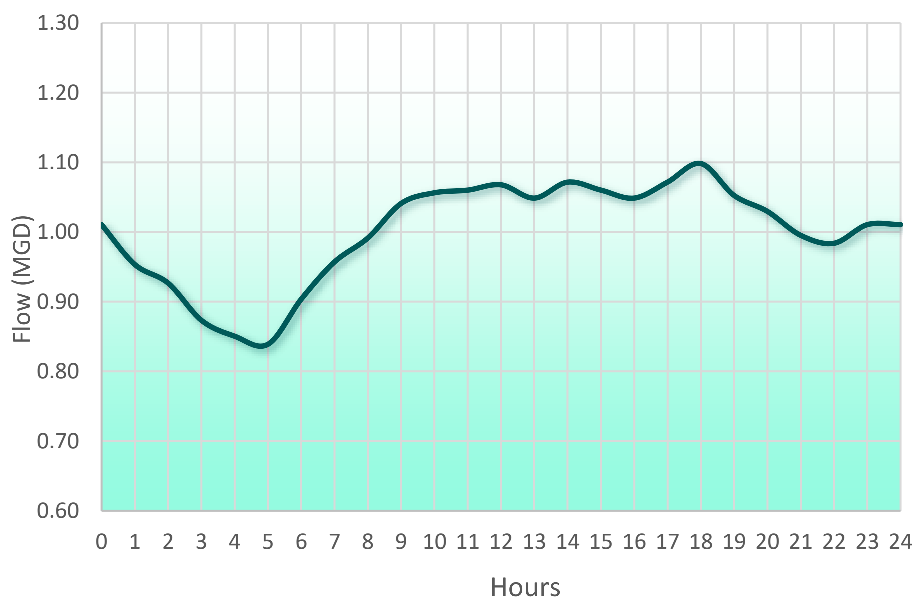
Flow Monitor: N-01



Average Dry Flow
0.03 MGD



Flow Monitor: N-02

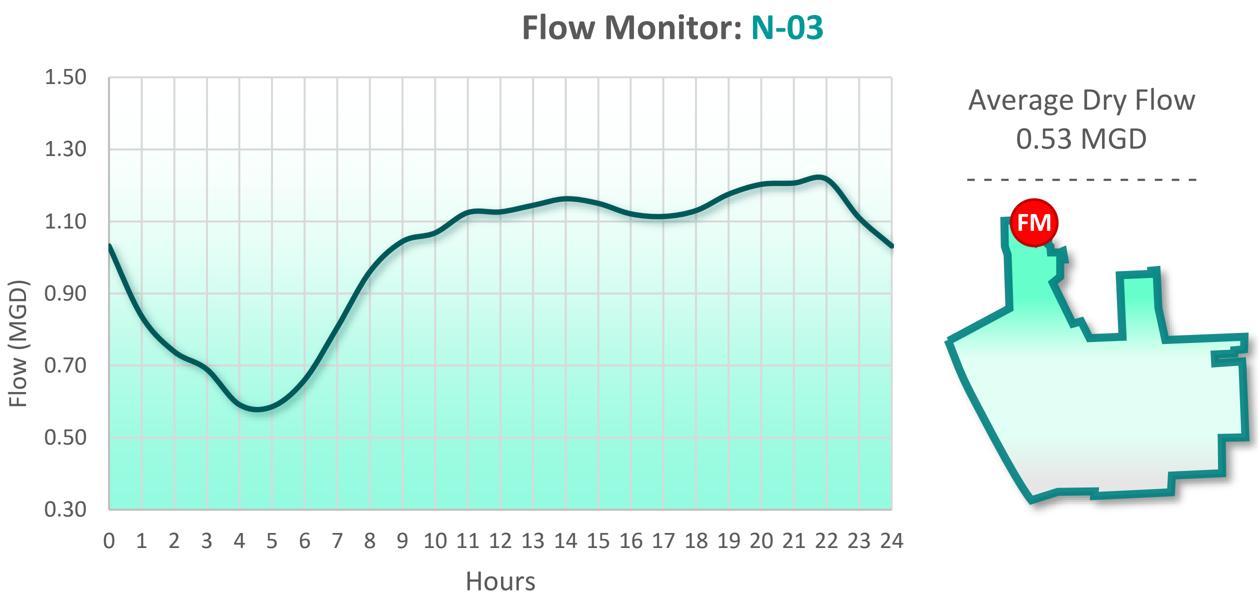


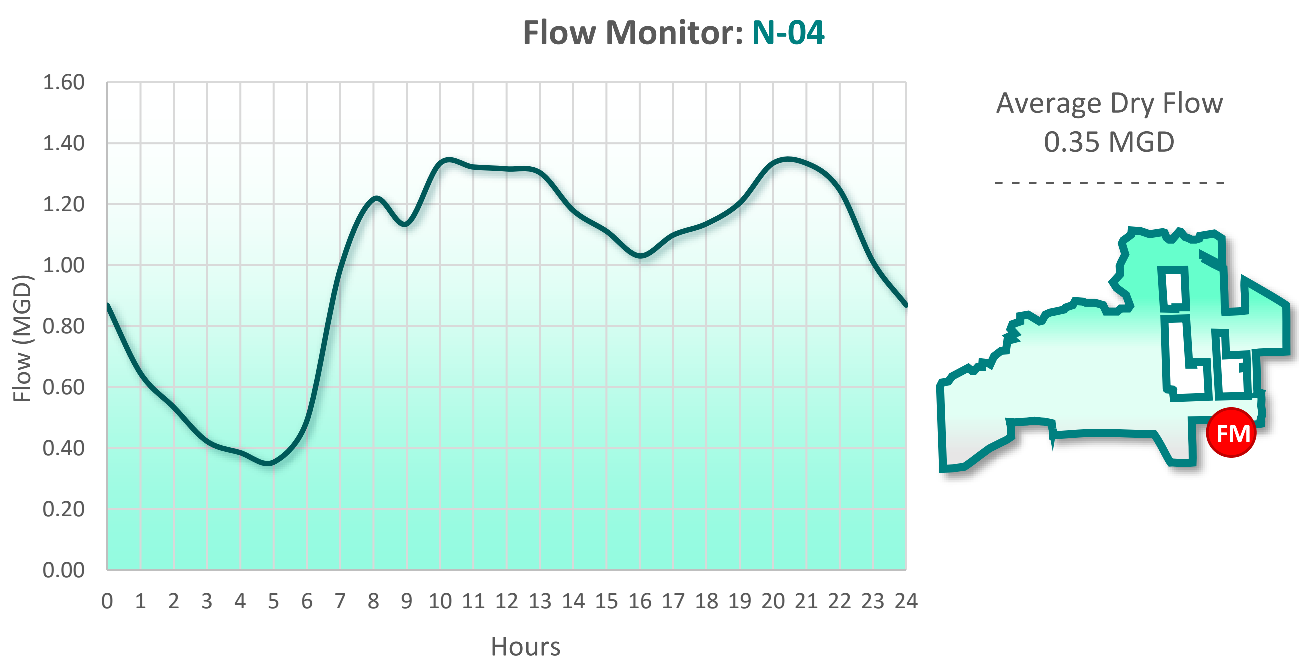
Average Dry Flow
0.40 MGD

Weekday Diurnal

FM *Flow Monitor Location*

City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns

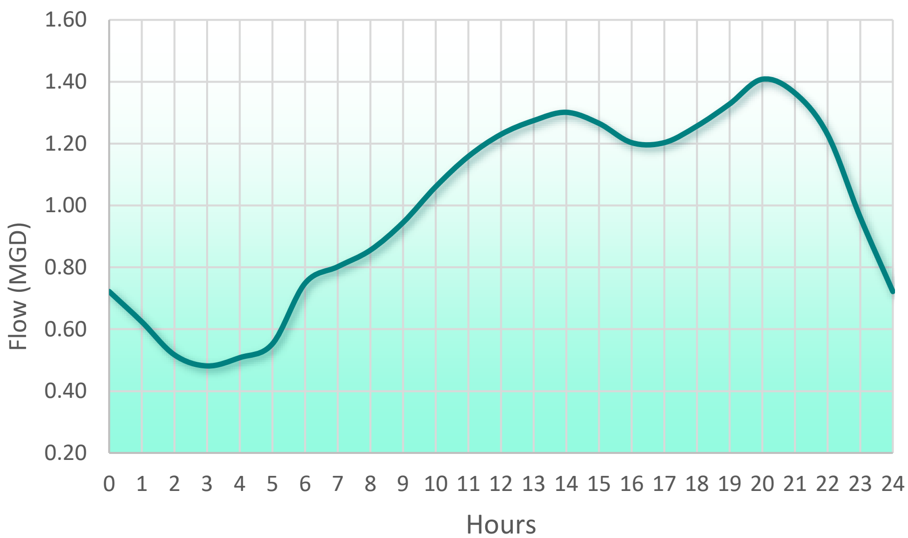




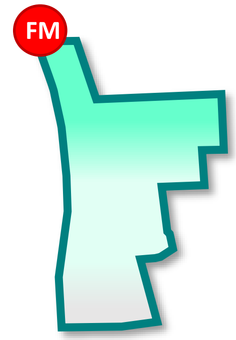
Weekday Diurnal *Weekend Diurnal* FM *Flow Monitor Location*

City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns

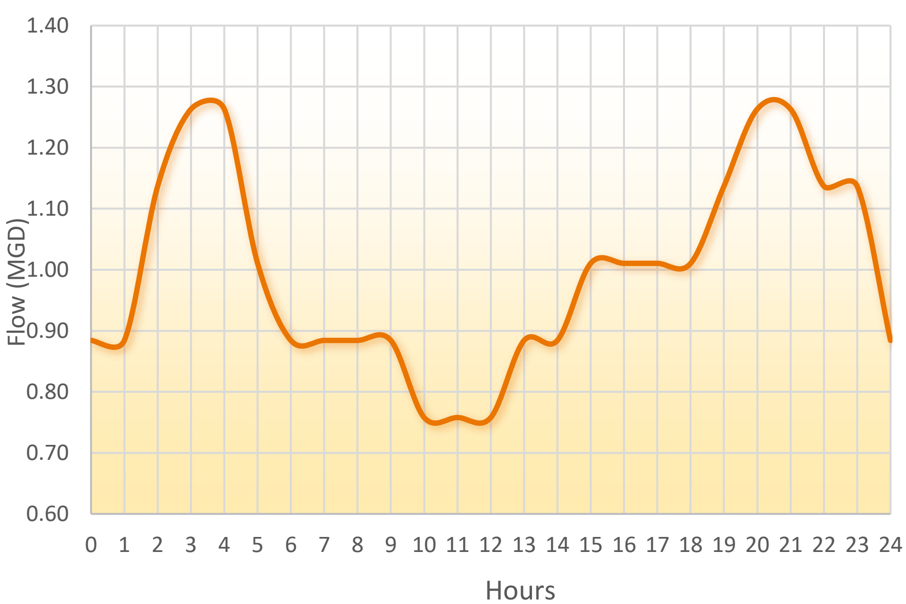
Flow Monitor: N-05



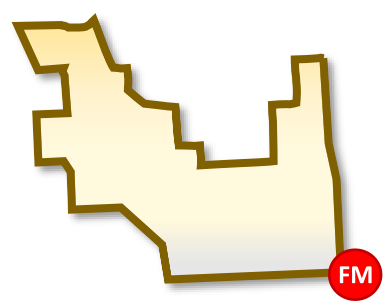
Average Dry Flow
0.26 MGD



Flow Monitor: S-01



Average Dry Flow
0.007 MGD

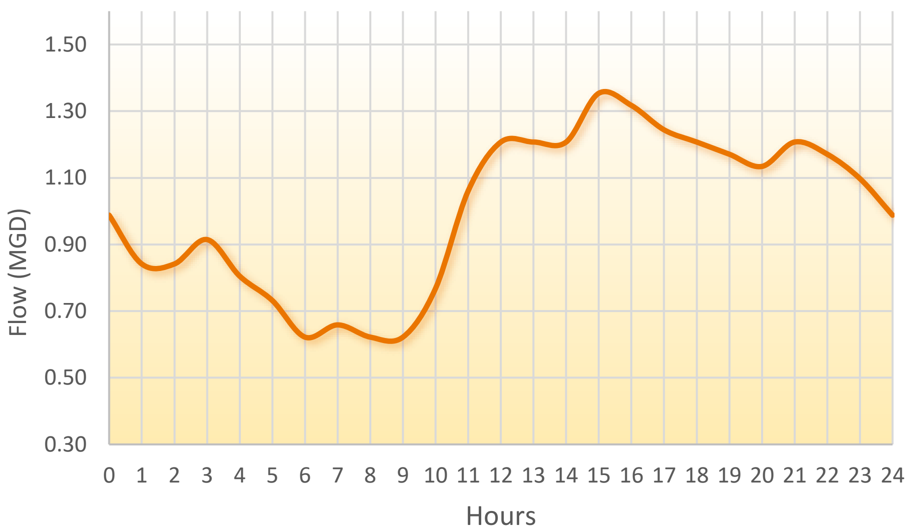


Weekday Diurnal

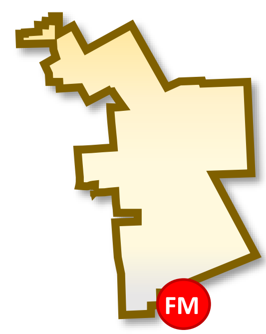
FM *Flow Monitor Location*

City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns

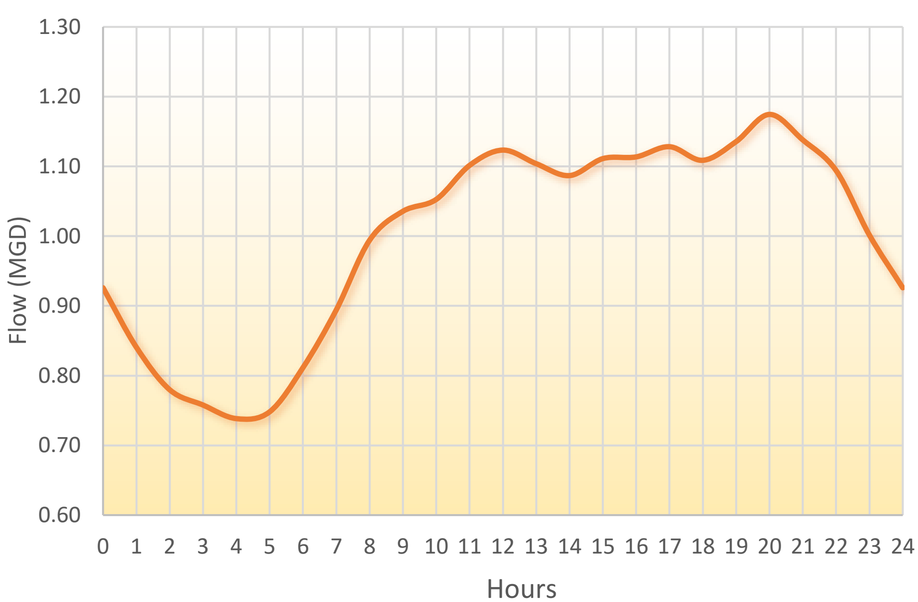
Flow Monitor: S-02



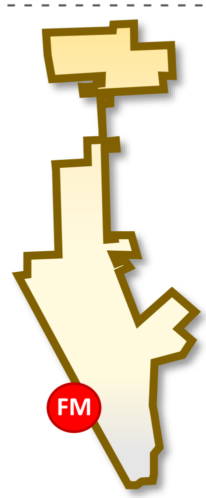
Average Dry Flow
0.70 MGD



Flow Monitor: S-03



Average Dry Flow
0.20 MGD

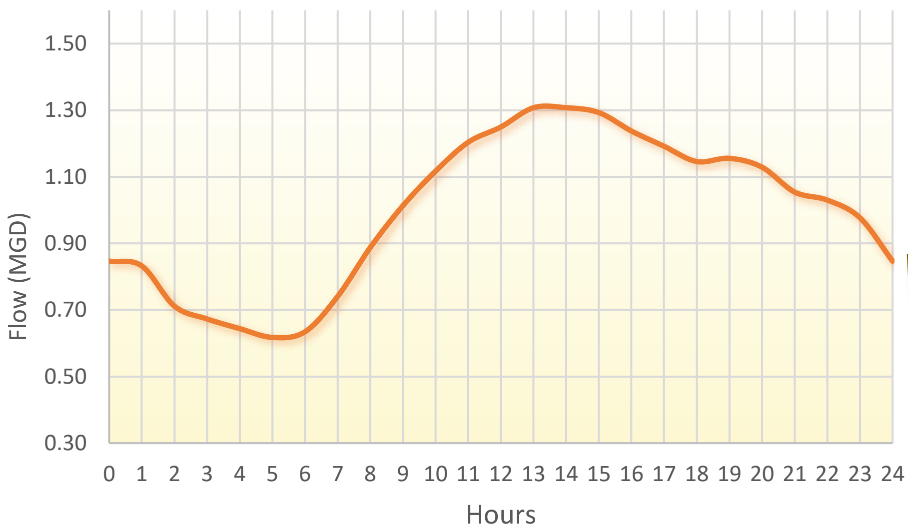


Weekday Diurnal

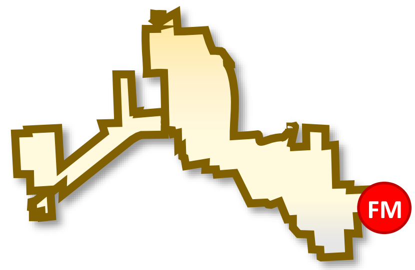
FM *Flow Monitor Location*

City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns

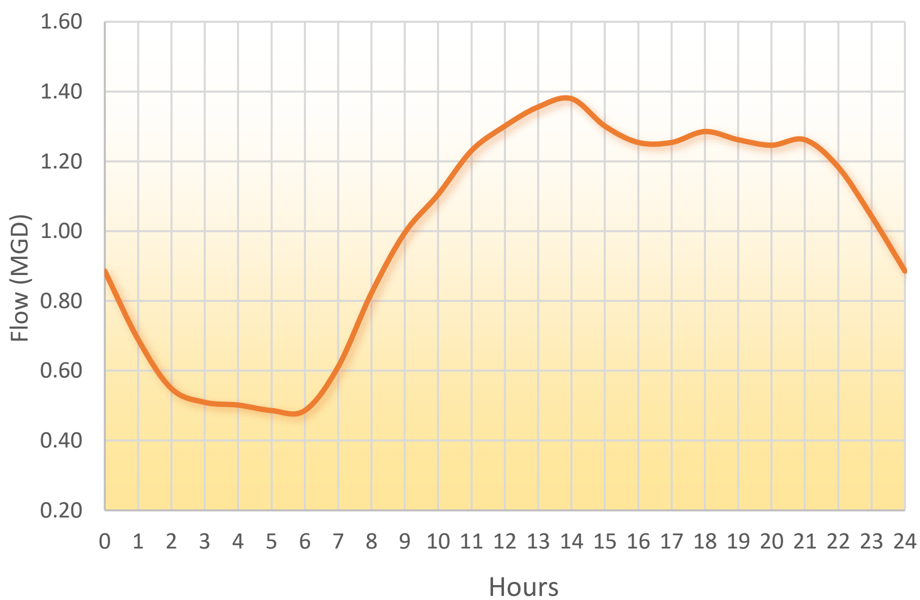
Flow Monitor: S-04



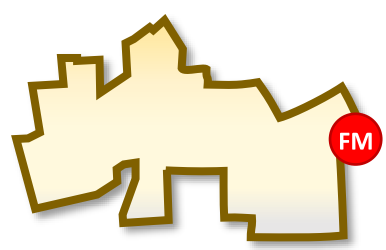
Average Dry Flow
0.38 MGD



Flow Monitor: S-05



Average Dry Flow
0.10 MGD



Weekday Diurnal

FM *Flow Monitor Location*

APPENDIX J
Wastewater Model Calibration Results

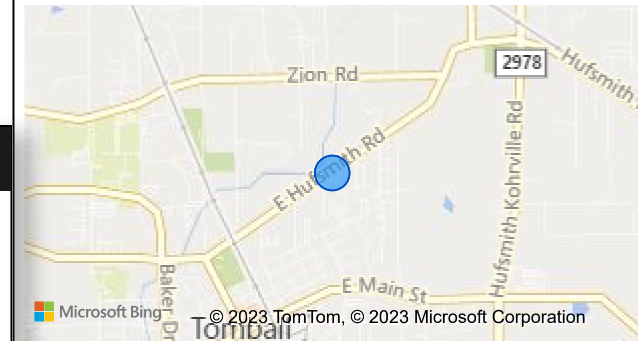
City of Tomball

Wastewater Master Plan Update

Wastewater Model Dry Weather Calibration

Flow Meter Location

FM_ID ● N-01



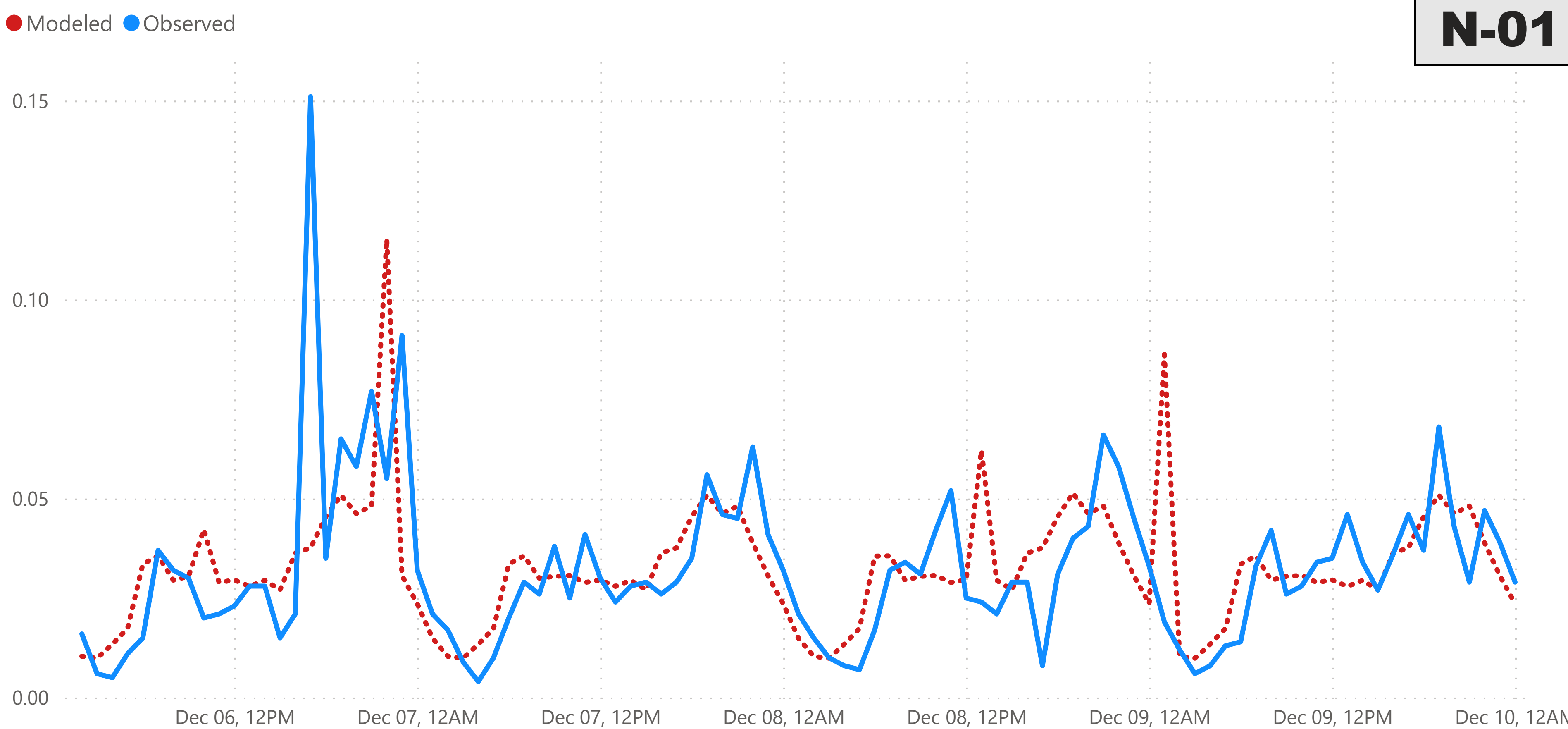
12/6/2022 12/11/2022

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow

N-01



Average Day Flow (MGD)

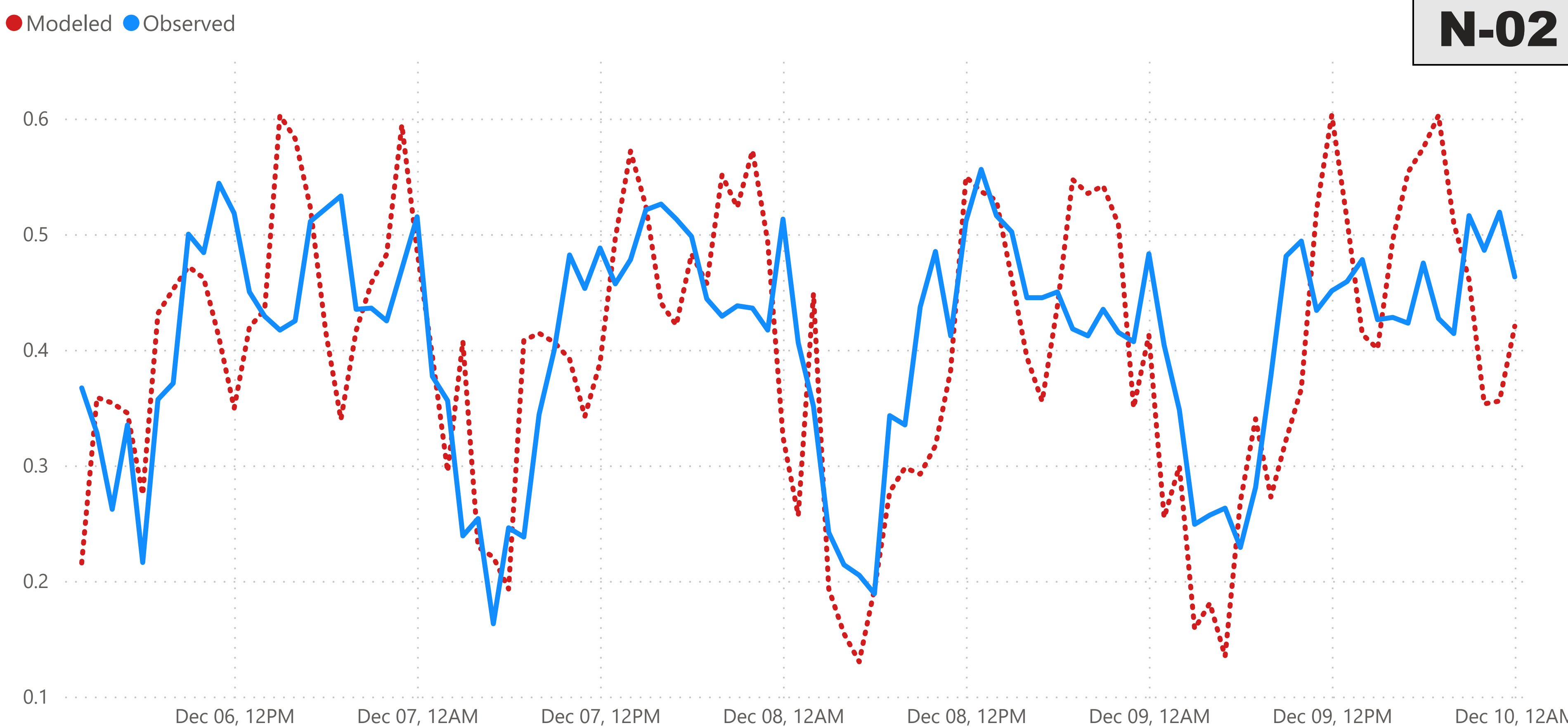
Observed	Modeled	% Difference
0.03	0.03	-1.38%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

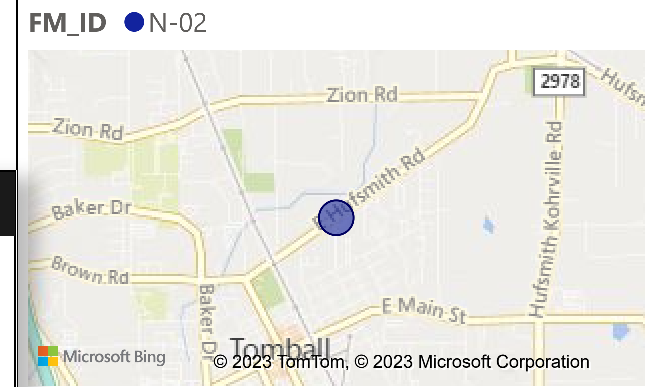
Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow



Flow Meter Location



12/6/2022 12/11/2022

Average Day Flow (MGD)

Observed	Modeled	% Difference
0.41	0.40	-3.25%

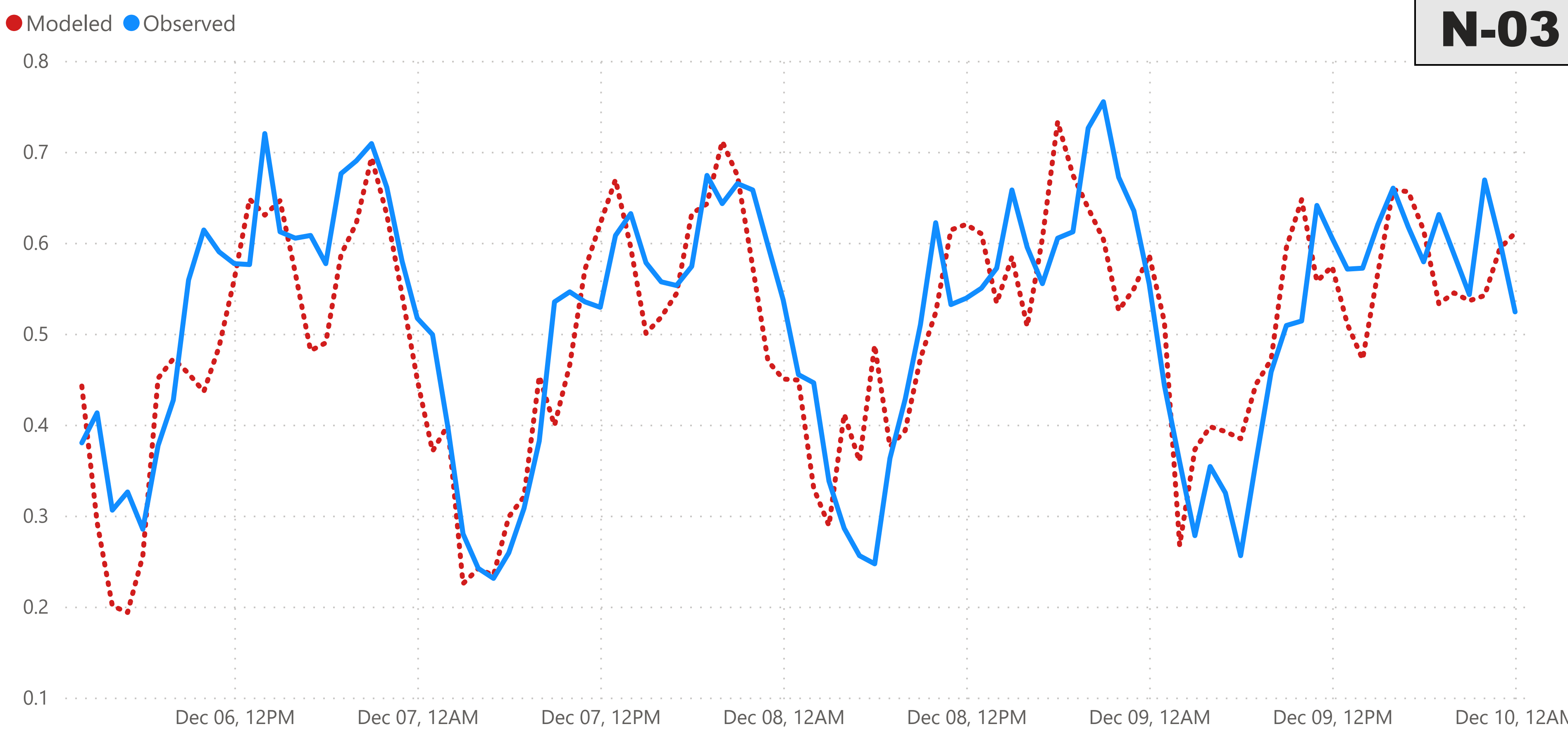
City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

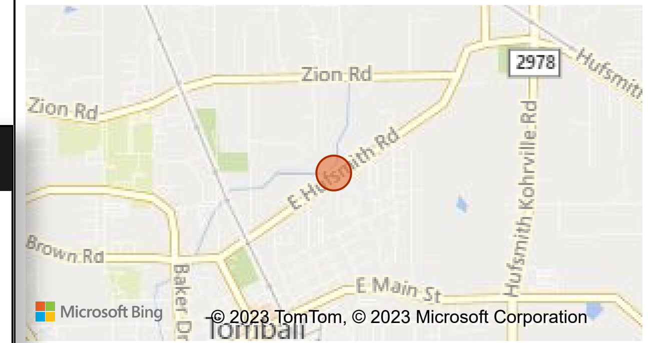
Model Calibration Results - Flow

N-03



Flow Meter Location

FM_ID N-03



12/6/2022 12/11/2022

Average Day Flow (MGD)

Observed	Modeled	% Difference
0.52	0.50	-3.60%

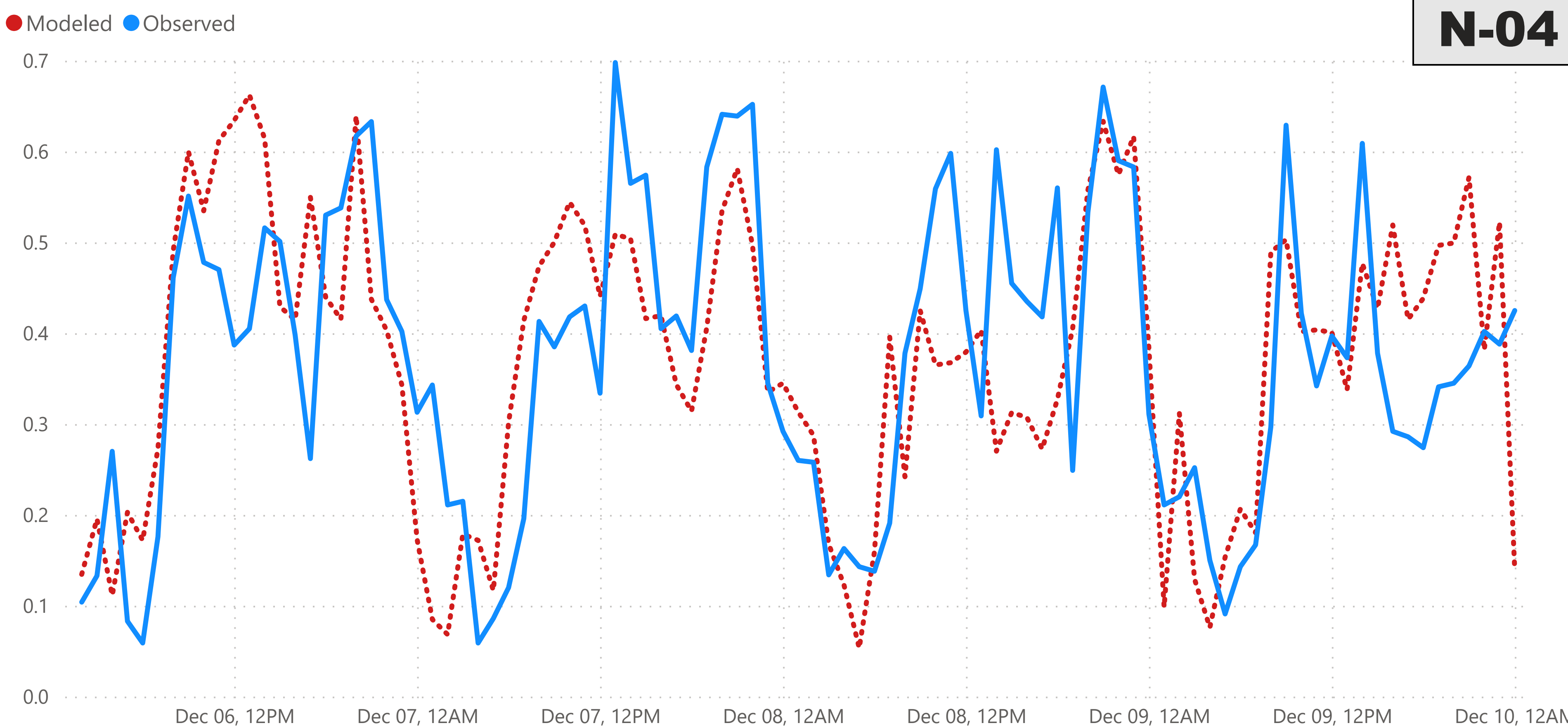
City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow

N-04



Flow Meter Location

FM_ID ● N-04

12/6/2022 12/11/2022

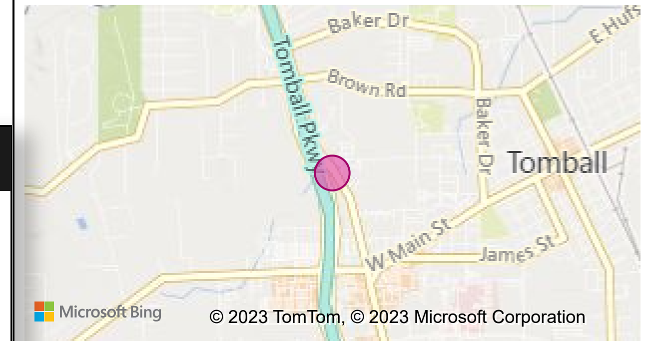
Average Day Flow (MGD)

Observed	Modeled	% Difference
0.37	0.37	-0.69%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Meter Location

FM_ID N-05



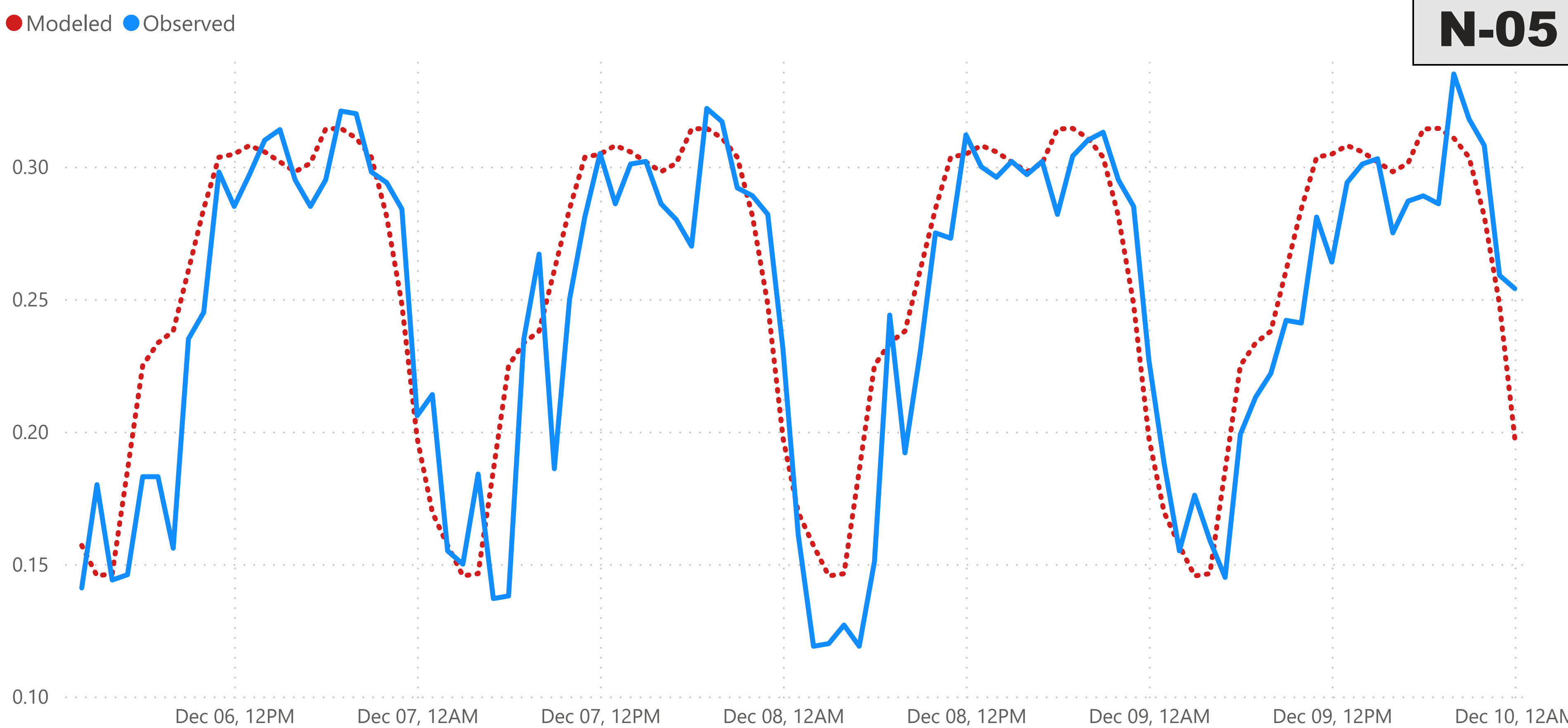
Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

12/6/2022 12/11/2022

Model Calibration Results - Flow

N-05



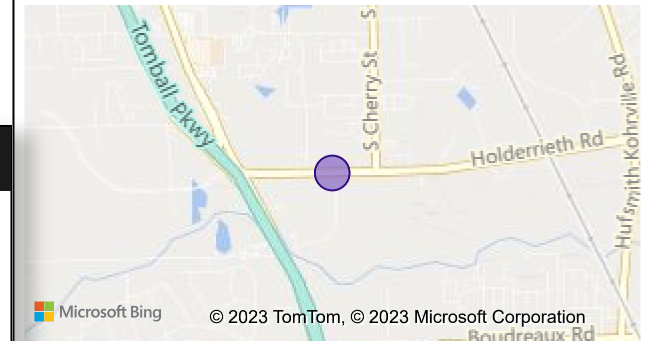
Average Day Flow (MGD)

Observed	Modeled	% Difference
0.25	0.25	2.83%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Meter Location

FM_ID ● S-01

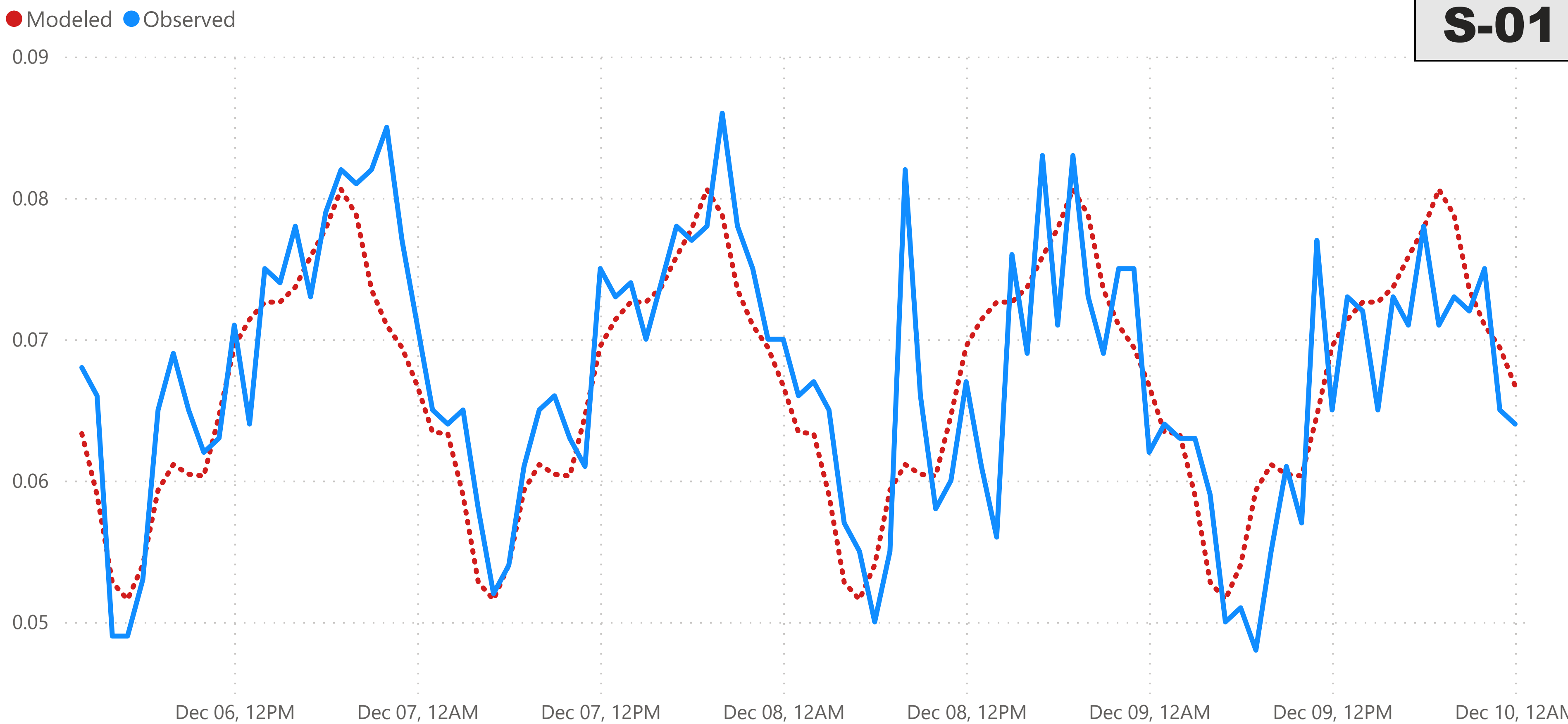


Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow

S-01



12/6/2022 12/11/2022

Average Day Flow (MGD)

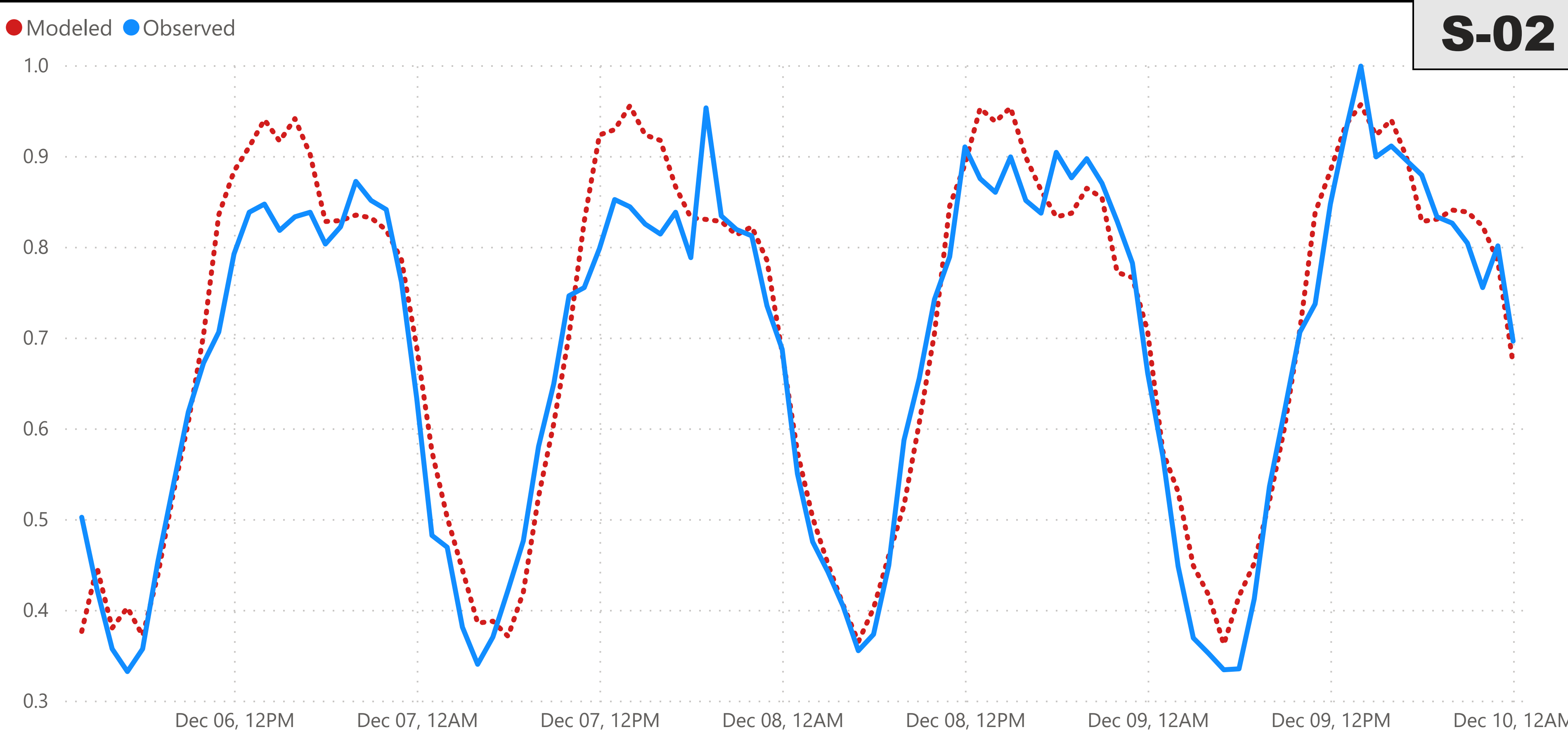
Observed	Modeled	% Difference
0.07	0.07	-1.91%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow



Flow Meter Location

FM_ID S-02

12/6/2022 12/11/2022

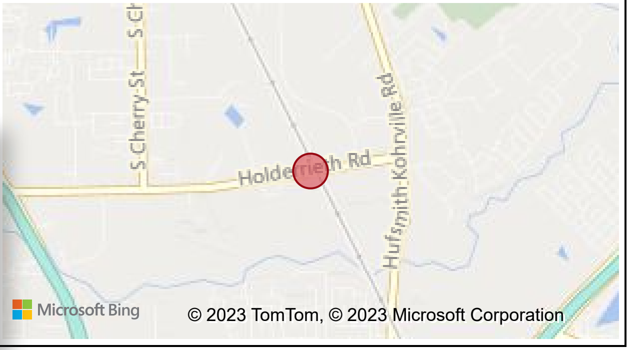
Average Day Flow (MGD)

Observed	Modeled	% Difference
0.68	0.70	1.84%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Meter Location

FM_ID S-03



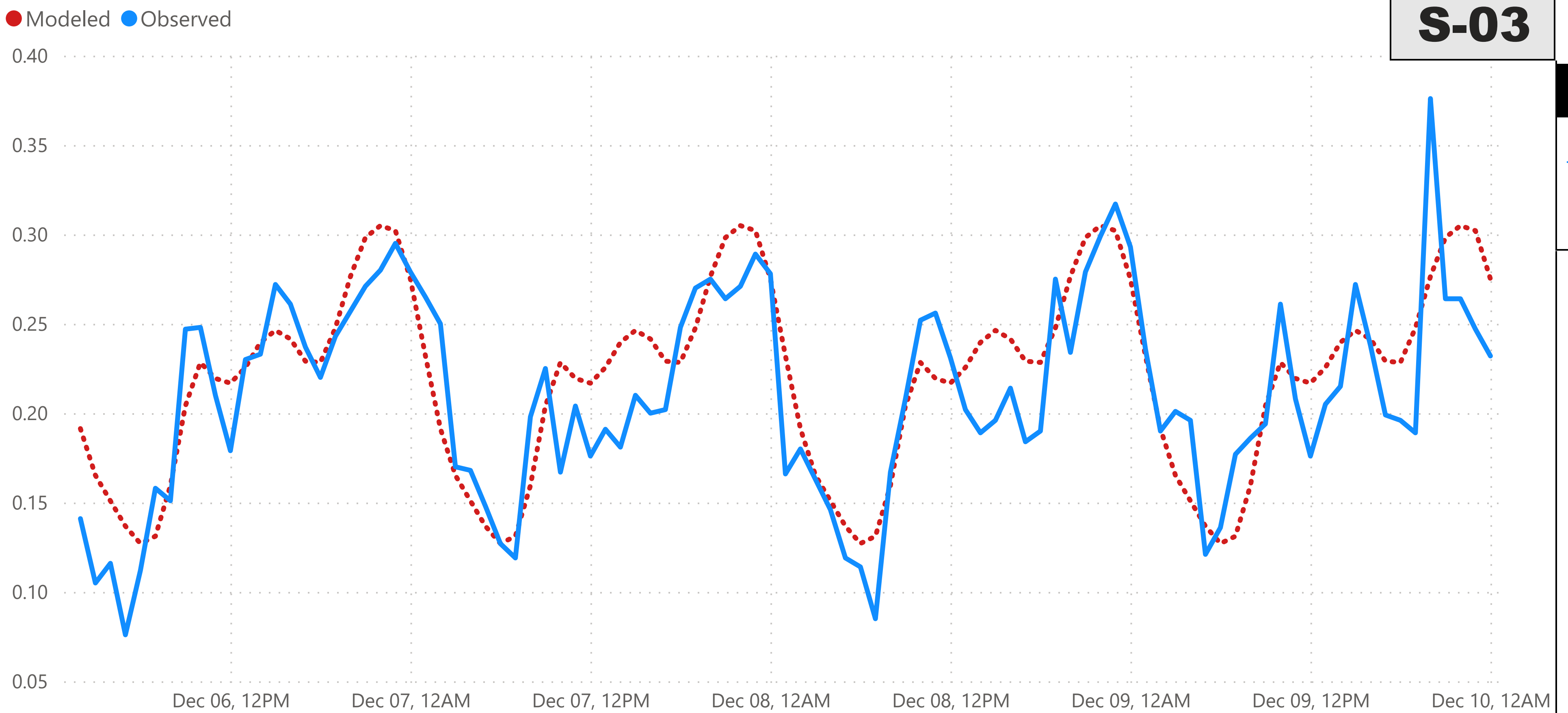
Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

12/6/2022 12/11/2022

Model Calibration Results - Flow

S-03



Average Day Flow (MGD)

Observed	Modeled	% Difference
0.21	0.22	2.52%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

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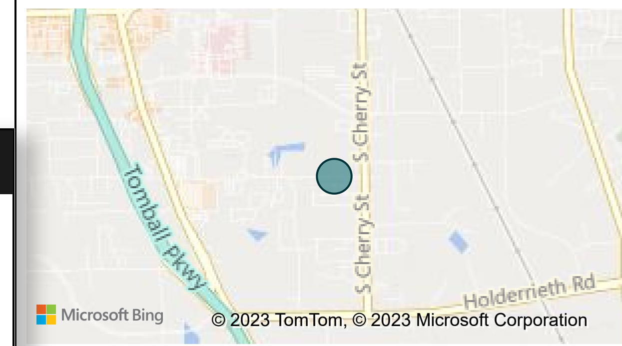
Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Flow Meter Location

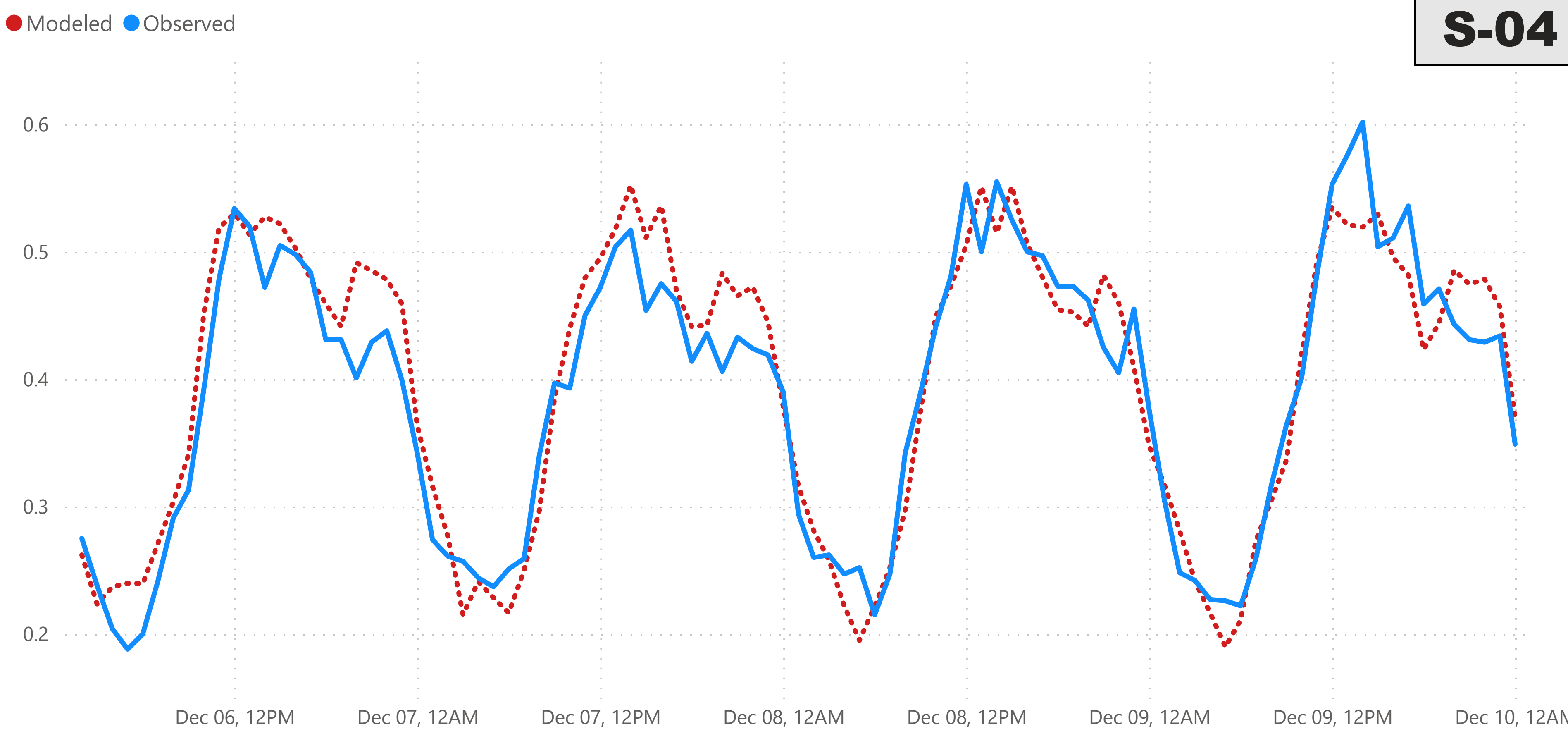
FM_ID ● S-04



12/6/2022 12/11/2022

Model Calibration Results - Flow

S-04



Average Day Flow (MGD)

Observed	Modeled	% Difference
0.39	0.39	1.22%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Dry Weather Calibration

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

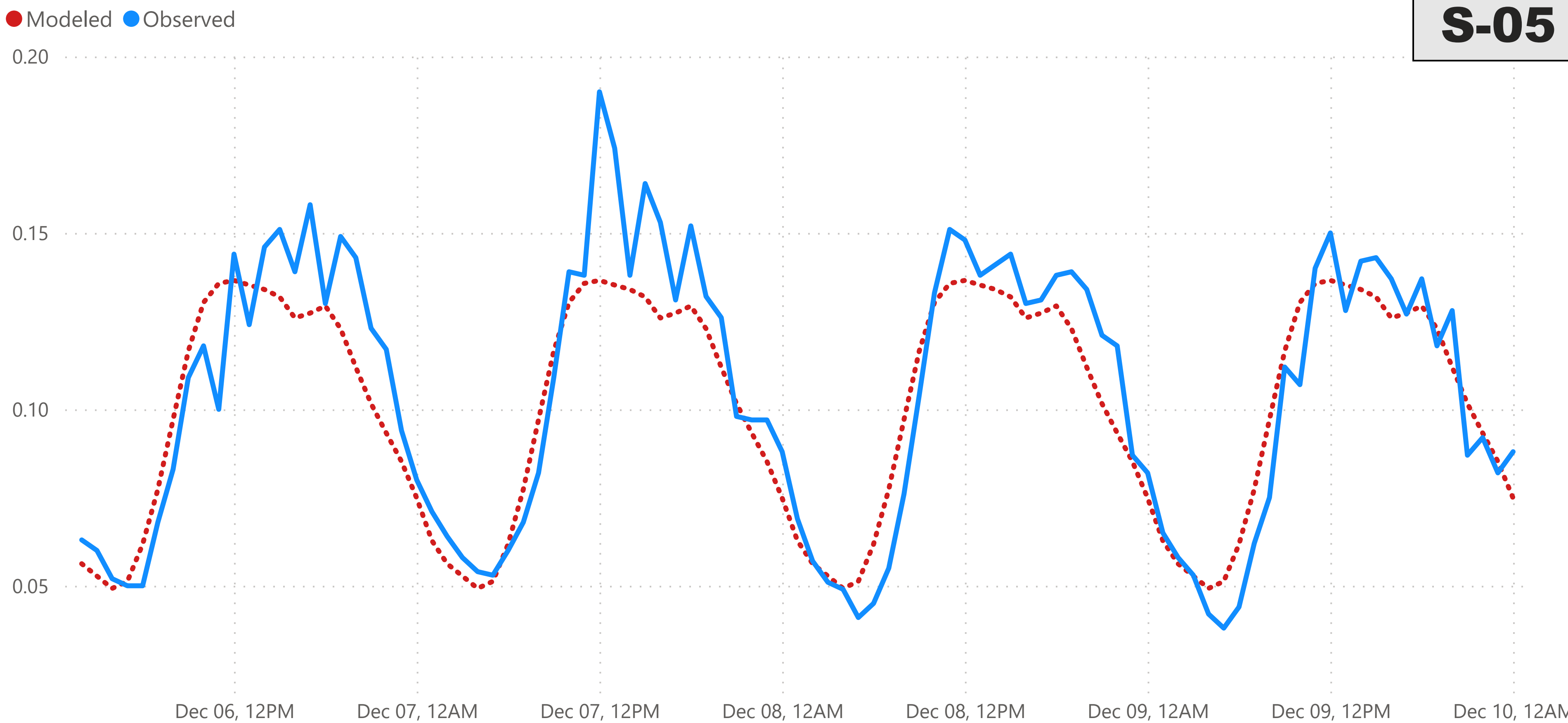
Flow Meter Location

FM_ID S-05

12/6/2022 12/11/2022

Model Calibration Results - Flow

S-05



Average Day Flow (MGD)

Observed	Modeled	% Difference
0.10	0.10	-4.38%

Average Rainfall Intensity: 0.45 in/hr

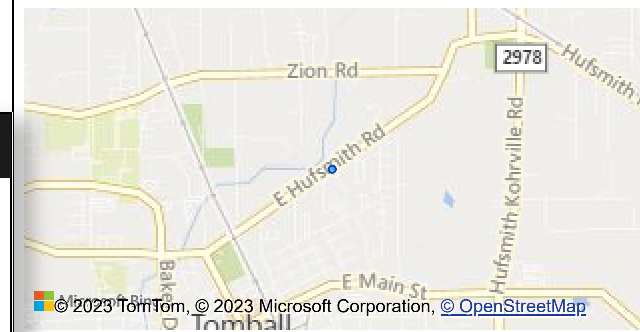
City of Tomball

Wastewater Master Plan Update

Wastewater Model Wet Weather Calibration

Flow Meter Location

FM_ID ● N-01



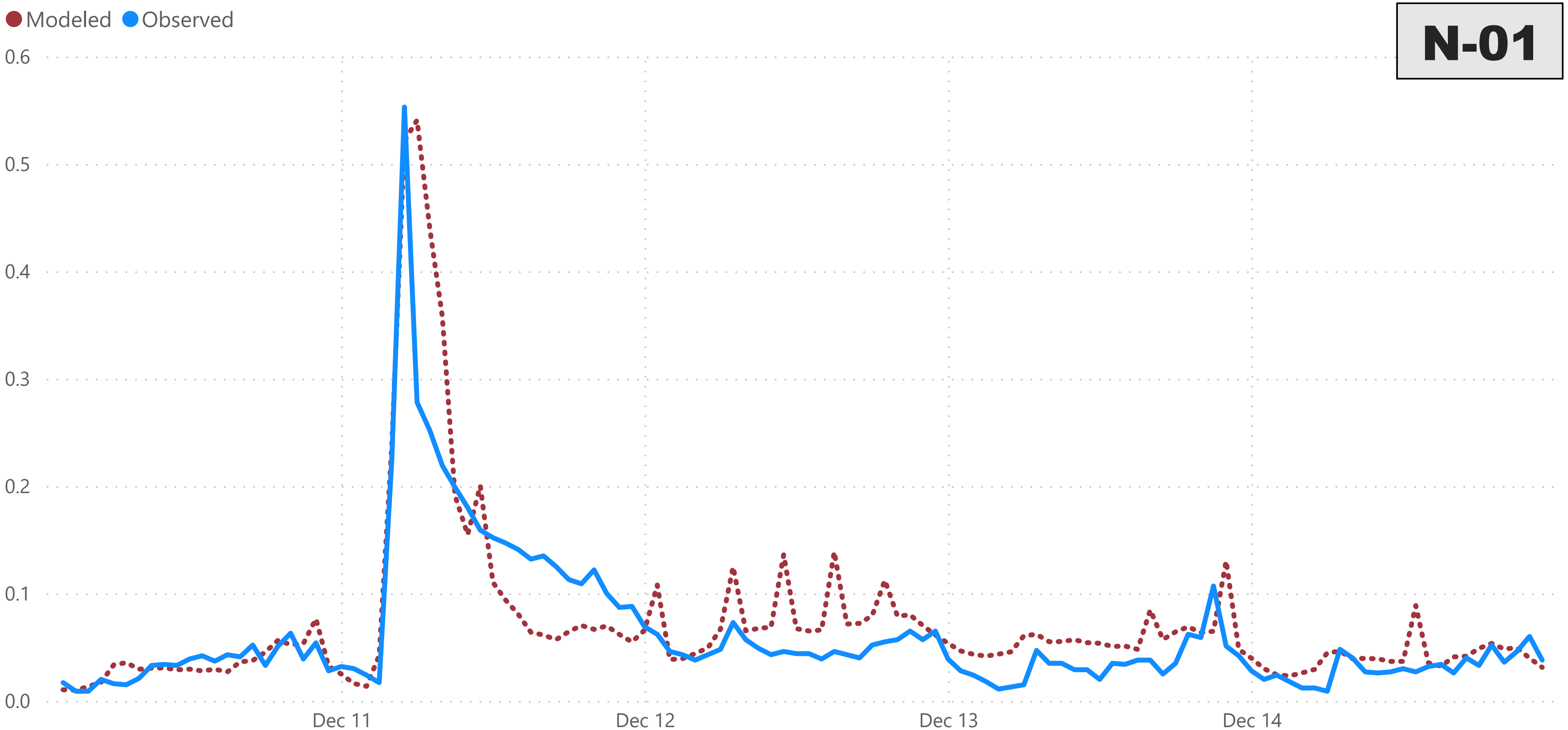
Flow Monitor ID

N-01 | N-02 | N-03 | N-04 | N-05 | S-01 | S-02 | S-03 | S-04 | S-05

12/10/2022 – 12/14/2022

Model Calibration Results - Flow

N-01



Peak Flow (PF)

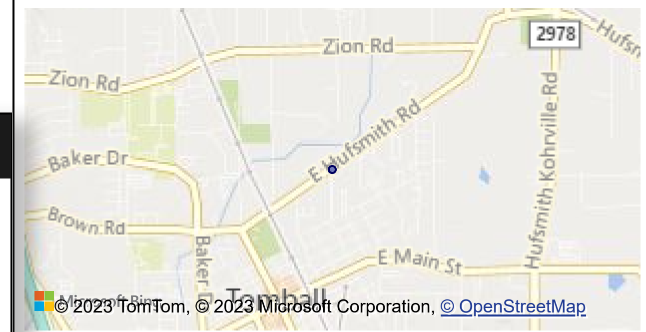
Modeled	Observed	% Difference
0.54	0.55	-2.22%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

FM_ID N-02



12/10/2022 12/14/2022

Flow Monitor ID

N-01 | N-02 | N-03 | N-04 | N-05 | S-01 | S-02 | S-03 | S-04 | S-05

Model Calibration Results - Flow

Peak Flow (PF)

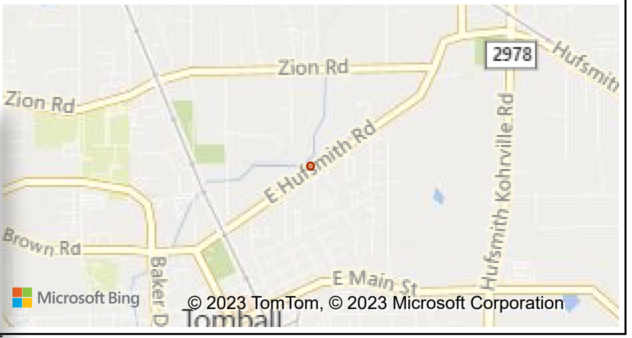
Modeled	Observed	% Difference
1.87	1.94	-3.32%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

FM_ID N-03

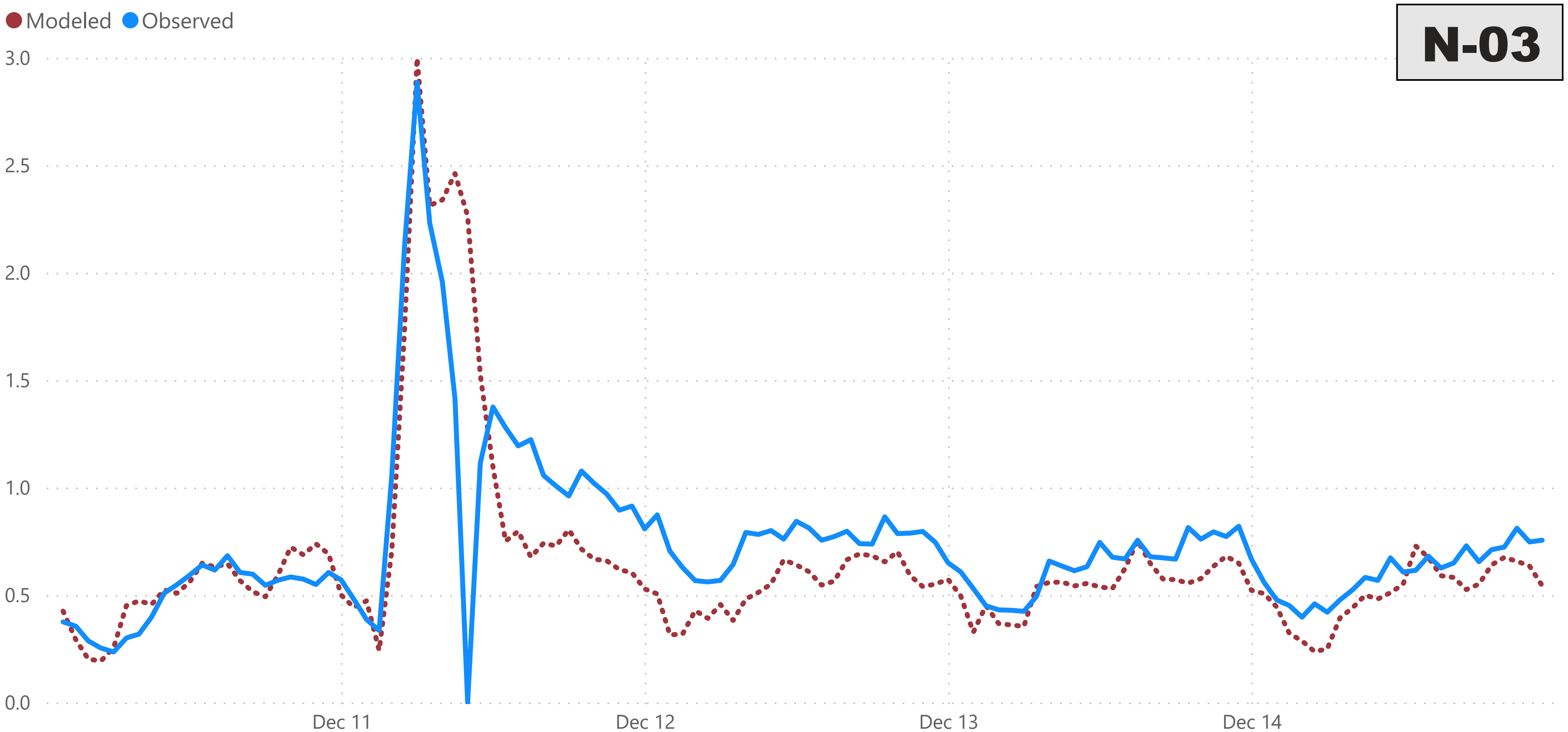


12/10/2022 12/14/2022

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Model Calibration Results - Flow



Peak Flow (PF)

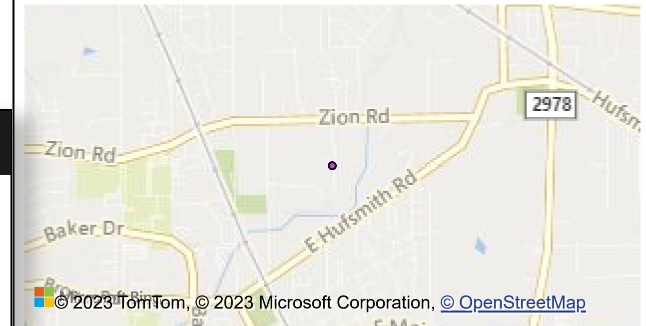
Modeled	Observed	% Difference
3.00	2.89	3.92%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

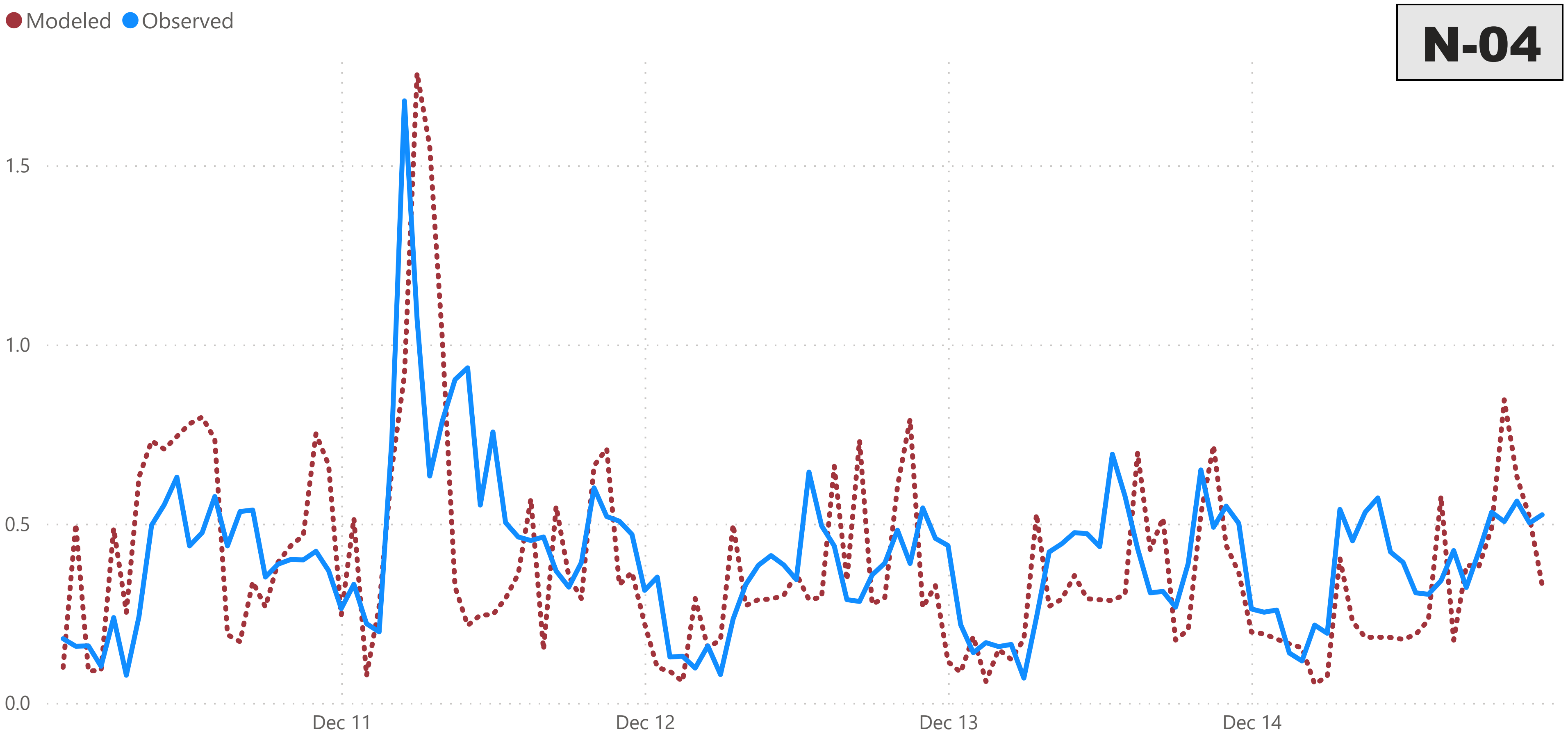
FM_ID ● N-04



Flow Monitor ID

N-01 | N-02 | N-03 | N-04 | N-05 | S-01 | S-02 | S-03 | S-04 | S-05

Model Calibration Results - Flow



12/10/2022 12/14/2022

Peak Flow (PF)

Modeled	Observed	% Difference
1.76	1.68	4.62%

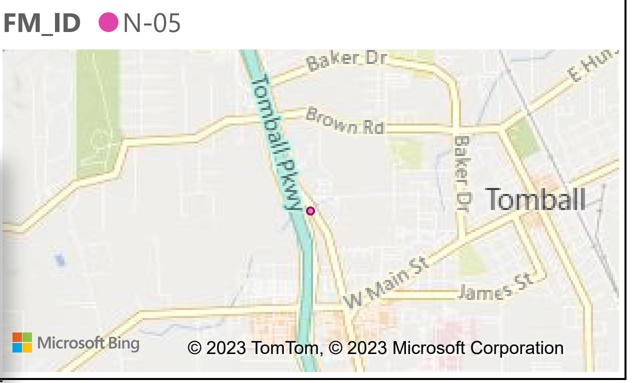
City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Monitor ID

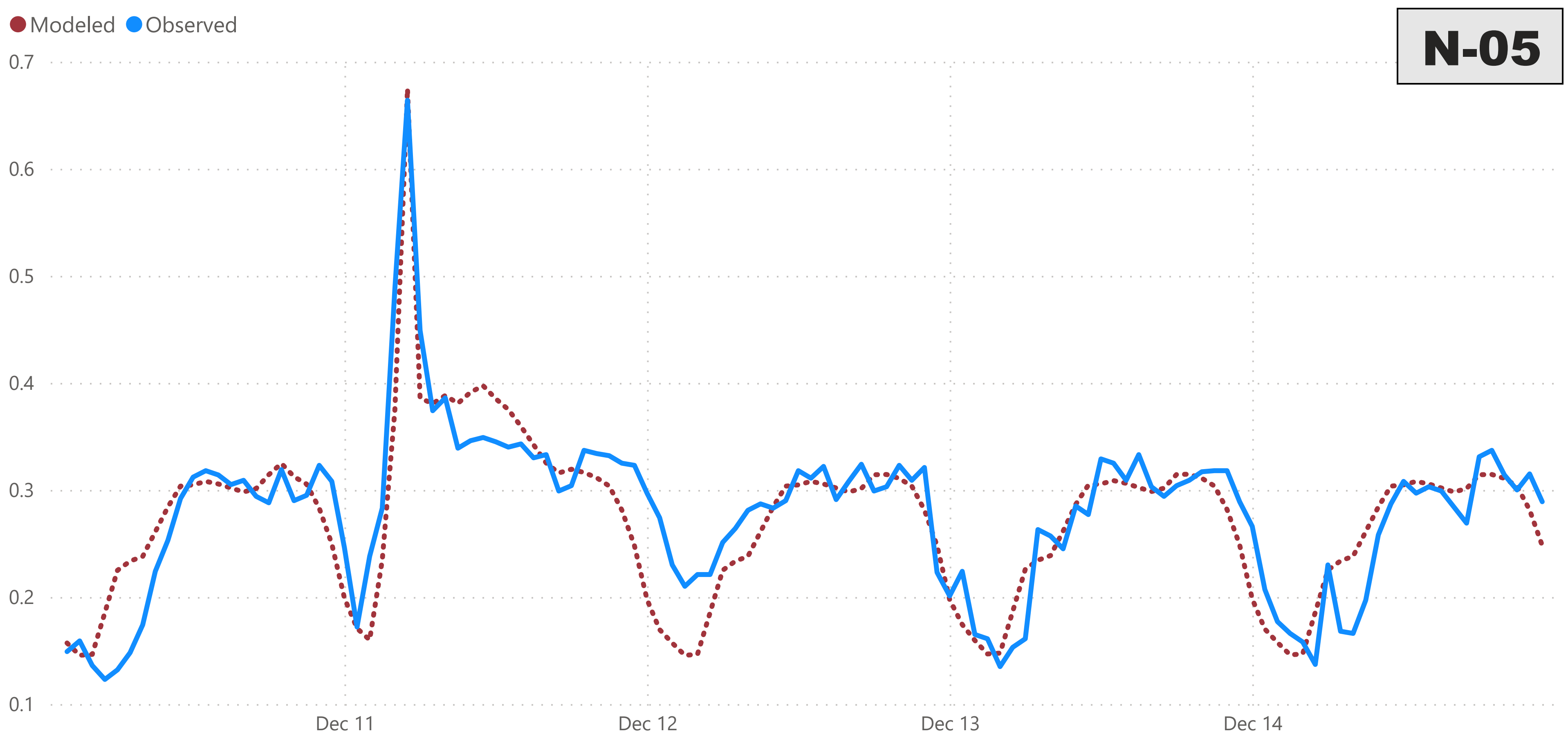
N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

Flow Meter Location



12/10/2022 12/14/2022

Model Calibration Results - Flow



Peak Flow (PF)

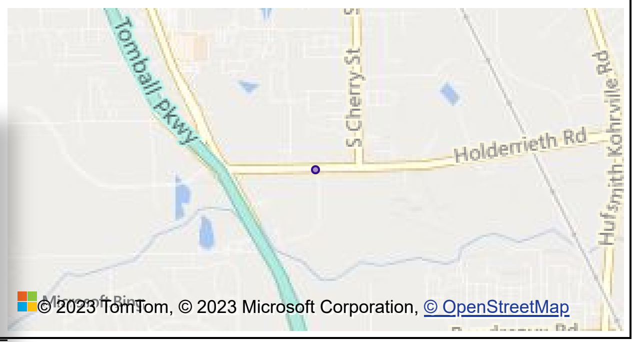
Modeled	Observed	% Difference
0.67	0.66	1.61%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

FM_ID S-01

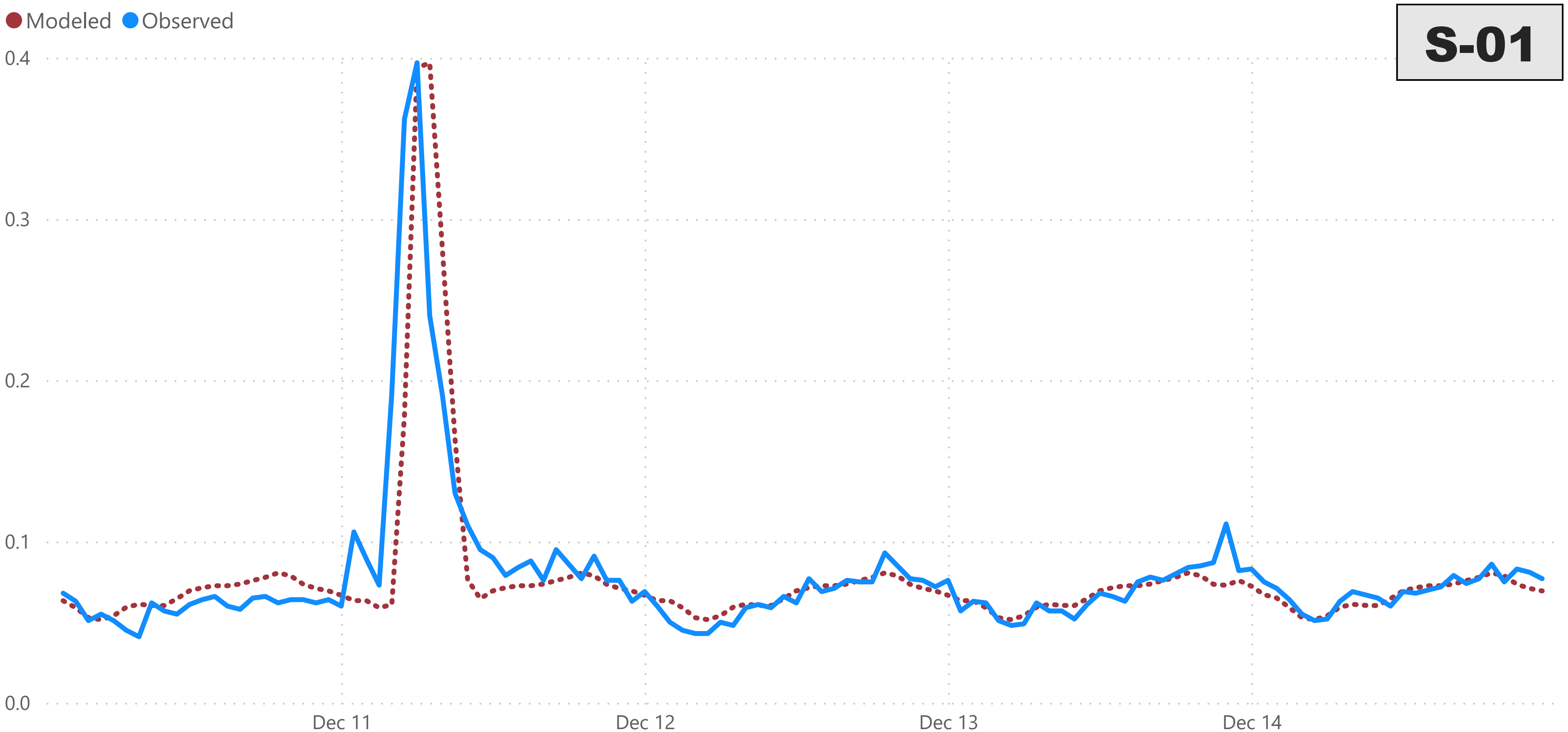


Flow Monitor ID

N-01 | N-02 | N-03 | N-04 | N-05 | S-01 | S-02 | S-03 | S-04 | S-05

12/10/2022 – 12/14/2022

Model Calibration Results - Flow



Peak Flow (PF)

Modeled	Observed	% Difference
0.40	0.40	-0.03%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

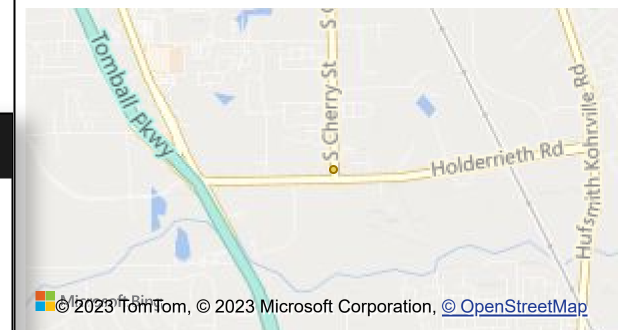
Average Rainfall Intensity: 0.45 in/hr

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

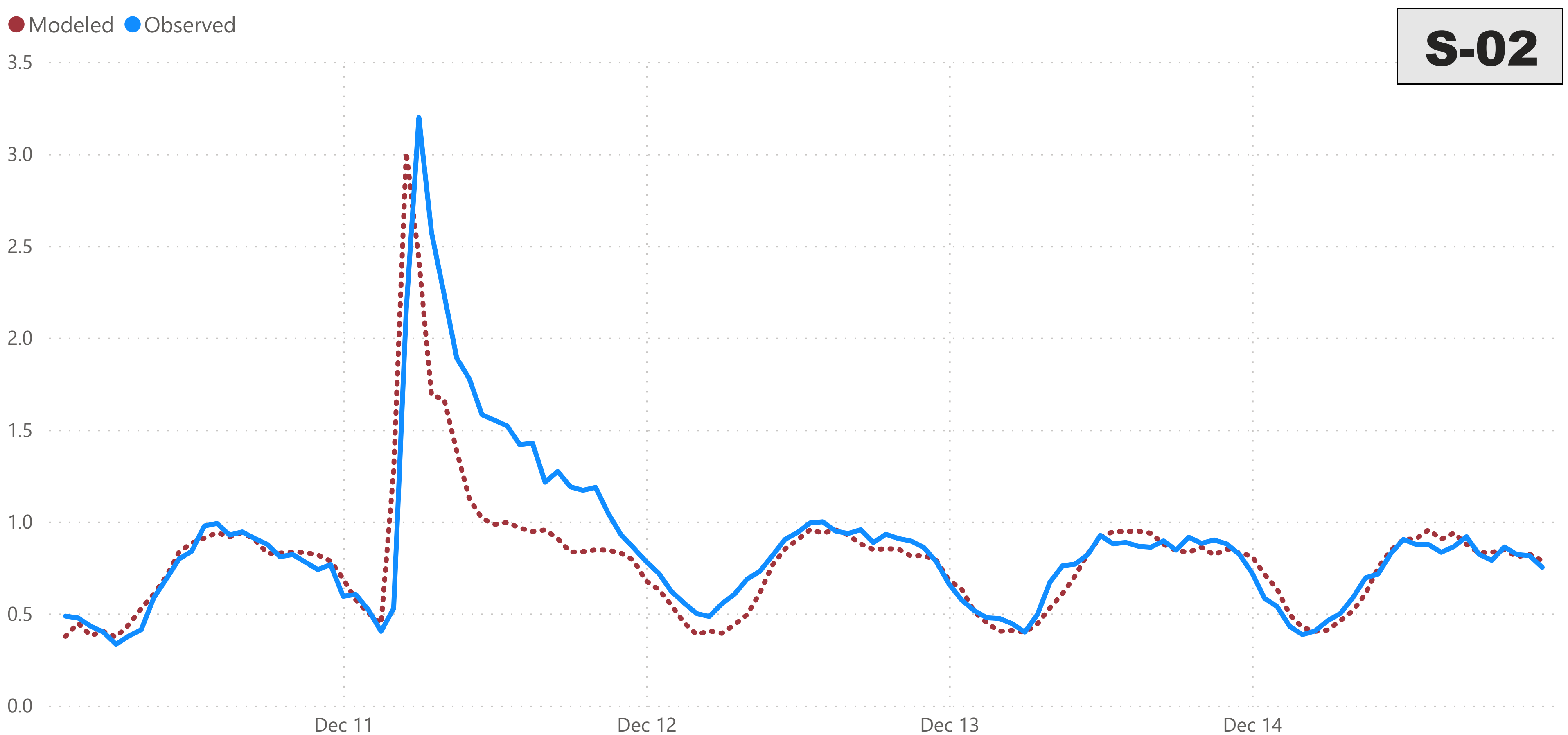
Flow Meter Location

FM_ID ● S-02



12/10/2022 12/14/2022

Model Calibration Results - Flow



Peak Flow (PF)

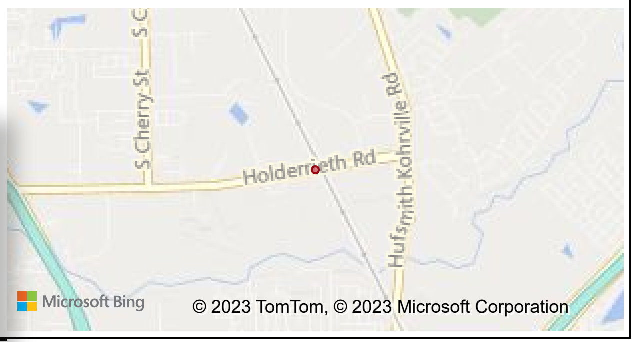
Modeled	Observed	% Difference
3.01	3.20	-5.92%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

FM_ID S-03

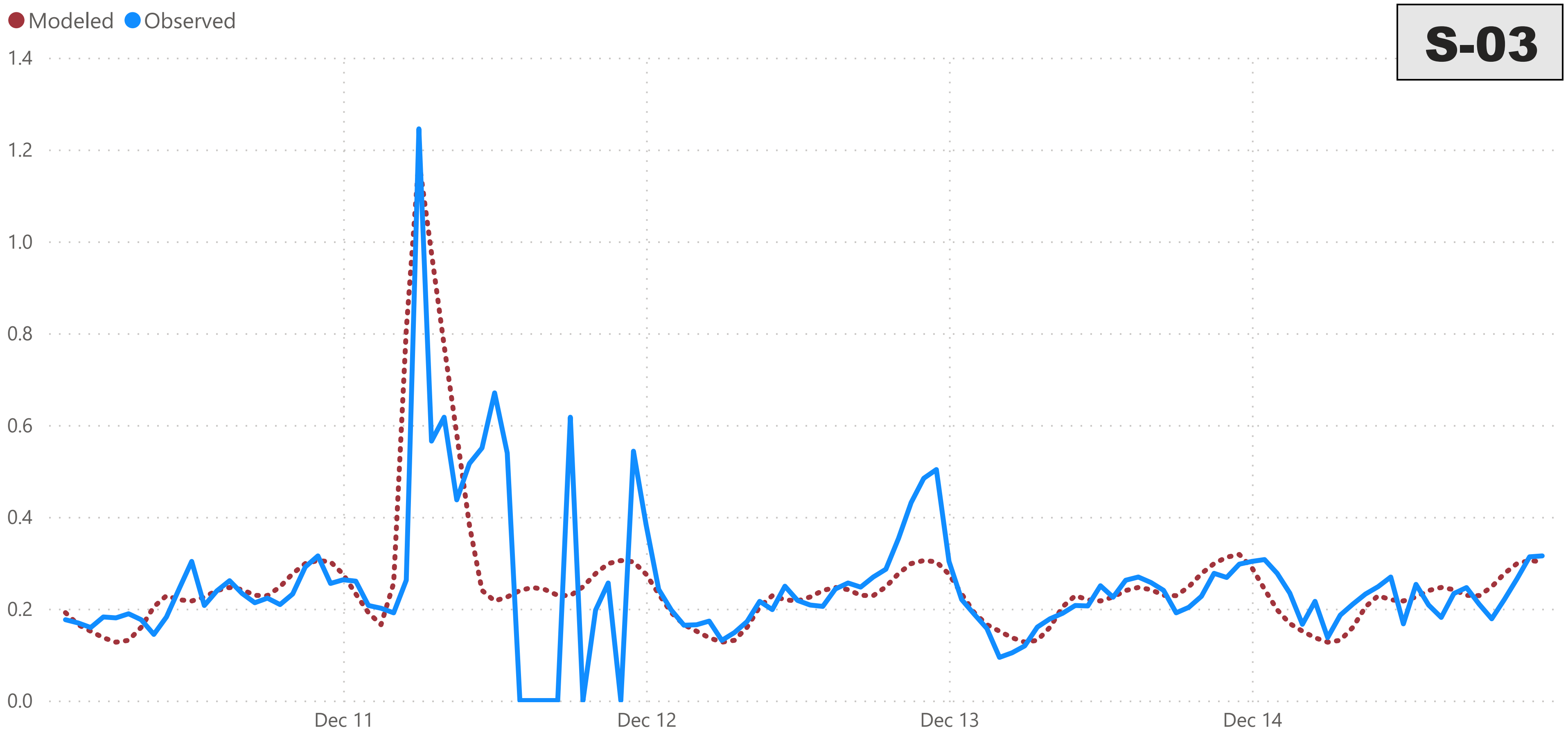


Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

12/10/2022 12/14/2022

Model Calibration Results - Flow



Peak Flow (PF)

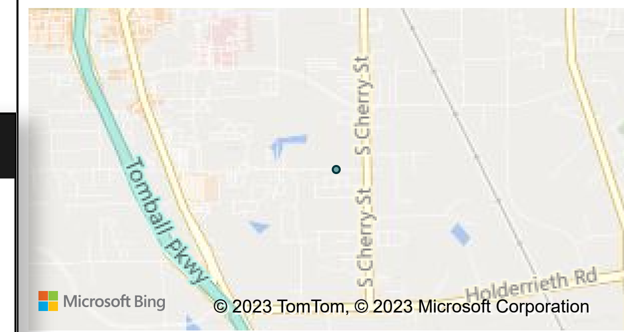
Modeled	Observed	% Difference
1.18	1.25	-5.45%

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Average Rainfall Intensity: 0.45 in/hr

Flow Meter Location

FM_ID S-04



Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

12/10/2022 12/14/2022

Model Calibration Results - Flow

Peak Flow (PF)

Modeled	Observed	% Difference
1.10	1.17	-6.12%

Average Rainfall
Intensity: 0.45 in/hr

City of Tomball
Wastewater Master Plan Update
Wastewater Model Wet Weather Calibration

Flow Meter Location

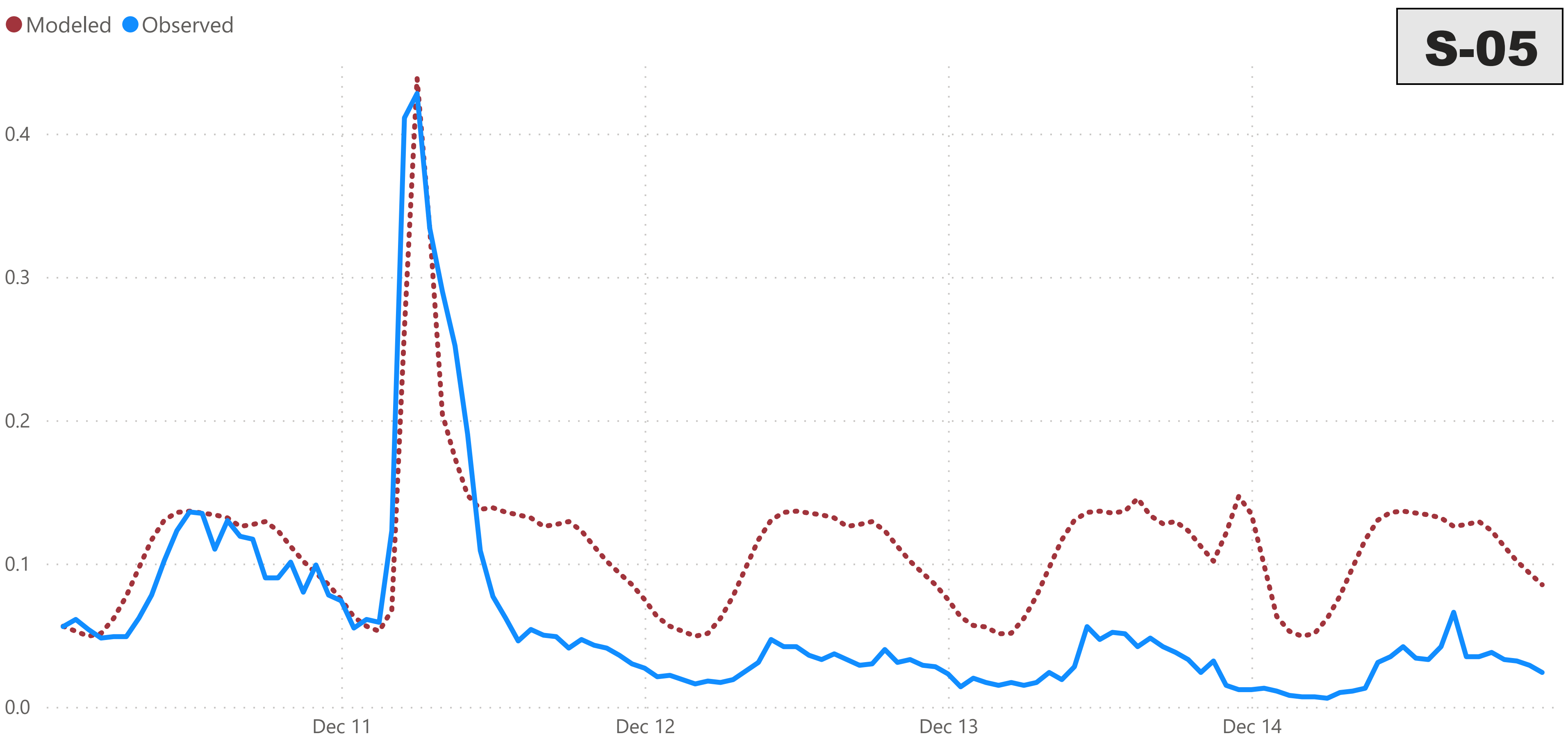
FM_ID ● S-05

Flow Monitor ID

N-01	N-02	N-03	N-04	N-05	S-01	S-02	S-03	S-04	S-05

12/10/2022 12/14/2022

Model Calibration Results - Flow



Peak Flow (PF)

Modeled	Observed	% Difference
0.44	0.43	2.46%

APPENDIX K
Wastewater System Analysis Figures

FIGURE J-1
CITY OF TOMBALL
WATER AND WASTEWATER MASTER PLAN UPDATE
EXISTING WASTEWATER SYSTEM ANALYSIS

Created By Freese and Nichols, Inc.
Job No.: TMB22779
Location: H:\W_WW_PLANNING\01_DELIVERABLES\00_FINAL_REPORT\02_Master_Plan_Report\Appendix\(Figure_J-1)-Existing_Wastewater_Analysis.mxd
Updated: Monday, October 30, 2023 2:59:44 PM
User Name: 03812

Created By Freese and Nichols, Inc.
Job No.: TMB22779
Location: H:\W_WW_PLANNING\01_DELIVERABLES\00_FINAL_REPORT\02_Master_Plan_Report\Appendix\(Figure_J-2)-Buildout_Wastewater_Analysis.mxd
Updated: Monday, October 30, 2023 3:13:49 PM
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