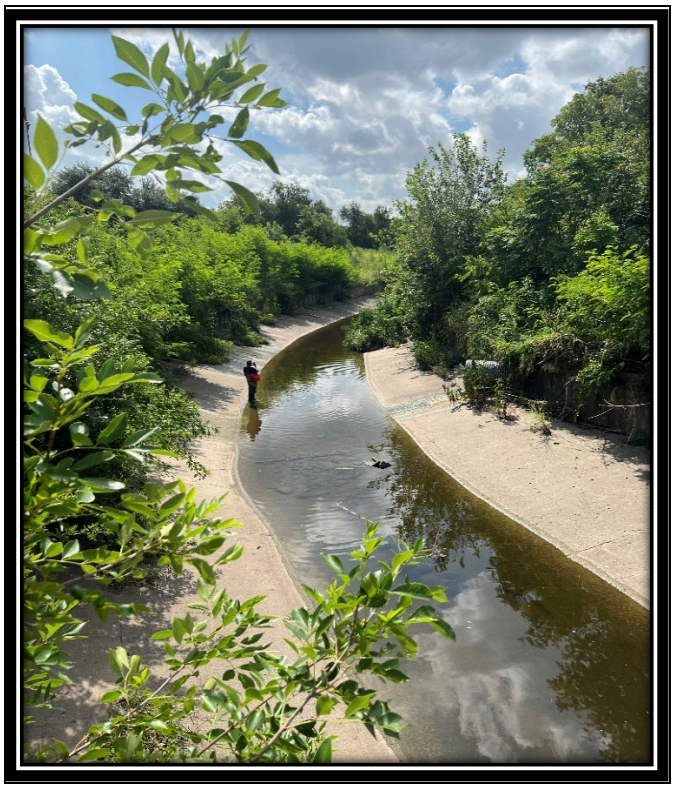
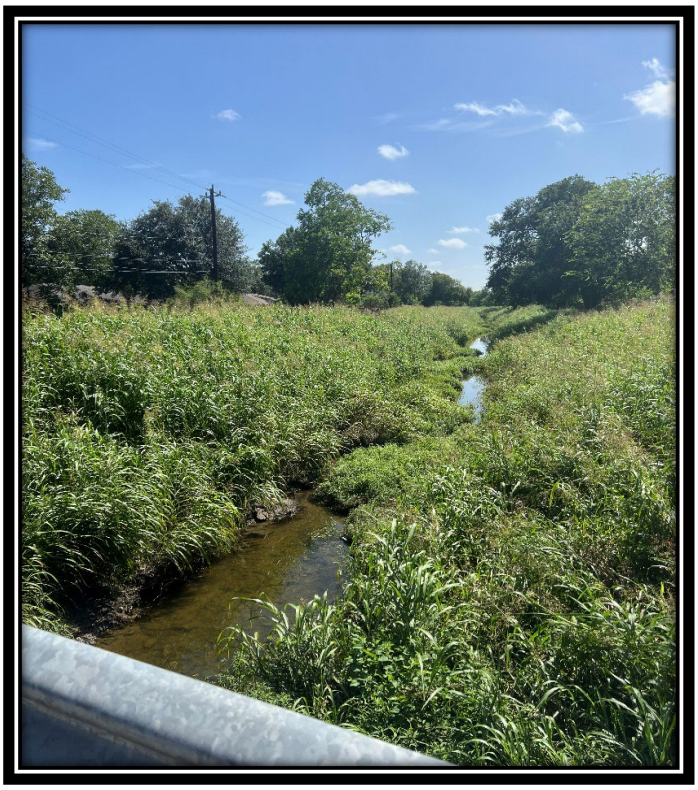
Targeted Bacteria Monitoring Project

FY24 Final Report

Assessment Units: 1007E_01 Willow Waterhole Bayou Above Tidal and 1007I_01 Plum Creek Above Tidal





Houston-Galveston Area Council

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Final Report

Assessment Units (AU): 1007E_01 Willow Waterhole Bayou Above Tidal and 1007I_01 Plum Creek Above Tidal

Segment Description

H-GAC conducted targeted monitoring on Plum Creek and Willow Waterhole Bayou, both waterbodies within the Bacteria Implementation Group project area (Figure 1). Plum Creek Above Tidal is a tributary to Sims Bayou, Segment ID 1007I (Figure 2). This segment is 3.8 miles long, consists of one assessment unit of concern, AU 1007I_01, and is defined as an unclassified segment from the confluence with Sims Bayou to Telephone Road in Harris County. Land cover consists of a mix of urban, residential, and industrial development, and there is one current surface water quality monitoring station located on this AU (station ID: 16658). This AU has a *Escherichia coli (E. coli)* bacteria seven-year geometric mean of 3,564.22 colony forming unit (cfu)/100 mL and has a current impairment category of 4a and 5c for fecal indicator bacteria (FIB) in water and depressed dissolved oxygen in water, respectively. The TCEQ freshwater recreation use water quality standard for *E. coli* is a geometric mean at or below 126 cfu/100 mL or a single grab standard of 399 cfu/100 mL.

Willow Waterhole Bayou Above Tidal is a tributary to Brays Bayou, Segment ID 1007E (Figure 3). Willow Waterhole Bayou is 6.5 miles long, consists of one assessment unit of concern, AU 1007E_01, and is defined as an unclassified segment from the confluence with Brays Bayou upstream to South Garden (in Missouri City). Land cover consists of urban and residential development, and there is one current surface water quality monitoring (SWQM) station located on this AU (station ID: 16652). This AU has a bacteria seven-year geometric mean of 1,108.76 cfu/100 mL and has a current contact recreation impairment, category of 4a, for FIB in water.

Background

FIB continue to be the most prevalent pollutant in the H-GAC area basins. H-GAC, working under contract for the Texas Commission on Environmental Quality (TCEQ), facilitates the BIG[1]. The BIG is a watershed stakeholder group implementing the BIG Implementation Plan (I-Plan)[2], which was approved by the TCEQ on January 31, 2013. There are at least 144 impaired AUs in the BIG project area (Figure 1) which covers most segments within the San Jacinto River Basin, Basin 10, and a few segments within the San Jacinto-Brazos River Basin, Basin 11. The AUs are impaired due to elevated concentrations of FIB. One specific strategy to address these impairments described in the I-Plan is to conduct geographically focused targeted monitoring. Also identified in the I-Plan is to monitor best practices that will identify and remove sources of FIB causing the impairments.

[1] Bacteria Implementation Group (BIG) | Houston-Galveston Area Council (H-GAC)
[2] Bacteria Implementation Group Reports | Houston-Galveston Area Council (H-GAC)

H-GAC, using information from previous Clean Rivers Program[3] Basin Highlights/Summary Reports[4], BIG annual reports[5], and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways.

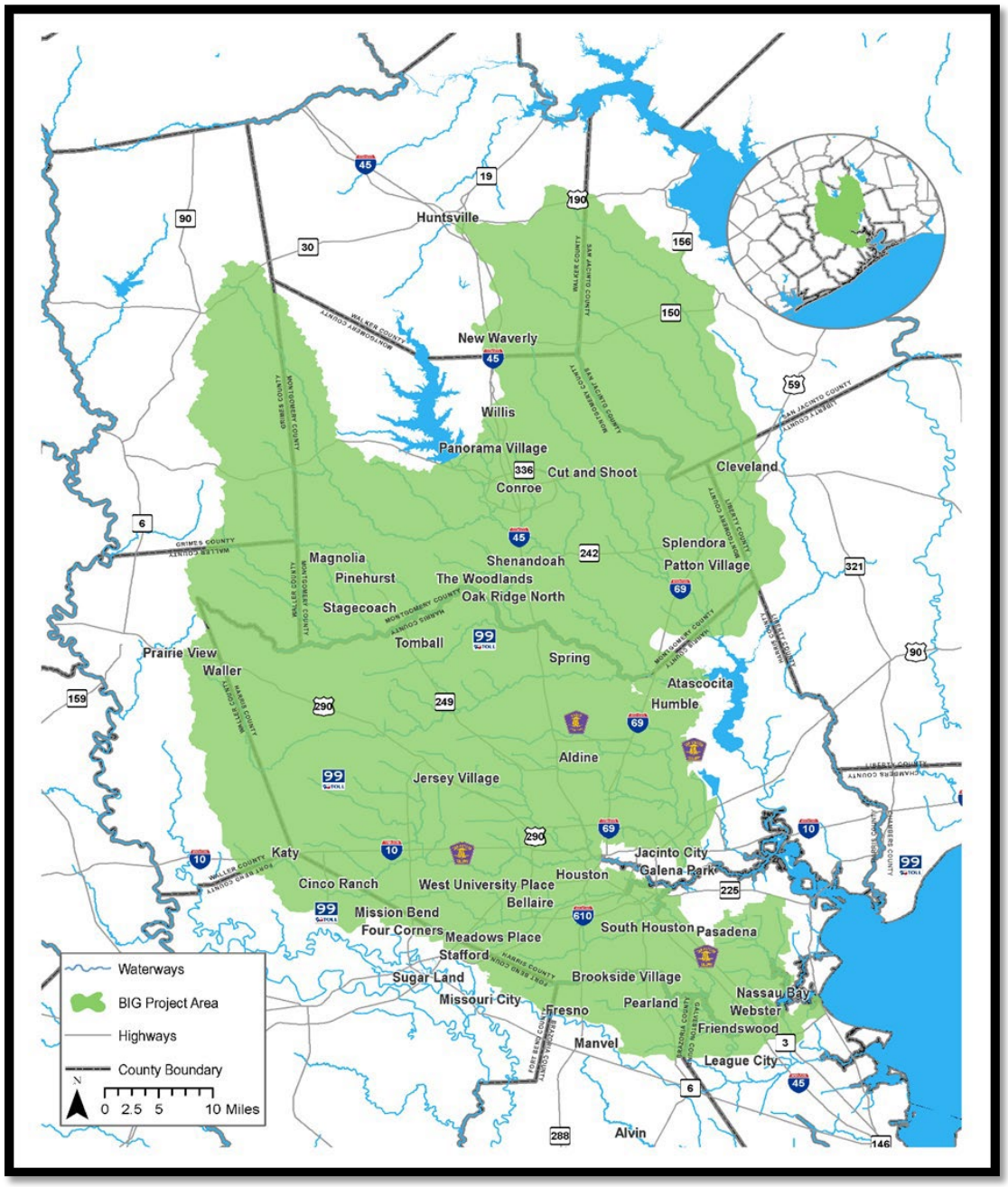

Figure 1. Bacteria Implementation Group Project Area

[3] Clean Rivers Program | Houston-Galveston Area Council (H-GAC)
[4] Basin Highlights/Summary Reports | Houston-Galveston Area Council (H-GAC)
[5] Bacteria Implementation Group Reports | Houston-Galveston Area Council (H-GAC)

Targeted monitoring is a systematic method to identify, report, and hopefully correct sources of fecal bacteria. Targeted monitoring of water bodies within the BIG have been conducted since the I-Plan was approved in 2013. The methodology was formalized with a quality assurance project plan and completion of the Top Five Most and Top Five Least Impaired Water Bodies in 2016[6]. Phase I of this targeted monitoring project included an intensive desktop review of the most up to date imagery available and completed windshield surveys (WS). Phase II of this targeted monitoring project included field investigations (FI) of each AU conducted during dry conditions where all flowing point and non-point sources were evaluated. Phase III includes documentation of findings and sharing with local jurisdictions for possible remediation.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted on-site sewage facilities (OSSFs), and potential locations of unpermitted OSSFs were identified. If present, other potential sources such as landfills and industrial facilities were also identified. Apartment complexes were noted, as these can contribute to bacterial sources through sanitary sewer overflows (SSO) and domesticated pets. Bridge crossings and other public entry points were identified to provide access into the stream to collect bacteriological samples. H-GAC conducted this review in April 2024. Final selection of the two AUs was coordinated with local jurisdictions on April 25, 2024.

Results

The results of this desktop review revealed a list of 24 AUs, of which 5 were chosen for the final selection (Table 1). The other 15 AUs were removed from the list due to a variety of factors. For one AU, there are a lack of access points, making it insufficient for targeted bacteria monitoring. For two others, there are several impaired tributaries that flow into them, and until corrective action is taken on the tributaries, it was determined the AUs were not a good option. Multiple AUs were repeated targeted monitoring studies that had their issues previously identified, and there were a couple that were outside the BIG project area. Of the 5 on the list, the two selected were chosen after a discussion with stakeholders from various jurisdictions revealed that the segments had been investigated by City of Houston in the past and there was heavy interest in investigating them further.

[6] Bacteria Implementation Group Reports | Houston-Galveston Area Council (H-GAC)

Table 1. Top Geometric Mean List from the BIG Project Area

Rank	Parameter	AU_ID	Seven Year Geomean cfu/100 mL	Results	Ratio	Segment Name	Reason
1	*E. Coli*	1007T_01	6,933.54	54	55.028	Bintliff Ditch (unclassified water body)	Most of the AU runs underneath surface. Lack of access points to perform monitoring.
2	*E. Coli*	1017_04	3,781.42	102	30.01	Whiteoak Bayou Above Tidal	AU is particularly long. Could be sectioned off but several tributaries that flow into it are also on the list and until corrective action is taken on those may not be best option.
3	*E. Coli*	1007I_01	3,564.22	54	28.29	Plum Creek Above Tidal (unclassified water body)	AU Runs underneath ground for most of the length. Is a tributary of Sims Bayou. Discussion with jurisdictions revealed that it had been investigated by City of Houston in the past and there was heavy interest in investigating it further.
4	*E. Coli*	1007F_01	3,079.44	54	24.44	Berry Bayou Above Tidal (unclassified water body)	AU has many access points.
5	*E. Coli*	1007H_01	2,421.62	52	19.22	Pine Gully Above Tidal (unclassified water body)	Decided to not do this AU because it would be a repeat of an AU that recently had targeted monitoring performed on it. Monitored in Summer 2023.
6	*E. Coli*	1017B_02	2,308.77	54	18.32	Cole Creek (unclassified water body)	Decided to not do this AU because it would be a repeat of an AU that recently had targeted monitoring performed on it.
7	*E. Coli*	1004J_01	2,253.68	28	17.89	West Fork San Jacinto River	Repeat from TRIES last year - Issues have been identified.
8	*E. Coli*	1007K_01	2,245.70	107	17.82	Country Club Bayou Above Tidal (unclassified water body)	A lot of access points through park. GBEP did a study in 2021 - Can get initial access through golf course, but water doesn't flow and there are tons of trash everywhere.
9	*E. Coli*	1016C_01	2,180.21	55	17.3	Unnamed Tributary of Greens Bayou	Repeat targeted monitoring study.

Rank	Parameter	AU_ID	Seven Year Geomean cfu/100 mL	Results	Ratio	Segment Name	Reason
10	*E. Coli*	1017E_01	2,062.39	55	16.37	Unnamed Tributary of White Oak Bayou (unclassified water body)	Repeat targeted monitoring study - Issues have been Identified.
11	*E. Coli*	1013C_01	1,894.46	53	15.04	Unnamed Non-Tidal Tributary of Buffalo Bayou Tidal (unclassified water body)	Repeat targeted Monitoring Study - Issues have been Identified.
12	*E. Coli*	1007B_01	1,891.83	489	15.01	Brays Bayou Above Tidal (unclassified water body)	AU is almost the entirety of brays bayou at 22 miles. Several tributaries that feed into it have been done repeatedly and are high on the BIG list but until action is taken on them it may not be the best option.
13	*E. Coli*	1017_03	1,763.48	54	14	Whiteoak Bayou Above Tidal	Repeat targeted monitoring study - Issues have been Identified.
14	*E. Coli*	1013A_01	1,597.49	110	12.68	Little White Oak Bayou	Repeat targeted monitoring study - Issues have been Identified.
15	*E. Coli*	1016D_01	1,485.62	55	11.79	Unnamed Tributary of Greens Bayou	Repeat targeted monitoring study - Issues have been Identified.
16	*E. Coli*	1017A_01	1,413.49	53	11.22	Brickhouse Gully/Bayou	Repeat targeted monitoring study.
17	*E. Coli*	1007U_01	1,365.28	55	10.84	Mimosa Ditch (unclassified water body)	Repeat study - Issues have already been Identified.
18	*E. Coli*	1014O_01	1,268.88	55	10.07	Spring Branch (unclassified water body)	Repeat targeted monitoring study - Issues have been identified.
19	Enterococci	1103G_01	332.67	28	9.5	Gum Bayou (unclassified water body)	Outside BIG project area.

Rank	Parameter	AU_ID	Seven Year Geomean cfu/100 mL	Results	Ratio	Segment Name	Reason
20	*E. Coli*	2432A_02	1,119.96	29	8.89	Mustang Bayou (unclassified water body)	Outside BIG project area.
21	E. Coli	1007E_01	1,108.76	54	8.8	Willow Waterhole Bayou Above Tidal (unclassified water body)	Located in Missouri City / Stafford. could be a possibility. There is a bike path running along AU.
22	Enterococci	1101D_01	305.43	4	8.73	Robinson Bayou (unclassified water body)	Repeat study - Issues have already been Identified.
23	E. Coli	1006D_02	1,062.24	173	8.43	Halls Bayou (unclassified water body)	AU is approximately over 8 miles long.
24	E. Coli	1007G_01	962.46	53	7.64	Kuhlman Gully Above Tidal (unclassified water body)	Located in southwest Houston / Pasadena area - very short AU.

*Rows highlighted in gray were the five AUs chosen for a final selection with jurisdictions.

As previously mentioned, Plum Creek Above Tidal and Willow Waterhole Bayou Above Tidal run through highly commercial areas, positioned beside multiple apartment complexes and residential areas, which have the potential to introduce bacteria into the water. Much of Plum Creek Above Tidal runs underground in southeast Houston, with the first access point daylighting at an abandoned parking lot behind Gulf Fwy-I-45. It disappears again under I-610 behind a Gus & Sons Auto Repair shop and Browne Rd, and then reappears 0.34 miles between the Broadway Apartments and I-610, where it flows an additional 1.49 miles into Sims Bayou, adjacent to Hwy 225 and City of Houston Sims Bayou WWTP. A lift station was observed near the water body close to Hwy 3, potentially serving as a source for SSOs.

Willow Waterhole Bayou Above Tidal begins in northeast Missouri City and southwest Houston near west Beltway 8. The watershed is a mix of industrial, lite industrial and commercial, and residential land use. Willow Waterhole has been straightened and highly channelized with portions in cement to hinder erosion. The main channel has been crisscrossed with ditched conveyances to alleviate flooding. A large flood detention basin, Willow Waterhole Greenway is found adjacent to the main channel about 5.22 miles downstream. The waterbody terminates into Brays Bayou, just inside the west belt of the I-610 loop near the United Orthodox Synagogue and the City of Houston Southwest WWTP.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This is to ensure that any flowing water into the segment is not stormwater. The WS for Plum Creek Above Tidal were conducted on 05/09, 06/05, and 06/25, while the WS for Willow Waterhole Above Tidal was conducted on 06/26. Significant rainfall throughout the months of May and June factored heavily into delays for completing the WS portion of the project. Bacteria sampling was performed at public access points throughout both AUs, primarily collected via buckets at bridge crossings (Figure 2. The surveys consisted of driving the catchment to confirm potential pollution sources found during the desktop review and to find any sources not identified during the review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Reaches with elevated bacteria levels identified in the WS monitoring were focused on during the FI of this study.

Sample collection and laboratory methods, as well as data handling practices for this study are detailed in Appendices B and E of the Houston Area Bacteria Implementation Group Public Participation Project Quality Assurance Project Plan for Monitoring (QAPP), approved April 5, 2024. For all WS bacteria monitoring conducted, field personnel documented the latitude and longitude of sample locations and provided descriptions of outfall pipes where appropriate. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP).

Figure 2. Bucket sampling at Browne Rd. and I-610 Plumb Creek

Results

At the respective times of all WS conducted on 05/09, 06/05, and 06/25 for 1007I_01, it had been four days since the last significant rainfall in the watershed. A total of 18 samples were collected on the AU. Bacteria results from the ambient water samples collected during all WS ranged from less than 100 cfu/100 mL to 48,800 cfu/100 mL (Figure 3). At the time of the WS conducted on 06/26 for 1007E_01, it had been seven days since the last significant rainfall in the watershed. A total of 16 samples were collected on the AU. Bacteria results from the ambient water samples collected during the WS ranged from less than 100 cfu/100 mL to 2,950 cfu/100 mL (Figure 4).

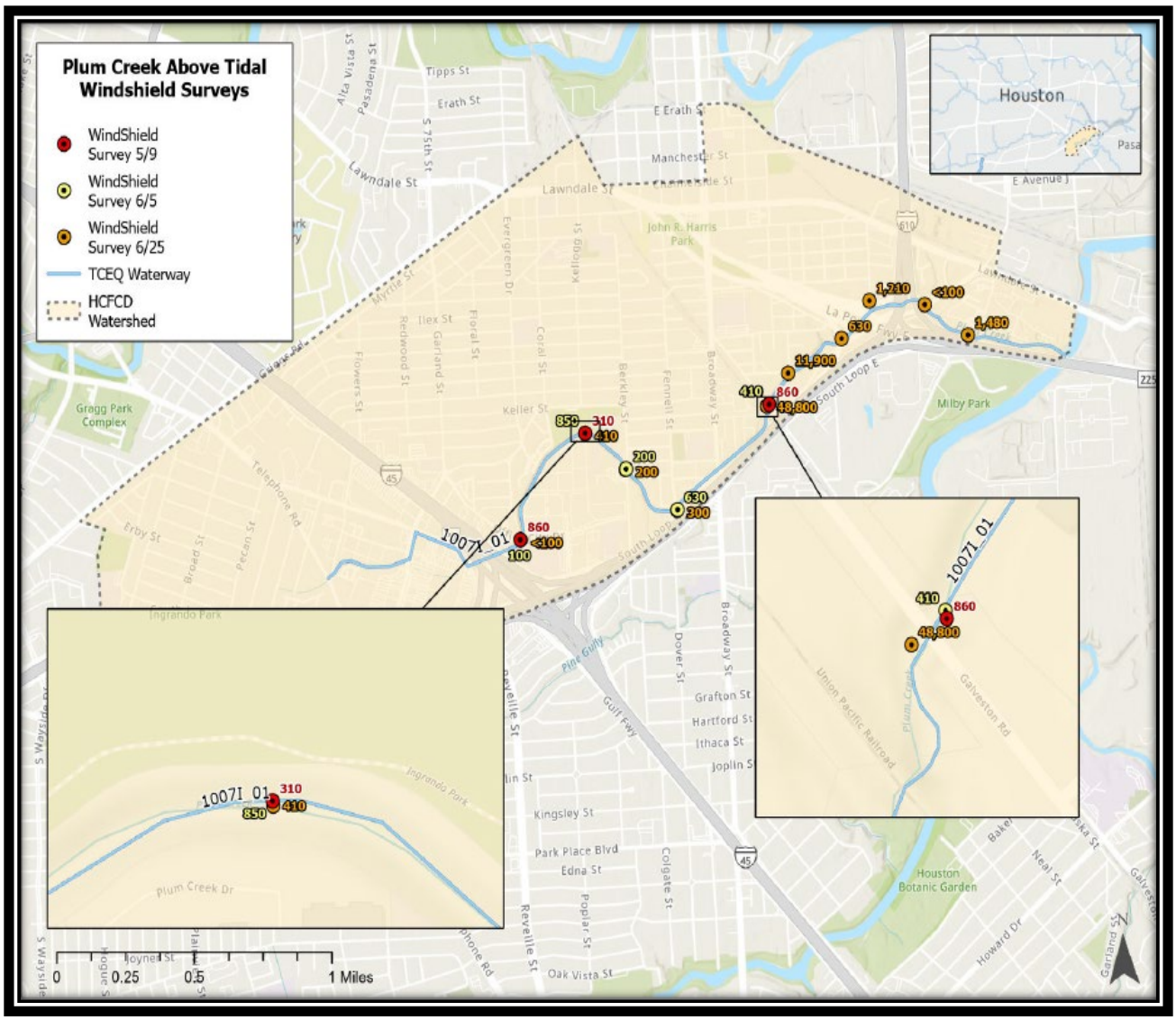

Figure 3. 1007I_01 Plum Creek Above Tidal Windshield Surveys

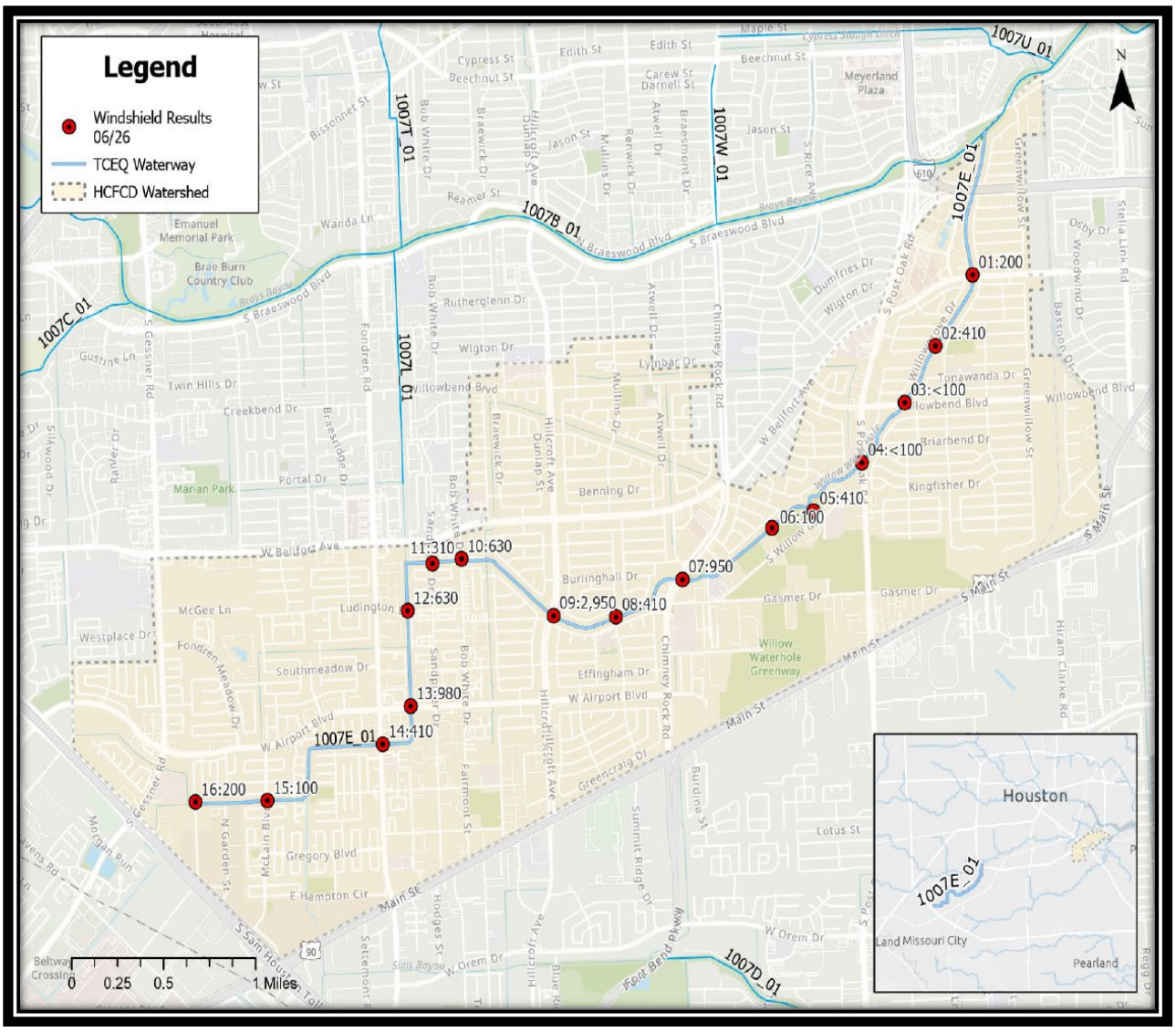

Figure 4. 1007E_01 Willow Waterhole Bayou Above Tidal Windshield Survey

Field Investigation

Methods

The first FI for Plum Creek took place on 07/17, four days after significant rainfall within the watershed. The second FI took place on 08/06, nine days after significant rainfall. There was a single FI that took place for Willow Waterhole Bayou, which took place over the course of two days between 08/01 and 08/02 (Figure 5). The initial access point for 1007I_01 features extremely tall and steep banks with riparian overgrowth, making visibility difficult as field staff made their way down into the water body. There was considerably more litter present than in the windshield survey, potentially a response to Hurricane Beryl, which had made landfall on 07/08.

The initial access point for 1007E_01 was located near Piccadilly Place Apartments across from

Chimney Rock Park. The banks were more accessible in comparison to Plum Creek, but much of the AU was covered with a substantial amount of riparian overgrowth, making an extended walk quite difficult.

Due to the lengths of the AUs and for time management, the field crew focused sampling efforts on reaches identified during the WS with high bacteria levels. The standard practice is to walk the AU moving upstream to prevent disturbance when collecting samples. In some instances, this could not be done due to limited access points. Priority reaches identified from the WS of 1007I_01 and 1007E_01 are listed in Table 2 below.

Figure 5. Field investigation of Willow Waterhole Bayou at Hillcroft Road

The FI was a thorough survey where a team of two walked the assessment unit and sampled any water observed flowing into the stream from "dry weather" flowing outfalls or other portions of the AU at the discretion of the field investigator (e.g. downstream of a potential source, such as OSSFs, livestock, etc.). Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) "homemade" pipes and tributaries.

Tributaries were sampled directly with a single ambient sample taken upstream of the confluence of the main channel. For investigated reaches where no outfalls or tributaries were identified, yet showed elevated levels of bacteria during the WS, ambient samples were taken

by bracketing locations to narrow down where unseen bacteria sources might be present.

Sampling collection, laboratory methods, and data handling practices are detailed in Appendices B and E of the QAPP. For all field investigations, the flowing outfall (latitude and longitude) as well as the diameter, material, water depth of the flowing outfall and site conditions were recorded by taking photos and other relevant notes. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP).

Table 2. Priority reaches for Phase II Field Investigation

Sample ID	Date	Latitude	Longitude	*E. coli* Sample Results (cfu/100 mL)	Comments
1007I_01_WS_01	5/9/2024	29.70019656	-95.2899905	860	Site runs along near Office City Drive. Ambient sample under bridge with storm drain outfall observed. Significant amount of litter observed.
1007I_02_WS	6/5/2024	29.70514577	-95.28588806	850	Site runs along Evergreen Dr and Ingrando Park. Ambient sample at crossing point over concrete channel.
1007I_WS3_05	6/25/2024	29.7061329	-95.27485443	48,800	Ambient sample taken at AU running along S Loop Fwy E, crossing Galveston Rd. There is also the SWQM station 16658 located at this point.
1007I_WS3_06	6/25/2024	29.70765507	-95.27351277	11,900	Ambient sample, observed extreme amount of litter surrounding location. This site at Millet St and Romans St is near where the AU goes underground I-610.
1007E_WS_07	6/26/2024	29.65266387	-95.48062511	950	Ambient sample taken from AU near Chimney Rock Park with outfall pipe nearby. Observed significant riparian growth.
1007E_WS_09	6/26/2024	29.65042667	-95.49235836	2,950	Bucket sample taken from bridge at Hillcroft Ave. Observed either oil sheen or bacteria film growing on top of water. Observed outfall pipes across from sample location including possible natural gas pipe. Riparian overgrowth blocking stream flow.
1007E_WS_10	6/26/2024	29.65463822	-95.50053752	630	Ambient sample taken at Bob White Dr. Riparian growth blocking flow in Assessment Unit.
1007E_WS_13	6/26/2024	29.64442003	-95.50548285	980	Bucket sample taken from bridge at W Airport Blvd, observed water line pipe and gas pipeline above bridge. Observed outfall pipe across from sample location.

RESULTS: 1007I_01 Plum Creek Above Tidal Field Investigation

1007I_01 Field Investigation 1

For the first FI for 1007I_01, 14 samples were collected at 14 locations (Table 3). Outfalls where direct samples were collected were noted as such in field staff notes. To enhance clarity of the sampling efforts, the field survey map (Figure 6) displays a singular icon for the collections. All locations are listed in Table 3 below.

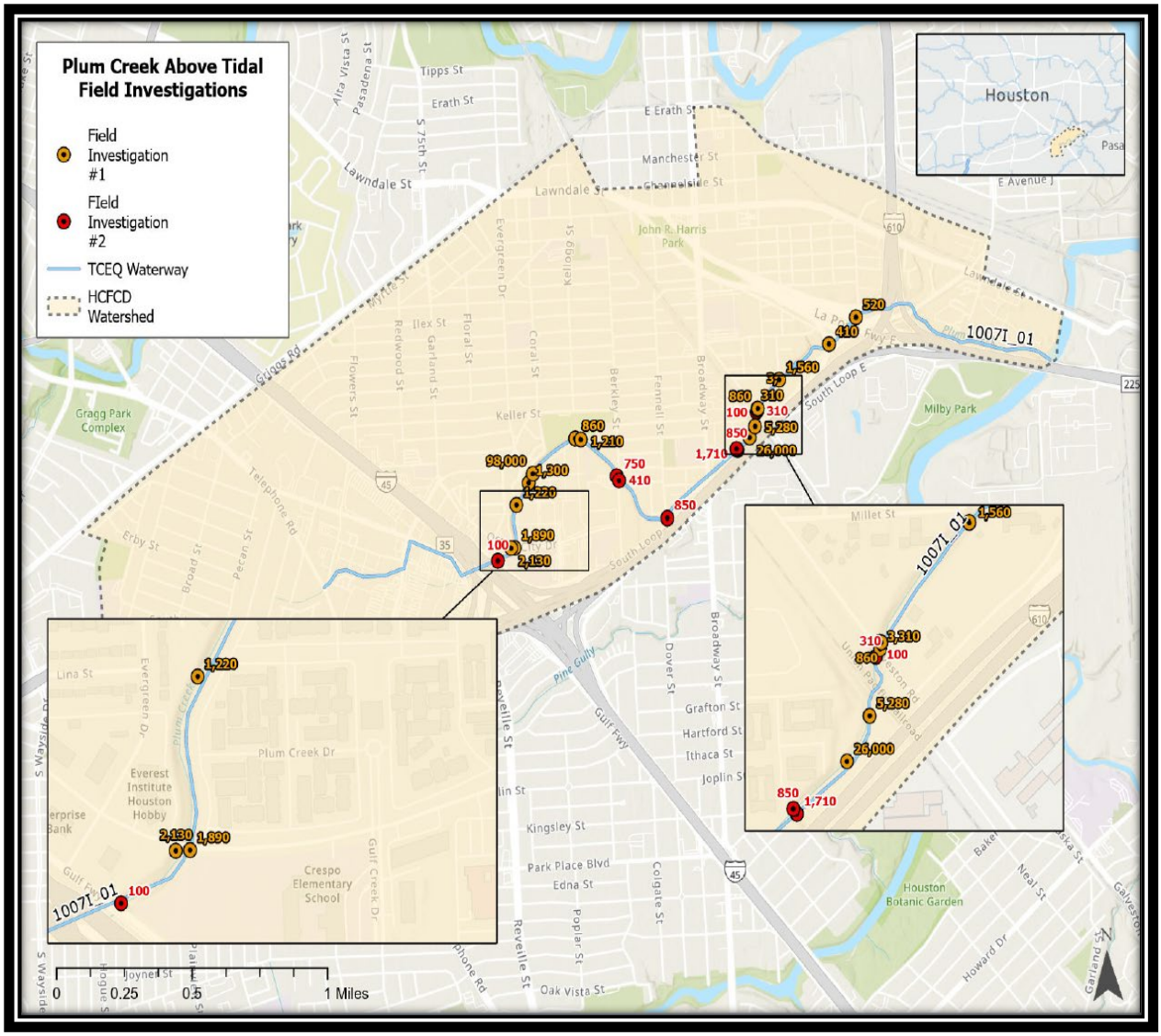

Figure 6. 1007I_01 Plum Creek Above Tidal Field Investigations 1 and 2

Table 3. Field Investigation 1 locations. Upstream and Downstream coordinates and E. coli reported

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007I_01_FI_01	29.70021542	-95.28990928	N/A	N/A	1,890	Grab sample taken from creek below bridge. Considerably more litter than during windshield survey.
1007I_01_FI_02	29.70021396	-95.29011998	Concrete	N/A	2,130	Grab sample taken at storm drainpipe. The water was flowing from less than an inch from pipe.
1007I_01_FI_03	29.70217166	-95.28972417	N/A	N/A	1,220	Grab sample taken from section of creek with concrete walls. Observed purple flowers nearby, litter hanging from branches. Depth is 0.125 meters +/- 0.05m.
1007I_01_FI_04	29.70317703	-95.28892851	N/A	N/A	1,300	Grab sample taken from creek near where water leaked from crack in concrete wall. Depth is 0.125 meters +/- 0.05m.
1007I_01_FI_05	29.70360181	-95.2886588	Concrete	N/A	98,000	Grab sample taken from leaking storm drainpipe along concrete lined creek. The water was flowing from less than an inch from the pipe.
1007I_01_FI_06	29.705175	-95.28600531	Concrete	N/A	860	Grab sample taken from section of creek where evidence of leaking storm drainpipe was seen. Depth is 0.0625 meters +/- 0.05m.
1007I_01_FI_07	29.70511624	-95.28566346	Metal	N/A	1,210	Grab sample taken near where there was evidence of leaking storm drainpipe. Observed green algae.
1007I_01_FI_08	29.70492601	-95.27530678	N/A	N/A	26,000	Grab sample taken from creek section with nearby highway bridge. Observed alligator snapping turtle and litter among trees. Lift station observed nearby as well.
1007I_01_FI_09	29.70542255	-95.27487884	N/A	N/A	5,280	Grab sample taken from section of creek with significant tree branches nearby. Lift station observed nearby as well.
1007I_01_FI_10	29.70589312	-95.27442367	N/A	N/A	3,310	Bucket sample taken from bridge. Observed pipe over creek.

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007I_01_FI_11	29.70625433	-95.2747479	Metal	N/A	860	Bucket sample taken from bridge downstream from where site 10 sample was taken. Direct sample taken from leaking pipe. Unsafe to take depth flowing from outfall pipe.
1007I_01_FI_12	29.70770772	-95.27354142	N/A	N/A	1,560	Took grab sample at section of creek with large amount of litter and debris. Observed tree blockage downstream of creek
1007I_01_FI_13	29.70914656	-95.27027264	N/A	N/A	410	Sample collected before AU goes underground beneath freeways.
1007I_01_FI_14	29.71042345	-95.26866419	N/A	N/A	520	Bucket sample taken from bank. Creek section is partially concrete lined. Observed tunnels upstream of creek.

Of the samples collected, all 14 reflected a bacteria level greater than the primary contact recreation single sample criterion of 399 cfu/100 mL. Although these samples were all higher than the single sample criterion, there were only two locations that were deemed necessary for further investigation as they had particularly high bacteria levels that were direct sample collections from outfalls. It should be noted that samples 1 through 5 were analyzed within the 9th hour, past the required holding time (8 hours) for E coli. due to traffic. Areas suggested for further investigation are detailed in the Referrals to Responsible Parties section of the report.

Most of the locations sampled on the 1007I_01 channel showed higher bacteria results than during the WS. In particular, the sample taken from the stormdrain pipe at Office City Dr (1007I_01_FI_02) where the tributary comes aboveground was higher than all three results at the same location from previous WS (860 cfu/100mL, 100 cfu/100mL, and <100 cfu/100mL) and is recommended for further investigation. Additionally, the sample collected from the storm drainpipe at the location near Patricia Ln (1007I_01_FI_05) was exceptionally high compared to the nearest locations sampled during previous WS (310 cfu/100mL, 850 cfu/100 mL, 410 cfu/100 mL). Both areas had apartment complexes nearby which could be the source of the high bacteria levels.

The bacteria results also varied significantly between samples 1007I_01_FI_08 and 1007I_01_FI_09. Although no pipes, outfalls, or flows were identified, those samples enclose a sector of the channel where a lift station was observed. More information on the locations recommended for further investigation is included in the Referrals to Responsible Parties section.

1007I_01 Field Investigation 2

Field Investigation 2 (FI 2) was conducted to re-investigate areas from FI 1 that had high results without specific sources identified. During FI 2, 8 samples were collected at 8 locations (Table 4). There was one direct sample collected from a flowing outfall. To enhance clarity of the sampling efforts, the field survey map displayed in Figure 4 shows all collections. All locations from FI 2 are listed in Table 4.

Table 4. Field Investigation 2 locations. Upstream and Downstream coordinates and E. coli reported

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007I_F2_01	29.6996429	-95.29095315	N/A	N/A	100	Ambient bucket sample taken at bridge next to I-45. Vegetation surrounding section of AU, this is the point where AU comes aboveground.
1007I_F2_02	29.7033443	-95.28352261	N/A	N/A	750	Bucket sample taken at concrete lined section of AU, upstream. Overgrown vegetation observed in within the AU.
1007I_F2_03	29.70313918	-95.28338371	N/A	N/A	410	Bucket sample taken on concrete lined section of AU downstream of F2_02.
1007I_F2_04	29.70132039	-95.28048399	N/A	N/A	850	Took bucket sample at bridge, observed wildlife including snapping turtle and snake. Observed larger metal cylinder, sheen on water, and debris made up of branches and litter right in tunnel.
1007I_F2_05	29.70435441	-95.27607036	N/A	N/A	1710	Bucket sample taken at right bank at opening of culvert. Sample was taken 3-5 feet into the tunnel.
1007I_F2_06	29.70441173	-95.27612226	N/A	N/A	850	Bucket sample taken at left bank at culvert opening. Observed drainpipe in tunnel on this side, evidence of leaking however not flowing or leaking at this time. Observed excessive amount of litter including shopping carts, trash on trees. When walking towards lift station we observed what looked to be a storm drainpipe under apartment complex, but there was no flow or evidence of leaking.
1007I_F2_07	29.70626457	-95.27477293	Metal	24 inches	100	Direct bucket sample at leaking storm drainpipe. Pipe is 24 inches, water flowing steadily from pipe is 0.5 inches.
1007I_F2_08	29.70612672	-95.27488931	N/A	N/A	310	Ambient sample from upstream of bridge at Old Galveston Road

Of the 8 samples, there are five that reflected a bacteria level greater than the primary contact recreation single sample criterion of 399 cfu/100 mL. Samples collected at 1007I_F2_01, 1007I_F2_07 and 1007I_F2_08 were the only samples that meet the single sample criterion. 1007I_F2_01 was collected via bucket at the same location from FI 1 near Office City Dr. 1007I_F2_07 was a direct bucket sample from a leaking pipe at a bridge on Galveston Rd, however the water observed was clear unlike the other samples, so it was surmised that this may have been from a wastewater treatment plant. 1007I_F2_08 was a bucket sample downstream from where the seventh sample was taken, and was the final sample taken for FI 2. It should be noted that these locations are both downstream from where the lift station from the previous field investigation was.

The locations targeted and sampled for FI 2 showed lesser values when compared with results from the first FI. Take samples 1007I_F2_07 and 1007I_F2_08 for instance, both were lower than the FI 1 results of 860 and 3,310 respectively. This could be due to there being no influence from significant rainfall as it had been nine days since the last, or it could also be that the high bacteria results seen in FI 1 were influenced by Hurricane Beryl which came through this area on 07/08, leaving a month for the flow to return to normal levels. Of the 8 locations, there were two recommended for referral for further investigation: 1007I_F2_05 and 1007I_F2_06. The former was a bucket sample taken at the right bank of the tributary at an opening of a culvert observed. The sample was collected from the tributary approximately three to five feet into the culvert, while the latter location's sample was collected at the opening of the culvert on the left bank of the tributary. A drainpipe with evidence of flowing water was observed on this side, however it was not flowing or leaking at this time. This area showcased an excessive amount of litter including various shopping carts and trash on trees. It is worth noting that when field staff walked downstream of these locations towards the lift station, they observed what appeared to be an additional storm drainpipe under an apartment complex, however no evidence of flow or leaking was seen.

RESULTS: 1007E_01 Willow Waterhole Bayou Above Tidal

1007E_01 Field Investigation

The FI for 1007E_01 featured 21 samples collected at 21 locations (Table 5). This tributary had extensive riparian overgrowth making extended walks for the field investigation difficult. An unnamed channel bracketing off north and south where two ambient samples were collected was also discovered. As with the previous FI, outfalls where direct samples were collected were noted as such in field staff notes. To enhance clarity of the sampling efforts, a field survey map (Figure 7) displays a singular icon for the collections. All locations are listed in Table 5 below.

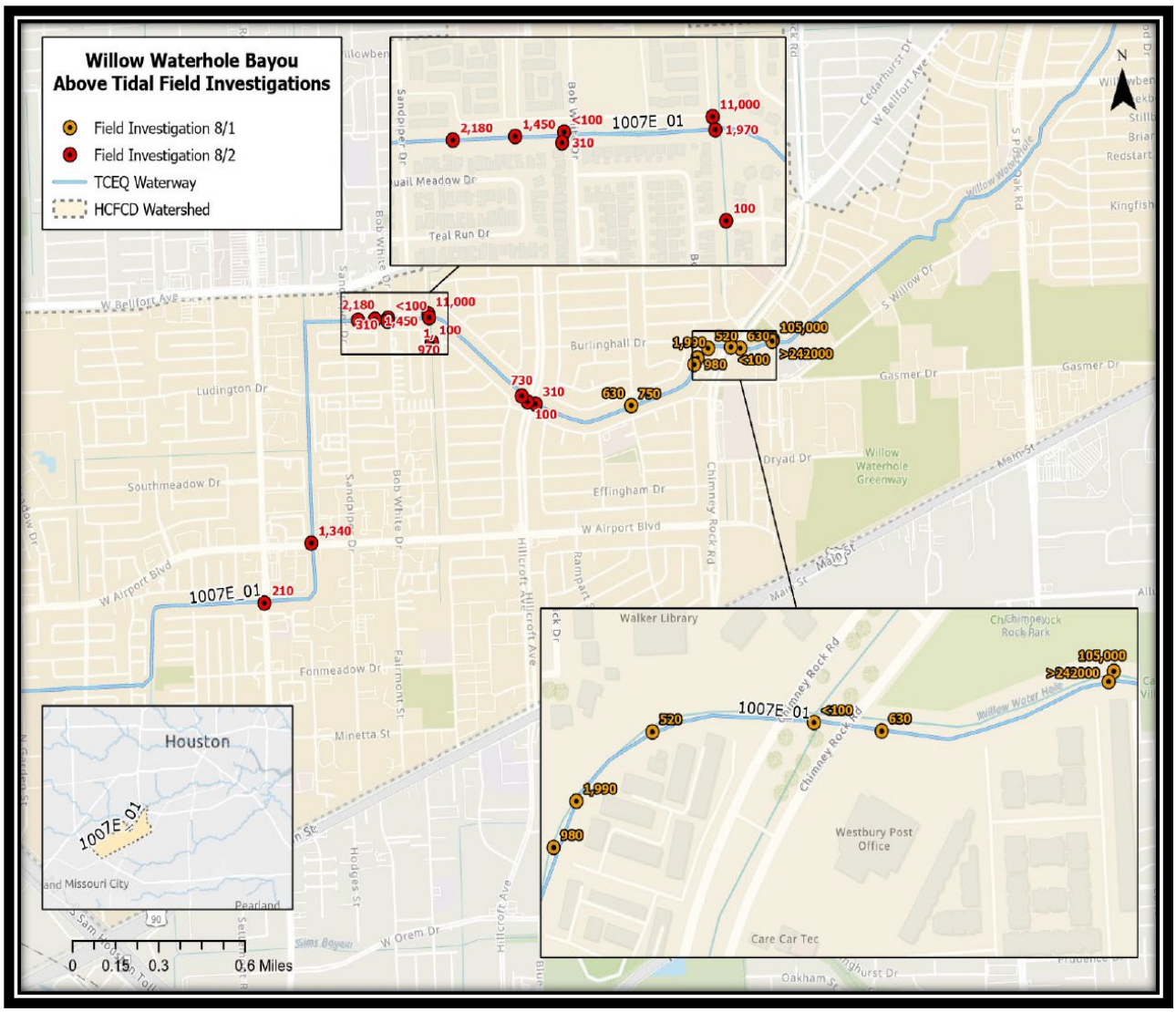

Figure 7. 1007E_01 Willow Waterhole Bayou Above Tidal Field Investigation

Table 5. Field Investigation locations. Upstream and Downstream coordinates and E. coli reported

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007E_01_FI_01	29.65296011	-95.47853856	N/A	N/A	105,000	Grab sample in pool downstream of storm drainpipe. Observed apartment complex nearby. Depth is 1.6 feet
1007E_01_FI_02	29.65289411	-95.47858254	Concrete	84	>242,000	Direct sample from storm drainpipe. Strong sewage smell and observed algae. Residue of material possibly toilet paper. Water is flowing 0.2 inches from the pipe. Pipe is 7 feet.
1007E_01_FI_03	29.65262471	-95.48043643	Metal	24	630	Direct sample taken from storm drainpipe near bridge. Water flowing pipe is less than 0.1 inches. Pipe is 2 feet.
1007E_01_FI_04	29.6526936	-95.48098448	N/A	N/A	<100	Ambient sample on the tributary, right bank, between Chimney Rock bridges. Depth is 6 inches.
1007E_01_FI_05	29.65266825	-95.48229806	N/A	N/A	520	Observed storm drainpipe where possible evidence of leaking pipe was seen. Observed sediment within pipe. Due to uncertainty of flowing an ambient sample was taken downstream on left bank. Depth is 1.2 feet
1007E_01_FI_06	29.65223868	-95.48293133	N/A	N/A	1,990	Ambient sample taken 15 yards from start of box channel.
1007E_01_FI_07	29.65194572	-95.48312646	Metal	24	980	Direct sample taken from leaking storm drainpipe on the left bank. There is a sheen. Water is flowing less than 0.1 inches from pipe. Pipe is 2 feet.
1007E_01_FI_08	29.65014753	-95.48683595	Concrete	72	750	Direct sample taken from storm drainpipe on right bank 5 yards in the culvert. Did not observe water flowing but can hear sound of rushing water in the culvert. Water is flowing 0.5 inches from pipe. Pipe is approximately 6 feet.

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007E_01_FI_09	29.65016589	-95.48683042	Concrete	60	630	Direct sample taken at storm drainpipe on the left bank. Pipe is 5 feet. Water is flowing 1.0 inches from pipe.
1007E_01_FI_10	29.6503758	-95.49235848	N/A	N/A	310	Observed two storm drain pipes in section of AU however no flow and did not hear sound of rushing water. Took ambient sample under bridge, noticed film on water. Depth is 1.5 feet.
1007E_01_FI_11	29.65048938	-95.49281792	N/A	N/A	100	Ambient sample under upstream Hillcroft bridge between overgrown vegetation. Depth is 8 inches.
1007E_01_FI_12	29.65076661	-95.49315139	N/A	N/A	730	Sample upstream of Hillcroft bridges upstream of vegetation block. Anoxic.smell when soil disturbed, and riparian growth under water too. Depth 1.1 ft.
1007E_01_FI_UNC_13	29.65336082	-95.49856353	N/A	N/A	100	Ambient sample on unnamed tributary that flows to Willow Water hole. Also choked with vegetation. Grate on left bank but no outlet seen in channel. Depth 1.6 ft. Slight sewage smell in water and dead smell on bank. UNC stands for unnamed channel.
1007E_01_FI_UNC_14	29.65466354	-95.49842156	N/A	N/A	11,000	Depth is 3 inches, took ambient sample at UNC where section of AU forms a T-like shape on left channel. Intermittently clogged. UNC stands for unnamed channel.
1007E_01_FI_15	29.65449958	-95.49838437	N/A	N/A	1,970	Ambient sample taken at section of AU where it is blocked off by overgrown vegetation and forms a T like shape with UNC. No flow. Depth is 3 inches
1007E_01_FI_16	29.6545326	-95.50075048	Metal	24	<100	Direct sample taken from storm drainpipe on left bank. Algae in outfall. Outfall is 24 inches; water is flowing less than 0.1 inches.

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results *(cfu/100 mL)*	Comments
1007E_01_FI_17	29.65440225	-95.50078743	Metal	24	310	Direct sample taken from storm drainpipe on right bank. Water flowing from pipe is less than 0.1 inches. Pipe is 24 inches.
1007E_01_FI_18	29.65449903	-95.5015178	N/A	N/A	1,450	Ambient sample taken at section of AU in front of storm drainpipe that was not flowing. Depth is 1 inch.
1007E_01_FI_19	29.65447994	-95.50249416	N/A	N/A	2,180	Ambient sample taken in front of metal storm drainpipe that was not leaking.
1007E_01_FI_20	29.64438769	-95.50554183	N/A	N/A	1,340	Depth is 0.9 feet. Took bucket sample at bridge overlooking section of AU with water pipe hanging over.
1007E_01_FI_21	29.64171791	-95.50834423	N/A	N/A	210	Ambient sample from bridge at Fondren Road. Depth is 0.9 ft.

Most of the 21 samples collected during the FI reflected a bacteria level greater than the primary contact recreation single sample criterion of 399 cfu/100 mL. There was a total of seven that met the single sample criterion: 1007E_01_FI_04 was an ambient sample collected downstream of Houston Fire Station 48, in between two bridges on Chimney Rock Rd. 1007E_01_FI_10 was an ambient grab downstream from two storm drainpipes at a bridge on Hillcroft Ave, while 1007E_01_FI_11 was taken just upstream from the same location. It was observed at the time that both storm drainpipes in between the two samples were not flowing, thus a direct sample was not collected.

1007E_01_FI_UNC_13 was unique in that this was at a point in the field investigation where an unnamed channel bracketing off from 1007E_01 in two directions was discovered near Quail Meadow Dr. The thirteenth sample was grabbed on the channel flowing south, while the fourteenth sample was grabbed on the part of the channel flowing towards the north. While 007E_01_FI_UNC_13 was one of the samples that met the single sample criterion, the sample collected just south of it saw a level of 11,000 cfu/100 mL and was suggested for further investigation due to possible SSOs and other complaints. This location was discussed with jurisdictions, and it may be worth bringing to the attention of TCEQ to reevaluate as a possible separate tributary.

1007E_01_FI_16 was a direct sample from an outfall located just under Bob White Dr on the left bank, while 1007E_01_FI_17 was a direct sample under the same road from an outfall on the right bank. The last of the seven samples meeting the single sample criterion and the final sample collected during the FI, 1007E_01_FI_21, was an ambient bucket sample taken at a bridge on Fondren Rd.

In total there were four locations that were highlighted for further investigation, particularly 1007E_01_FI_02, as it had the highest level of bacteria at > 242,000 cfu/100 mL. This was a direct sample from a storm drainpipe near Chimney Rock Park and Piccadilly Place Apartments; field staff noticed a strong sewer smell from the pipe and downstream pool. What looked to be degraded toilet paper was also floating in the water body at the time of sampling. Sample sites suggested for further investigation are detailed in the Referrals to Responsible Parties section of the report.

Referrals to Responsible Parties 1007I_01 (Plum Creek Above Tidal)

Nearly all the samples collected on this AU exceeded the single sample criterion, especially during field investigation 1. Further investigation is recommended for all of these samples where possible, but as many of the samples were ambient, investigation may not always be possible. Four sites in particular are being referred for investigation because of high bacteria levels coming from either direct sources or an underground portion of the waterway.

Referral Site: 1007I_01_FI_02
Latitude: 29.70021 Longitude: -95.2901

Sample 1007I_01_FI_02 (2,130 cfu/100 mL) was a grab sample taken at a concrete storm drainpipe on a tributary on the right bank of 1007I_01 (Figure 8). The outfall was under a bridge on Office City Dr near where the AU comes aboveground. This location featured steep banks, extensive riparian overgrowth, and large amounts of litter (more so than during previous WS), making it a bit difficult for field staff to enter the water body and begin their walk. Bacteria levels for this location were spiked from the first grab sample,1007I_01_FI_01 (1,890 cfu/100 mL), and it is worth noting that there is an apartment complex just downstream from where field staff retrieved the sample.

Figure 8. Referral Site 1007I_01_FI_02. Map showing proximity to apartment complex and subset image of tributary view

Referral Site: 1007I_01_FI_05
Latitude: 29.70360181 Longitude: -95.2886588

Sample 1007I_01_FI_05 (98,000 cfu/100 mL) was a grab sample taken from a flowing concrete storm drainpipe on the left bank of the tributary (Figure 9). This outfall was directly below Patricia Manor Apartments. The sample site is located approximately 400 meters downstream from where 1007I_01_FI_02 (2,130 cfu/100 mL) was retrieved and resulted in the highest level of bacteria seen in FI 1. Levels dramatically decreased in the mixing zone sample taken downstream from this site.

Figure 9. Referral Site 1007I_01_FI_05. Map showing proximity to apartment complex and subset image of tributary view

Referral Site: 1007I_F2_05
Latitude: 29.70435441 Longitude: -95.27607036

Sample 1007I_F2_05 (1,710 cfu/100 mL) was a bucket sample taken at the right bank of the tributary at an opening of a culvert right off I-610 (Figure 10). The sample was taken 3-5 feet into the tunnel. Bacteria levels spiked for this site in particular, and there is an apartment complex on the left bank if going downstream. A lift station was observed approximately 150 meters downstream from the sample site. After walking downstream towards the lift station from this sample site and towards 1007I_F2_06 (850 cfu/100 mL), field staff observed what appeared to be an outfall pipe under the apartment complex, however there was no evidence of flow or leakage.

Figure 10. Referral Site 1007I_F2_05. Map showing proximity to apartment complex and lift station and subset image of tributary view

Referral Site: 1007I_F2_06
Latitude: 29.70441173 Longitude: -95.27612226

Sample 1007I_F2_06 (850 cfu/100 mL) was taken on the left bank at the previously mentioned culvert opening (Figure 11). It was here that a storm drainpipe was observed inside the tunnel. There was evidence of past leakage, however no flow or leakage was observed at the time of sampling. As with 1007I_F2_05 (1,710 cfu/100 mL), an apartment complex was observed on the same bank as the sample, and the lift station was approximately 150 meters downstream. It should be noted that there was an excessive amount of litter in the vicinity including shopping carts and trash on trees.

Figure 11. Referral Site 1007I_F2_06. Map showing proximity to apartment complex and lift station and subset image of tributary view.

Referrals to Responsible Parties 1007E_01 (Willow Waterhole Bayou Above Tidal)
Nearly all the samples collected on this AU exceeded the single sample criterion. Further investigation is recommended for all of these samples where possible, but four sites in particular are being referred for investigation because of high bacteria levels coming from either direct sources or a specific tributary.

Referral Site: 1007E_01_FI_02
Latitude: 29.65289411 Longitude: -95.47858254

Sample 1007E_01_FI_02 (>242,000 cfu/100 mL) was a direct sample at an outfall pipe on the right bank of the tributary downstream from Chimney Rock Rd and Chimney Rock Park (Figure 12). Field staff noted a strong sewer smell coming from the pipe and the downstream pool and observed algae and possibly degraded toilet paper in the water. This sample had the highest levels of bacteria seen during the field investigation, with the source likely stemming from the apartment complex on the right bank.

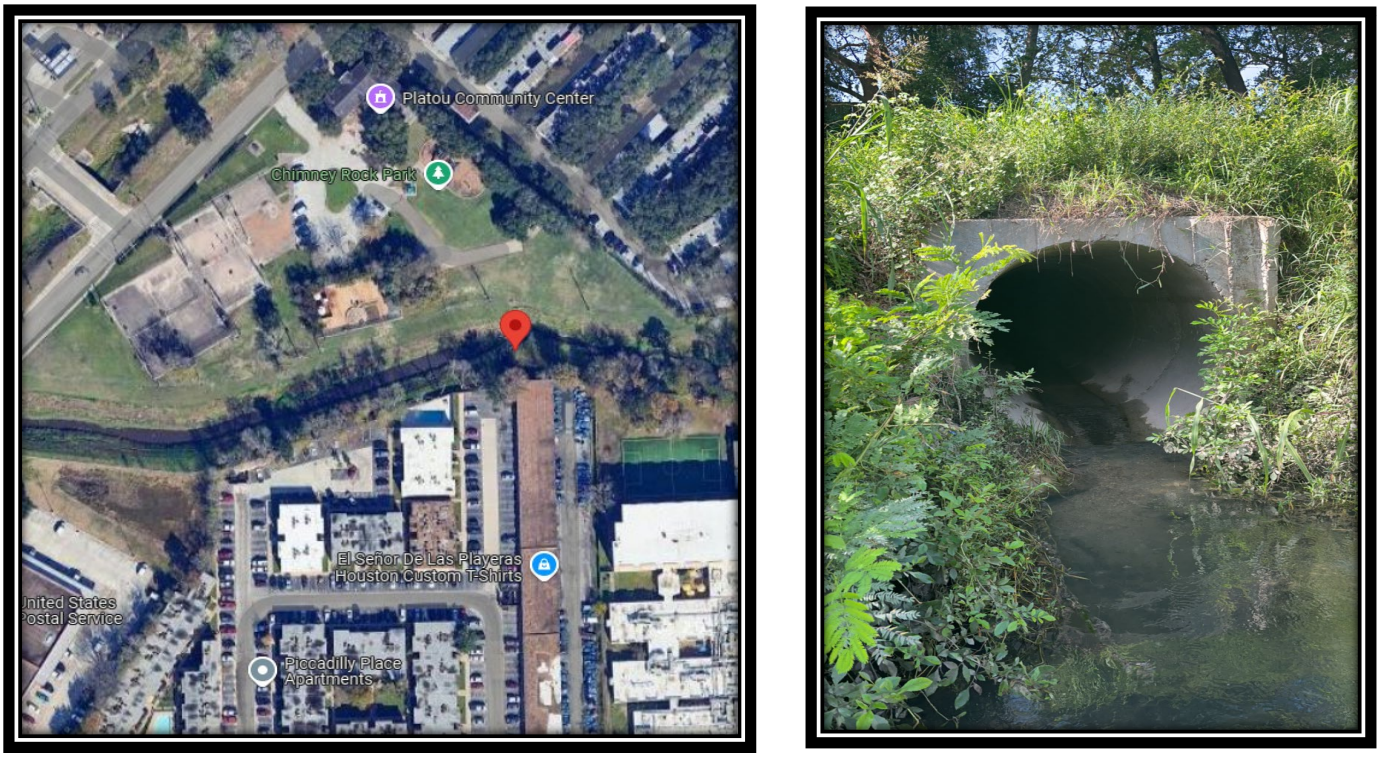

Figure 12. Referral Site 1007E_01_FI_02. Map showing proximity to apartment complex and park and subset image of tributary view.

Referral Site: 1007E_01_FI_08 and 1007E_01_FI_09
Latitude: 29.65014753 Longitude: -95.48683595
Latitude: 29.65016589 Longitude: -95.48683042

Samples 1007E_01_FI_08 (750 cfu/100 mL) and 1007E_01_FI_09 (630 cfu/100 mL) were direct samples taken from concrete pipes on the right and left banks of the tributary, respectively (Figure 13). Field staff did not observe flowing water however, they did hear the sound of rushing water from within the culvert. While these samples did not result in the highest values, they were both direct samples entering the waterway at the same location, and an ambient sample downstream spiked at 1,990 cfu/100 mL (1007E_01_FI_06). This location featured extensive riparian overgrowth and was beneath a bridge near the intersection of Landsdowne Dr and Ludington Dr and was approximately 130 meters and 260 meters away from an elementary school and park, respectively.

Figure 13. Referral Site 1007E_01_FI_08 and 1007E_01_FI_09. Map showing proximity to elementary school and park and subset image of tributary view.

Referral Site: 1007E_01_FI_UNC_14
Latitude: 29.65466354 Longitude: -95.49842156

Sample 1007E_01_FI_UNC_14 was an ambient sample taken at an unnamed channel bracketing off north and south from the main tributary near Quail Meadow Dr (Figure 14). At this point on the tributary, field staff observed that there was a berm and the channel chocked with vegetation to the east, preventing them from walking further downstream. An apartment complex was observed nearby on the left bank. Since this is an ambient sample, there may not be much to be investigated, however possible SSOs or other complaints, i.e., a trash receptacle may be present, influencing the bacteria result (11,000 cfu/100 mL). Due to the nature of the unnamed channel and flow diversion H-GAC discussed bringing this to the attention of TCEQ for further discussion.

Figure 14. Referral Site 1007E_01_FI_UNC_14. Map showing unnamed channel and proximity to apartment complex and subset image of tributary view

Conclusion

On August 27, 2024, H-GAC met with local jurisdictions to discuss the results of the Targeted Bacteria Monitoring project. During the discussion H-GAC staff noted the varying results shown throughout the project; and brought attention to sampling locations that had particularly high levels of bacteria near apartment complexes and parks, indicating possible influence from sanitary sewer overflows, domesticated pets, or complaints made by residents.

The City of Houston agreed with H-GAC's speculation that the high bacteria results seen in FI 1 for 1007I_01 were due to influence from Hurricane Beryl, as results in FI 2 were lower in comparison. The city also interjected that some of the sources for the observations made, were due to identified SSOs that were the result of the hurricane impacting the collection system and lift stations.

It was explained previously that the location of 1007E_01_FI_UNC_13 was unique, where an unnamed channel bracketing off from 1007E_01 in two directions was discovered near Quail Meadow Dr (Figure 15). H-GAC discussed this with the Harris County Flood Control District. The AU is bisected by numerous ditches to help alleviate flooding. A channel to the west of the figure takes the bulk of the flow north to Brays Bayou. At the "T" in the figure, flow for Willow Waterhole Bayou comes in from the west and turns north. The investigators observed a berm at the top of the "T" that prevents flow from continuing eastward. Based on Google Earth, the flow path is a diversionary channel that returns flow to the east near the Willow Waterhole Detention. H-GAC is considering if these observed diversions might necessitate a discussion with TCEQ assessors on whether the single Willow Waterhole Bayou AU should be broken up to address changes in flow.

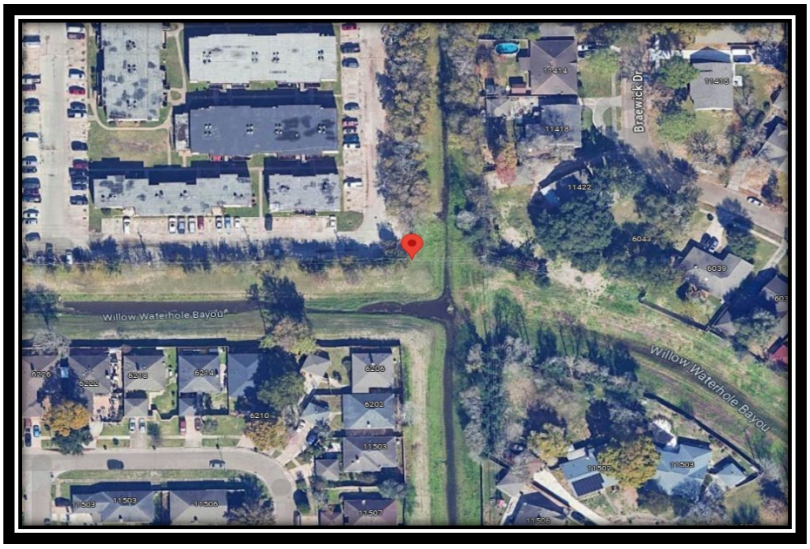

Figure 15. The "T" channel in Willow Waterhole Bayou

While not referred for further investigation, H-GAC staff inquired about sample 1007I_F2_07, where there was an initial sample at 860 cfu/100 mL (1007I_01_FI_11) and the referenced

second follow up sample analyzed was at 100 cfu/100 mL. The water was clear in comparison to observations of other samples collected at flowing outfalls. The City of Houston confirmed H-GAC's speculation that this was indeed a wastewater outfall.

A couple of lessons learned during this investigation was the difficulty with weather and vegetative growth. Starting an investigation in summer can be impacted by tropical rains and high temperatures. Additionally, the riparian vegetation went through its spring growth and if the channel has not been maintained, walking the AU can be difficult and observing outfalls problematic (Figure 16).

Figure 16. Willow Waterhole Bayou riparian cover of 5ft tall Johnson Grass

H-GAC and local jurisdictions explored ideas to address these lessons for future targeted bacteria monitoring. In FY25, amended work planned could include winter investigations removing the impact of summer heat and winter cutting back on vegetative growth. The investigations could be undertaken together with the jurisdictions. Harris County Flood Control District noted they could provide maintenance schedules for the target AUs, helping to avoid excessive riparian overgrowth, and thus making extended investigative walks more manageable for field staff.