Appendix C: Bacteria Source Identification Report

Bacteria Source Identification Report

BIG's Top Five Most and Top Five Least Impaired Water Bodies Project

GALVESTON BAY ESTUARY PROGRAM
A PROGRAM OF THE TCEQ

HDR Water Resources

TCEQ

Bacteria Source Identification Report

BIG's Top Five Most and Top Five Least Impaired Water Bodies Project

Prepared for:

Galveston Bay Estuary Program
Texas Commission on Environmental Quality
Local Jurisdictions

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Introduction

In the Houston-Galveston region, approximately 41% of stream miles exceed state water quality standards for bacteria. That equates to over 6,500 miles of streams and shoreline that pose a risk to human health during recreational activities and ingestion of untreated waters. There have been several initiatives throughout the region to address this issue. One of the more robust efforts includes implementation plan (I-Plan) development by the Bacteria Implementation Group (BIG), a partnership of government, business, and community leaders, that address elevated levels of bacteria in 72 bacteria-impaired stream segments in the Houston-Galveston region. The *BIG's Top Five Most and Top Five Least Impaired Water Bodies* project was developed as a result of the BIG's tracking of bacteria levels and development of the Top 10 Most and Top 10 Least Impaired Water Bodies lists. These lists identified the 10 waterways with the highest bacteria concentrations above the state standard and the 10 closest to meeting state water quality standards.

The purpose of *BIG's Top Five Most and Top Five Least Impaired Water Bodies* project is to investigate sources of bacteria in select AUs from the BIG's Top 10 Most and Top 10 Least lists, and to eliminate the sources by working with local jurisdictions. Focusing on the most and least bacteria-impaired waterways increases the potential for significantly reducing bacteria levels and ultimately removing streams from the state's list of bacteria-impaired waterways. The Houston-Galveston Area Council (H-GAC) is designated as the lead agency responsible for administration of the *BIG's Top Five Most and Top Five Least Impaired Water Bodies* project.

The project has been split into phases, Phase I, Phase II, and Phase III. The initial phase included prioritization of the BIG's Top 10 Most and Top 10 Least Impaired Water Bodies lists based on desktop reviews, analysis of preexisting data, and input from a technical workgroup made up of water resource professionals and representatives from local jurisdictions. Table 1 lists the Top 2 Most and Top 2 Least Impaired Water Bodies that were selected based on Phase I analysis and input. Refer to H-GAC's Preliminary Action Report for more information about how AUs were prioritized for this project.

TABLE 8. TOP 2 MOST AND TOP 2 LEAST IMPAIRED WATER BODIES SELECTED FOR BACTERIA SOURCE IDENTIFICATION.

Top 2 Most Impaired Water Bodies	Top 2 Least Impaired Water Bodies
Little White Oak Bayou (1013A_01)[1]	Upper Panther Branch (1008B_02)
Rummel Creek (1014N_01)	Canal C-147 (1007A_01)

[1]*Identification number included in parentheses represent TCEQ segment AUs.*

The following report summarizes the Phase II assessment and bacteria source identification for the four AUs in Table 1. The information contained in this report is intended to assist local jurisdictions in the identification and further investigation of illicit discharges and other significant sources of bacteria impacting the water bodies discussed herein. H-GAC will not correct the sources but will work with local jurisdictions to remove and/or eliminate the sources identified in this report.

Phase I Bacteria Screening & Station Selection

The Phase I bacteria screening process included exhaustive on the ground surveys where each of the four selected AUs were investigated, all outfalls were documented, and initial bacteria samples were collected from discharging outfalls, tributaries, and surface waters. This initial phase of bacteria screening was intended to provide baseline data used to identify potential illicit discharges, hot spots, and areas of greatest concern for each of the four AUs surveyed.

Phase I samples were analyzed using the Coliscan Easygel petri dish method to test for *E.coli* concentrations by counting the number of bacteria colonies that form on the Easygel medium (Figures 1 and 2). Two dilutions of each sample were tested using this methodology and the average bacteria concentration was reported. However, colony counting using this method provides limited measurement capability for *E.coli* due to the possibility of too numerous to count (TNTC) results that occur if greater than 200 colonies are formed on a dish. Results and findings from the bacteria screening process were used as a precursor to Phase II assessments where only the stations with the highest bacteria screening concentrations from Phase I were subject to follow up investigation. The following is a summary of Phase I bacteria screening results for the four selected AUs and details on the station selection process for Phase II investigations.

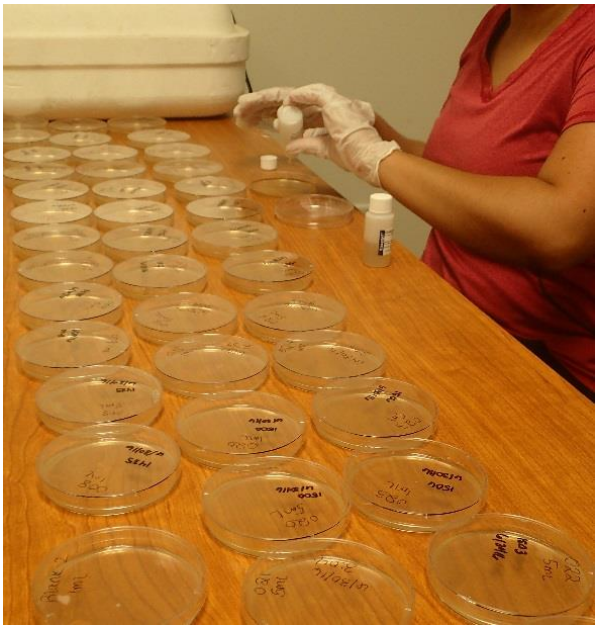

Figure 9. Coliscan Easygel set up

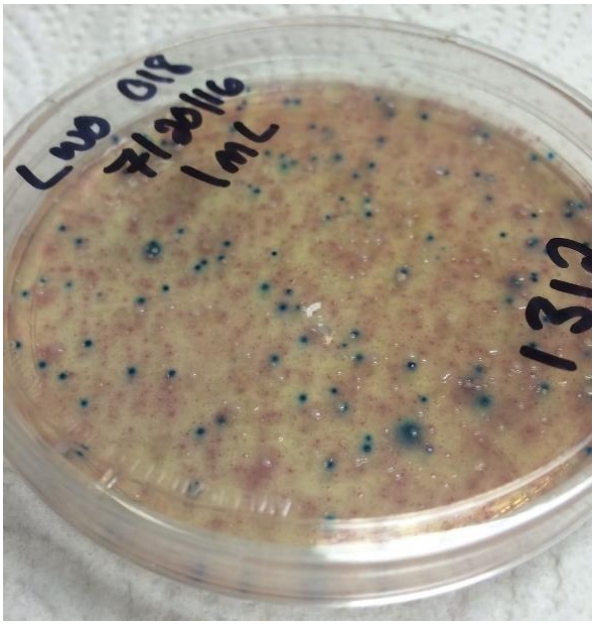

Figure 8. Bacteria Colony Counts using ColiScan Easygel Methods

Canal C-147 (1007A_01)

A total of 21 bacteria screening samples were collected along Canal C-147 during the Phase I survey conducted on June 30, 2016. Based on the bacteria screening results, stations that were TNTC or measured greater than 600 cfu/100mL were flagged as significant sources of bacteria subject to further sampling and investigation during Phase II. Refer to Table 2 for a list of chosen Canal C-147 stations and their initial bacteria screening *E.coli* concentrations. Sample numbers from Phase I are re-used for Phase II assessments to ensure facilitated tracking of sample locations.

TABLE 9. PHASE I BACTERIA SCREENING STATIONS CHOSEN FOR FOLLOW UP PHASE II INVESTIGATIONS

Water Body	Survey Date	Sample No.	Sample Type	*E.coli* (cfu/100mL)
Canal C-147 (1007A_01)	06/30/2016	8	Outfall	800
Canal C-147 (1007A_01)	06/30/2016	13	Outfall	TNTC
Canal C-147 (1007A_01)	06/30/2016	14	Outfall	1770
Canal C-147 (1007A_01)	06/30/2016	17	Tributary	TNTC
Canal C-147 (1007A_01)	06/30/2016	27	Outfall	2130

Upper Panther Branch (1008B_02)

A total of 15 bacteria screening samples were collected along Upper Panther Branch during the Phase I survey conducted on July 26 and 27, 2016. Based on the bacteria screening results, stations that measured greater than 500 cfu/100mL were flagged as significant sources of bacteria subject to further sampling and investigation during Phase II. Refer to Table 3 for a list of chosen Upper Panther Branch stations and their initial bacteria screening *E.coli* concentrations. Sample numbers from Phase I are re-used for Phase II assessments to ensure facilitated tracking of sample locations.

TABLE 10. PHASE I BACTERIA SCREENING STATIONS CHOSEN FOR FOLLOW UP PHASE II INVESTIGATIONS

Water Body	Survey Date	Sample No.	Sample Type	*E.coli* (cfu/100mL)
Upper Panther Branch (1008B_02)	07/26/2016	3	Tributary	3420
Upper Panther Branch (1008B_02)	07/26/2016	6	Tributary	580
Upper Panther Branch (1008B_02)	07/27/2016	9	Tributary	1040

Little White Oak Bayou (1013A_01)

A total of 25 bacteria screening samples were collected during the Phase I Little White Oak survey conducted on July 13, 18, and 20, 2016. Due to the significant number of extremely high *E.coli* concentrations found throughout this AU during the screening process, the City of Houston was consulted during the station selection process to help prioritize areas that should be further investigated during Phase II. Based on the knowledge and interests

communicated by City of Houston personnel, a total of 7 stations were chosen for follow up monitoring at Little White Oak Bayou (refer to Phase II section for more details). Table 4 lists the chosen stations and their initial bacteria screening *E.coli* concentrations. Sample numbers from Phase I are re-used for Phase II assessments to ensure facilitated tracking of sample locations.

TABLE 11. PHASE I BACTERIA SCREENING STATIONS CHOSEN FOR FOLLOW UP PHASE II INVESTIGATIONS

Water Body	Survey Date	Sample No.	Sample Type	*E.coli* (cfu/100mL)
Little White Oak Bayou (1013A_01)	07/18/2016	8	Outfall	0
Little White Oak Bayou (1013A_01)	07/18/2016	10	Outfall	TNTC
Little White Oak Bayou (1013A_01)	07/18/2016	15	Surface Water	TNTC
Little White Oak Bayou (1013A_01)	07/18/2016	16	Surface Water	TNTC
Little White Oak Bayou (1013A_01)	07/20/2016	17	Surface Water	10,900
Little White Oak Bayou (1013A_01)	07/20/2016	18	Outfall	13,300
Little White Oak Bayou (1013A_01)	07/20/2016	25	Surface Water	TNTC

Rummel Creek (1014N_01)

A total of 13 bacteria screening samples were collected during the Phase I Rummel Creek survey conducted on July 11, 2016. Based on Phase I results, areas that measured greater than 500 cfu/100mL were flagged as significant sources of bacteria subject to further sampling and investigation during Phase II. Refer to Table 5 for a list of chosen Rummel Creek stations and their initial bacteria screening *E.coli* concentrations. Multiple samples were collected at the downstream end of Rummel Creek during Phase I that had bacteria concentrations ranging from 500 to 750 cfu/100mL. Station 34 was chosen as the representative downstream station for Phase II investigations due to accessibility factors. Sample numbers from Phase I are re-used for Phase II assessments to ensure facilitated tracking of sample locations.

TABLE 12. PHASE I BACTERIA SCREENING STATIONS CHOSEN FOR FOLLOW UP PHASE II INVESTIGATIONS

Water Body	Survey Date	Sample No.	Sample Type	*E.coli* (cfu/100mL)
Rummel Creek (1014N_01)	07/11/2016	34	Surface Water	525
Rummel Creek (1014N_01)	07/11/2016	36	Outfall	2275
Rummel Creek (1014N_01)	07/11/2016	40	Surface Water	925

Phase II Investigations

Phase II investigations focused on areas in the prioritized AUs that had the highest bacteria screening concentrations or the greatest level of interest expressed by the technical workgroup and local jurisdictions. Sample collection during Phase II was intended to further refine source identification and aid in tracking the sources of bacteria impairment up the tributaries and ditches to the greatest extent practicable. Phase II investigations included three main components:

1) Collection of wet weather and dry weather samples at each Phase II station.
2) Bacteria samples analyzed at a NELAP certified laboratory using the IDEXX Colilert method.
3) Collection of field water quality data using a multiparameter datasonde to supplement the bacteria samples collected at each Phase II station.

All dry weather samples were collected following a minimum 72-hour antecedent dry period. Wet weather sampling was conducted during or immediately after a rain event with greater than 0.50 inches of rain following a minimum 72-hr antecedent dry period. The Harris County Flood Warning System website was used to determine if a monitoring event qualified as either wet or dry weather.

In an effort to improve source identification, selected monitoring locations from Phase I were further investigated and new sample stations were created to assess the areas surrounding the original station location. For example, if station number 14 was flagged during Phase I for follow up investigation, additional samples collected upstream or downstream of this location during Phase II are labeled as 14.1, 14.2, etc.

The following sections provide descriptions for each AU surveyed and summarize the findings associated with each Phase II sample location.

Canal C-147 (1007A_01)

Canal C-147, TCEQ segment AU 1007A_01, is located in an urban area of southwest Houston in Harris County. Major thoroughfares within the 2.63 square mile watershed area include West Fuqua Street and the Sam Houston Tollway. Primary land uses are residential and light commercial with auto body shops, small car dealerships, and restaurants representing the majority of businesses in the area.

Canal C-147 has been on TCEQ's 303(d) list of impaired waterways for bacteria since 2006. It is also included as the fourth AU on the BIG's Top 10 Least Impaired Water Bodies list from 2015. With a seven-year *E.coli* geometric mean value of 157 MPN/100mL, this AU is close to meeting the state water quality standard of 126 MPN/100mL and being removed from TCEQ's 303(d) list all together. Figure 3 shows the wet weather and dry weather bacteria concentrations from the Phase II Canal C-147 surveys by sample number. Figure 4 illustrates the location of Phase II sample stations for Canal C-147.

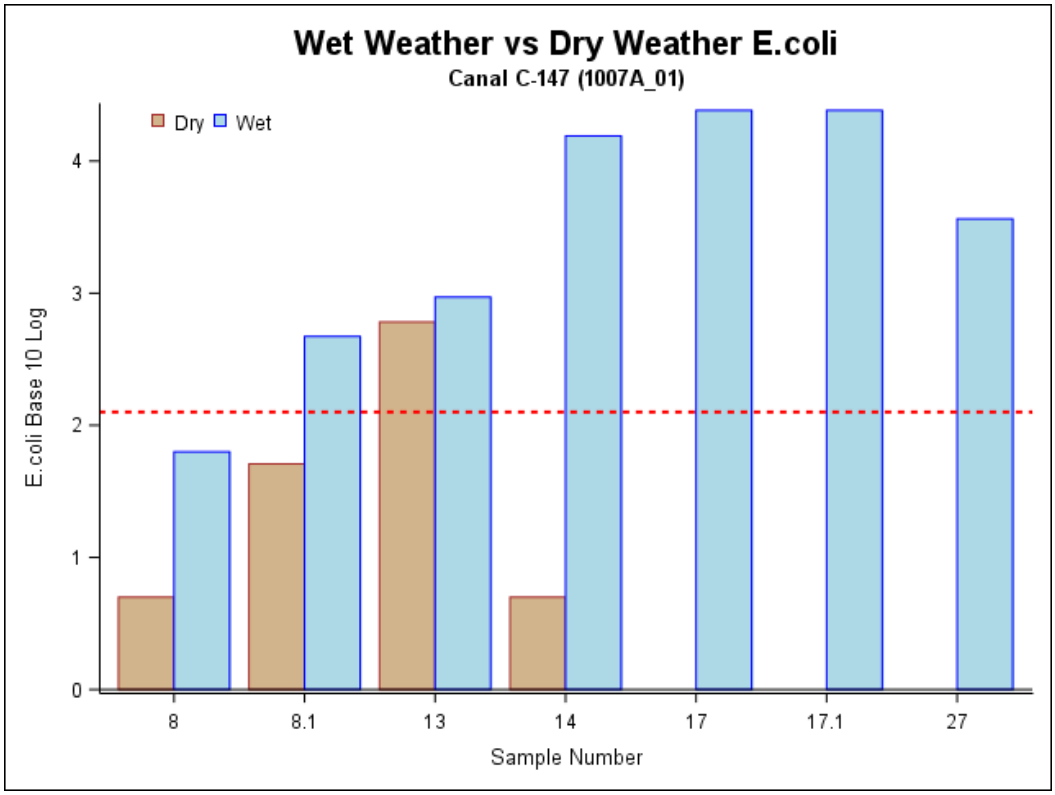

Figure 10. Wet weather and dry weather e.coli concentrations from Phase II Canal C-147 surveys. Red dotted line represents the state water quality standard for bacteria.

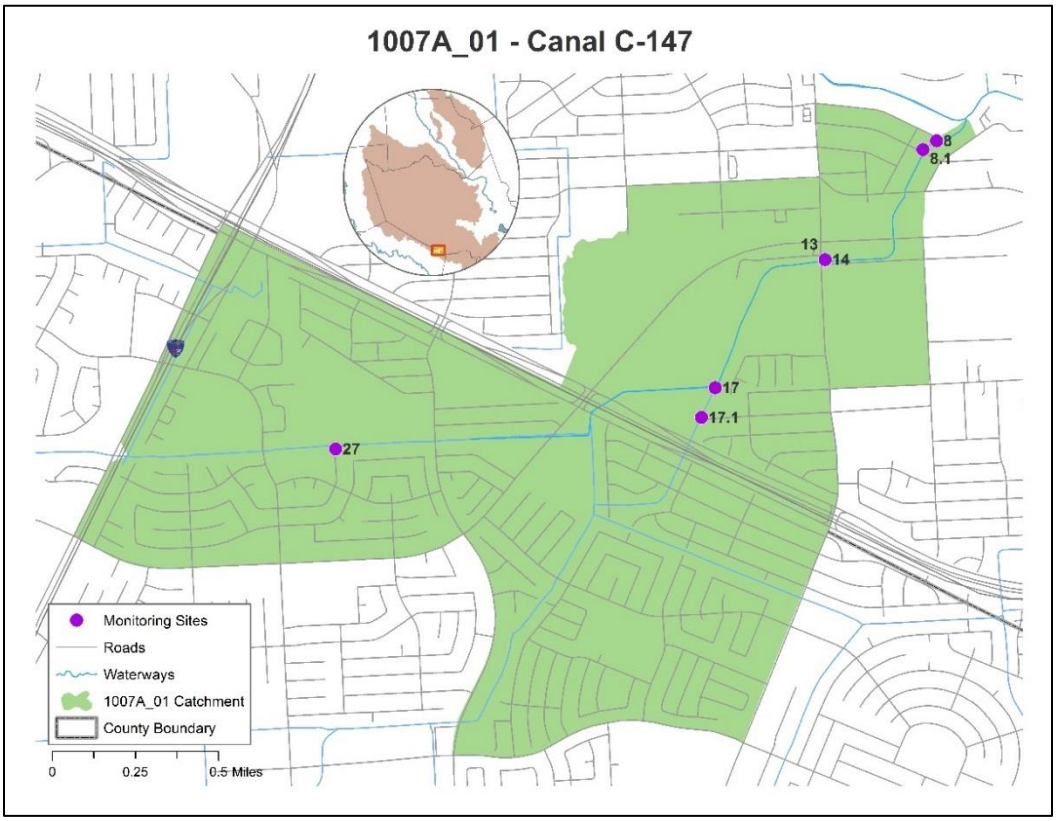

Figure 11. Phase II Canal C-147 monitoring stations

Station 8

Station 8 is a metal outfall located at the downstream end of the Canal C-147 watershed boundary adjacent to a residential neighborhood and a number of auto body junk yards. Illegal dumping of trash, tires, and large debris was common in the area (Figure 5). Figures 6 and 7 are photos of the outfall taken during the dry weather sampling event. Based on these results, the City of Houston initiated an investigation at this outfall location in September 2016 and detected a potable water leak. Information about corrective actions related to the potable leak are unknown. However, Phase II investigations resulted in wet and dry weather samples with *E.coli* concentrations that are now in compliance with state standards (Table 6).

Figure 12

Figure 13

Figure 14

TABLE 13. PHASE II WATER QUALITY DATA FOR CANAL C-147 STATION 8

Parameter	Wet Weather	Dry Weather
Latitude	29.61648	
Longitude	-95.45901	
Survey Date	11/7/2016	10/19/2016
Days Since Last Rain	1	8
Total Depth (m)	0.14	0.07
Temperature (°C)	23.19	26.79
Specific Conductance (µs/cm)	291	771.2
pH (standard units)	7.53	7.9
Dissolved Oxygen (mg/L)	7.8	10.17
E.coli (MPN/100mL)	63	<10
Turbidity (ntu)	>1.2	>1.2
Observed Turbidity	Low	Low
Water Clarity	Excellent	Excellent
Water Color	Brownish	Clear
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	Normal	Normal

Station 8.1

Station 8.1 is a metal outfall located approximately 85 meters upstream of the station 8 outfall (Figure 8). This outfall was not discharging during the Phase I survey so no bacteria screening samples were collected. However, during the Phase II survey, this outfall was intermittently discharging water during both wet and dry weather sampling events. The outfall is located directly underneath the Tiffany Street bridge across the street from a number of junk yards and residential homes. H-GAC field staff attempted to follow the outfall pipe to its origin and found that it is connected to the ditch running along the north side of Tiffany Street (Figures 9 and 10).

Samples were collected directly from the discharging outfall during both wet and dry weather events. Only the wet weather sample had an *E.coli* concentration that exceeded the state water quality standard of 126 MPN/100mL (Table 7).

Figure 15

Figure 16

Figure 17

TABLE 14. PHASE II WATER QUALITY DATA FOR CANAL C-147 STATION 8.1

Parameter	Wet Weather	Dry Weather
Latitude	29.61612	
Longitude	-95.45970	
Survey Date	11/7/2016	10/19/2016
Days Since Last Rain	1	8
Total Depth (m)	0.05	0.03
Temperature (°C)	23.04	-
Specific Conductance (µs/cm)	288.3	-
pH (standard units)	7.61	-
Dissolved Oxygen (mg/L)	7.7	-
E.coli (MPN/100mL)	471	51
Turbidity (ntu)	>1.2	>1.2
Observed Turbidity	Low	Low
Water Clarity	Excellent	Excellent
Water Color	Brownish	Clear
Water Odor	None	Musky/Earthy
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	Normal	Normal

Station 13

Station 13 is a large round storm drain located on the right side of Canal C-147 at the South Post Oak Road bridge directly across from station 14 (Figures 11 and 12). A tire shop and car dealership are located adjacent to Canal C-147 at this location. The bacteria screening *E.coli* concentration at this station was TNTC, representing one of the highest bacteria sources to Canal C-147 identified during Phase I of this project.

Both wet weather and dry weather samples collected at this location had *E.coli* concentrations that exceeded the state water quality standard of 126 MPN/100mL (Table 8). The high bacteria concentrations detected during both wet and dry weather events implies there is a consistent source of bacteria discharging into Canal C-147 at this location regardless of weather conditions. Schools of fish were observed swimming in the storm drain during all sampling events. Additionally, the pH level inside the storm drain during the wet weather event was significantly higher than levels outside the storm drain. Further investigation is recommended at this station.

Figure 19

Figure 18

Table 15. Phase II water quality data for Canal C-147 STATION 13

Parameter	Wet Weather	Dry Weather
Latitude	29.61142	
Longitude	-95.46475	
Survey Date	11/7/2016	10/19/2016
Days Since Last Rain	1	8
Total Depth (m)	0.23	0.05
Temperature (°C)	23.45	24.95
Specific Conductance (µs/cm)	201.2	1020
pH (standard units)	9.67	7.7
Dissolved Oxygen (mg/L)	6.32	5.44
E.coli (MPN/100mL)	934	605
Turbidity (ntu)	0.28	0.53
Observed Turbidity	High	Medium
Water Clarity	Poor	Fair
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	Normal	Normal

Station 14

Station 14 is a large square storm drain located on the left side of Canal C-147 at the South Post Oak Street bridge directly across from station 13. A tire shop and car dealership are located adjacent to Canal C-147 at this location.

During the dry weather event, there was only a shallow trickle of water discharging from the storm drain (Figures 13 and 14). The water appeared clean and colorless with no particular odor, but was too shallow for the collection of field water quality data using the multiparameter data sonde. There was a significant difference in *E.coli* concentrations between the wet weather and dry weather sampling events (Table 9). Further investigation is recommended at this location to identify the cause for this variation during different weather conditions.

Figure 21

Figure 20

TABLE 16. PHASE II WATER QUALITY DATA FOR CANAL C-147 STATION 14.

Parameter	Wet Weather	Dry Weather
Latitude	29.61145	
Longitude	-95.46475	
Survey Date	11/7/2016	10/19/2016
Days Since Last Rain	1	8
Total Depth (m)	0.06	<0.01
Temperature (°C)	23.31	-
Specific Conductance (µs/cm)	156	-
pH (standard units)	8.11	-
Dissolved Oxygen (mg/L)	7.46	-
E.coli (MPN/100mL)	15,500	<10
Turbidity (ntu)	0.72	>1.2
Observed Turbidity	Medium	Low
Water Clarity	Fair	Excellent
Water Color	Brownish	Clear
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	Normal	Low

Station 17 and 17.1

Station 17 is a tributary of Canal C-147 located approximately 600 meters northeast of the intersection of Sam Houston Tollway and West Fuqua Street. The tributary primarily runs through dense residential neighborhoods.

The tributary was dry during the dry weather event on October 19, 2016, so no dry weather sample was collected at this location (Figure 15). Wet weather samples were collected on November 7, 2016 following a significant rain event. The sample for station 17 was collected at the confluence of the tributary with Canal C-147 (Figure 16). A second sample was collected at station 17.1 located approximately 150 meters upstream of station 17. Both wet weather samples collected along this tributary resulted in an *E.coli* concentration of 24,200 MPN/100mL. This station was the most significant source of bacteria to Canal C-147 identified during Phase I and Phase II of the project. Further investigation is recommended.

Figure 22

Figure 23

TABLE 17. WET WEATHER WATER QUALITY DATA FOR CANAL C-147 STATIONS 17 AND 17.1

Parameter	Station 17	Station 17.1
Latitude	29.60601	29.60473
Longitude	-95.47043	-95.47116
Survey Date	11/7/2016	11/7/2016
Days Since Last Rain	1	1
Total Depth (m)	0.21	0.13
Temperature (°C)	22.63	22.67
Specific Conductance (µs/cm)	204	188.4
pH (standard units)	7.27	7.25
Dissolved Oxygen (mg/L)	2.99	1.28
E.coli (MPN/100mL)	24,200	24,200
Turbidity (ntu)	0.35	0.51
Observed Turbidity	High	Medium
Water Clarity	Fair	Fair
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Partly Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Calm	Calm
Flow Severity	Normal	Normal

Station 27

Station 27 is a metal outfall located on the right bank of Canal C-147 between Blue Ridge Road and Chimney Rock Road. The easiest access point is through a residential neighborhood at the end of Ohara Drive.

There was no discharge observed during the dry weather event conducted on October 19, 2016 (Figures 17 and 18) resulting in no dry weather samples collected at this location during Phase II investigations. A wet weather sample was collected on November 7, 2016. A sample was collected directly from the outfall and field water quality data from the data sonde were taken from the shallow pool of water accumulated in front of the outfall. The resulting bacteria concentration was 3,650 MPN/100mL which is significantly greater than the state water quality standard for *E.coli* (Table 11).

Figure 25

Figure 24

TABLE 18. WATER QUALITY DATA FOR CANAL C-147 STATION 27.

Parameter	Wet Weather	Dry Weather
Latitude	29.60384	
Longitude	-95.48948	
Survey Date	11/7/2016	10/19/2016
Days Since Last Rain	1	8
Total Depth (m)	0.25	0
Temperature (°C)	22.16	-
Specific Conductance (µs/cm)	109.3	-
pH (standard units)	7.71	-
Dissolved Oxygen (mg/L)	6.64	-
E.coli (MPN/100mL)	3,650	-
Turbidity (ntu)	0.91	-
Observed Turbidity	Low	-
Water Clarity	Good	-
Water Color	Brownish	-
Water Odor	None	-
Present Weather	Partly Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Calm	-
Flow Severity	Normal	Dry

Upper Panther Branch (1008B_02)

Upper Panther Branch, TCEQ segment AU 1008B_02, is located in the Woodlands area west of Interstate 45 off Research Forest Drive in Montgomery County. The watershed area is approximately 2.01 square miles with primarily wooded and natural terrain lining the waterway. All outfalls and storm drains observed in the Upper Panther Branch watershed during the Phase I and II surveys were designed to discharge from an outfall pipe approximately 50 meters or more away from Upper Panther Branch. The water flows over rocky or natural buffer areas before discharging into the main stream. These discharges were classified as tributaries of Upper Panther Branch during the surveys conducted for this project. Land use within the watershed is primarily residential with recreation centers, sporting facilities, and golf courses representing key facilities and businesses in the area.

Upper Panther Branch has been listed as impaired for bacteria on the Texas Integrated Report (IR) since 2006. It is the first AU on the BIG's Top 10 Least Impaired Water Bodies list from 2015, meaning that Upper Panther Branch is the AU on the list closest to meeting the state water quality standard for bacteria. The seven-year *E.coli* geometric mean value for Upper Panther Branch is 133 MPN/100mL compared to the *E.coli* water quality standard of 126 MPN/100mL. Figure 19 shows the wet weather and dry weather bacteria concentrations from the Phase II Upper Panther Branch surveys by sample number. Figure 20 illustrates the location of Phase II sample stations for Upper Panther Branch.

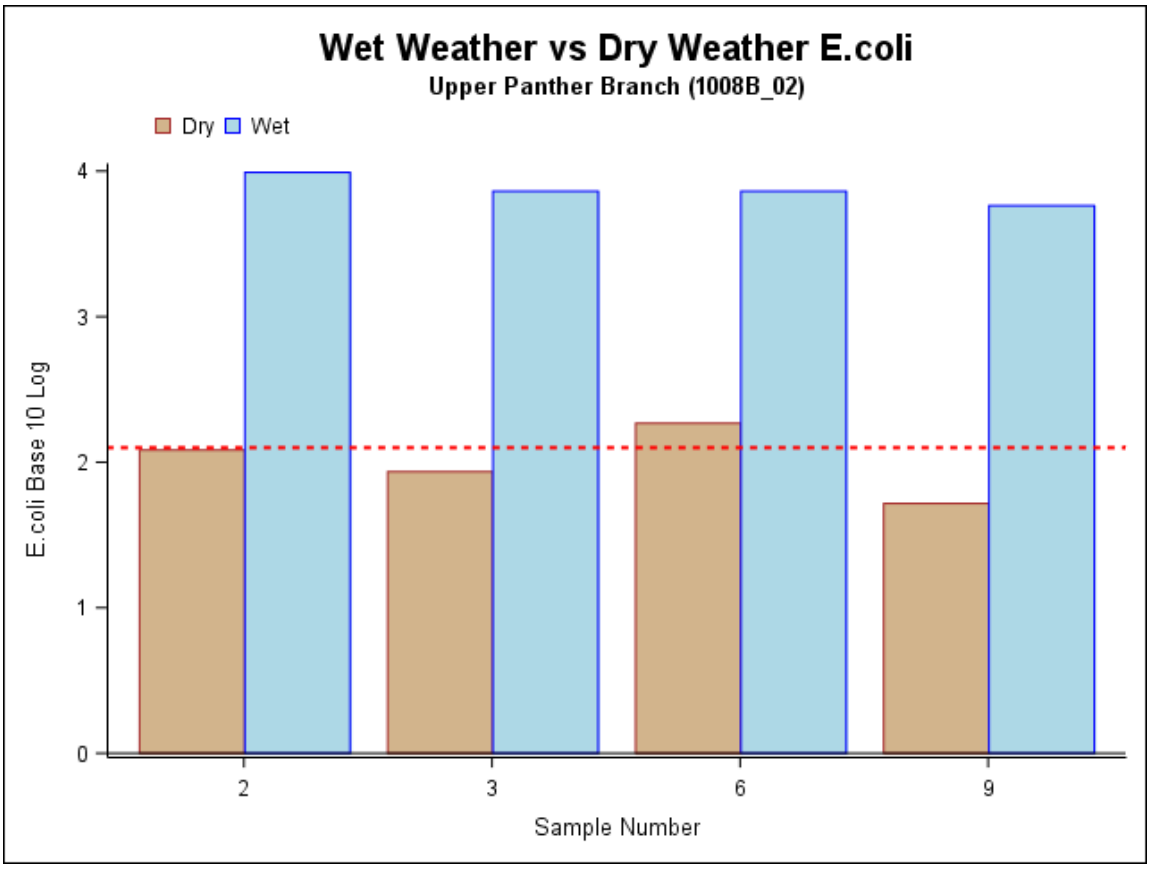

FIGURE 26. WET WEATHER AND DRY WEATHER *E.COLI* CONCENTRATIONS FROM PHASE II UPPER PANTHER BRANCH SURVEYS. RED DOTTED LINE REPRESENTS THE STATE WATER QUALITY STANDARD FOR BACTERIA.

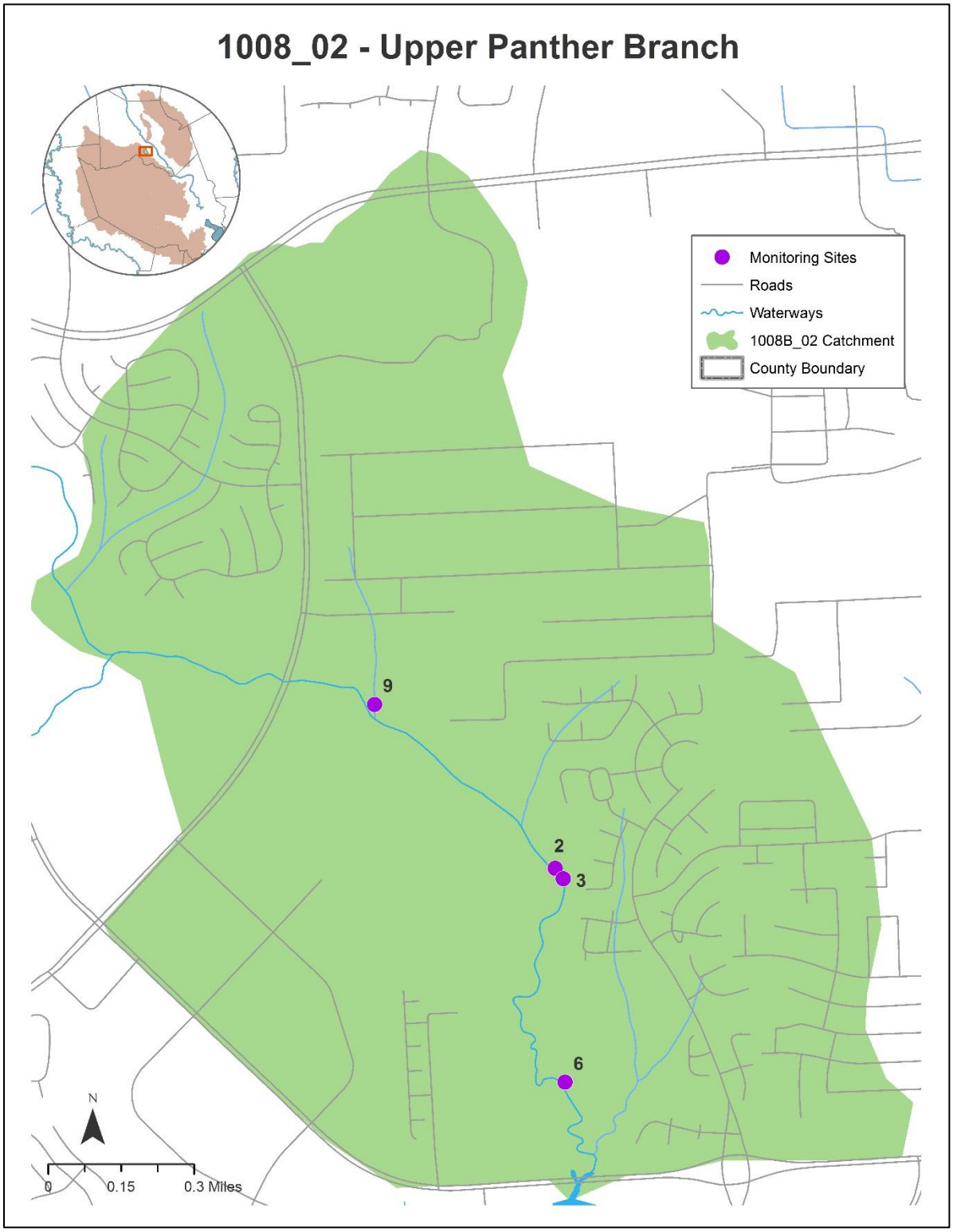

Figure 27. Phase II Upper Panther Branch monitoring stations

Station 2

Station 2 is located directly upstream of the station 3 tributary. Station 3 was identified as a potential source of bacteria to Upper Panther Branch during Phase I investigations. Station 2 was sampled during Phase II in an effort to compare upstream bacteria concentrations with samples collected from station 3.

A chlorine odor was detected during the Upper Panther Branch Phase I and Phase II investigations. Chlorine test strips detected concentrations measuring greater than 0.5 mg/L at this location during the dry weather sampling event (Figure 21). The local wastewater treatment facility was notified, but a source for the chlorine is still unknown.

A dry weather sample was collected on September 28, 2016 (Figure 22) resulting in an *E.coli* concentration of 121 MPN/100mL which is just below the state water quality standard of 126 MPN/100mL. The wet weather sample collected on February 15, 2017 had a much greater *E.coli* concentration measuring at 9,800 MPN/100mL (Table 12).

Figure 28

Figure 29

TABLE 19. WATER QUALITY DATA FOR UPPER PANTHER BRANCH STATION 2.

Parameter	Wet Weather	Dry Weather
Latitude	30.18568	
Longitude	-95.47247	
Survey Date	2/15/2017	09/28/2016
Days Since Last Rain	1	3
Total Depth (m)	0.42	0.41
Temperature (°C)	16.4	26.04
Specific Conductance (µs/cm)	247.3	432.7
pH (standard units)	7.4	6.99
Dissolved Oxygen (mg/L)	9.65	5.77
E.coli (MPN/100mL)	9,800	121
Turbidity (ntu)	0.24	0.34
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Fair
Water Color	Brownish/ Reddish	Brownish
Water Odor	None	Chlorine
Present Weather	Partly Cloudy	Clear
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	High	Normal

Station 3

Station 3 is a tributary of Upper Panther Branch located adjacent to a residential neighborhood off Grogans Mill Road at Tapestry Park Drive. The tributary's confluence with Upper Panther Branch is approximately 120 meters west of where the water discharges from a storm drain. The water flows over a grassy buffer area before discharging into Upper Panther Branch.

The dry weather sample collected on September 28 (Figure 23) was in compliance with state water quality standards for bacteria (Table 13). Chlorine test strips detected a chlorine level of approximately 0.65 mg/L at this location during the dry weather event. The wet weather event conducted on February 15, 2017 (Figure 24) resulted in a significantly higher bacteria concentration with levels measuring at 7,270 MPN/100mL (Table 13).

Figure 30

Figure 31

TABLE 20. WATER QUALITY DATA FOR UPPER PANTHER BRANCH STATION 3.

Parameter	Wet Weather	Dry Weather
Latitude	30.18542	
Longitude	-95.47245	
Survey Date	2/15/2017	09/28/2016
Days Since Last Rain	1	3
Total Depth (m)	0.43	0.28
Temperature (°C)	15.81	25.95
Specific Conductance (µs/cm)	299.1	433.4
pH (standard units)	7.41	7.04
Dissolved Oxygen (mg/L)	8.38	5.66
E.coli (MPN/100mL)	7,270	86
Turbidity (ntu)	0.24	0.45
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Fair
Water Color	Brownish	Brownish
Water Odor	None	Chlorine
Present Weather	Partly Cloudy	Clear
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	High	Normal

Station 6

Station 6 is a tributary of Upper Panther Branch located adjacent to a gated community off Grogans Mill Road and North Parkgate Circle. The tributary's confluence with Upper Panther Branch is approximately 55 meters southwest of where the water discharges from a storm drain. The water flows over rocky and natural terrain before discharging into Upper Panther Branch.

The dry weather sample collected on September 28 (Figure 25) was just above the state water quality standard for *E.coli* measuring at 185 MPN/100mL (Table 14). The water was consistently red in color at this location during all dry weather surveys conducted for this project. No chlorine was detected at this station. The wet weather event conducted on February 15, 2017 (Figure 26) resulted in the significantly higher bacteria concentration of 7,270 MPN/100mL (Table 14).

Figure 32

Figure 33

TABLE 21. WATER QUALITY DATA FOR UPPER PANTHER BRANCH STATION 6.

Parameter	Wet Weather	Dry Weather
Latitude	30.17967	
Longitude	-95.47174	
Survey Date	2/15/2017	09/28/2016
Days Since Last Rain	1	3
Total Depth (m)	0.19	0.23
Temperature (°C)	15.41	27.1
Specific Conductance (µs/cm)	471.9	941.2
pH (standard units)	7.55	8.09
Dissolved Oxygen (mg/L)	9.86	5.75
E.coli (MPN/100mL)	7,270	185
Turbidity (ntu)	0.27	0.4
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Fair
Water Color	Brownish/ Reddish	Reddish
Water Odor	None	None
Present Weather	Partly Cloudy	Clear
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	Normal	Normal

Station 9

Station 9 is a tributary of Upper Panther Branch located adjacent to a sporting facility off Marisco Place. The tributary's confluence with Upper Panther Branch is approximately 250 meters south of the facility which includes tennis courts, soccer and baseball fields, and concession stands. The tributary continues to the north of the sporting facility into a neighborhood that is serviced through on-site sewage facilities (OSSFs).

The dry weather sample collected on September 28 (Figure 27) was in compliance with state water quality standards for bacteria (Table 15). The water had a strong chemical odor during this sampling event and chlorine test strips detected a chlorine concentration of approximately 0.1 mg/L. The wet weather event conducted on February 15, 2017 (Figure 28) resulted in a bacteria concentration of 5,790 MPN/100mL (Table 15).

Figure 34

Figure 35

TABLE 22. WATER QUALITY DATA FOR UPPER PANTHER BRANCH STATION 9.

Parameter	Wet Weather	Dry Weather
Latitude	30.19107	
Longitude	-95.47797	
Survey Date	2/15/2017	09/28/2016
Days Since Last Rain	1	3
Total Depth (m)	0.19	0.04
Temperature (°C)	14.31	26.8
Specific Conductance (µs/cm)	168.7	50.1
pH (standard units)	7.27	7.12
Dissolved Oxygen (mg/L)	13.11	5.98
E.coli (MPN/100mL)	5,790	52
Turbidity (ntu)	0.55	0.68
Observed Turbidity	Medium	Low
Water Clarity	Fair	Good
Water Color	Brownish	Brownish
Water Odor	None	Oily/Chemical/ Chlorine
Present Weather	Partly Cloudy	Clear
Wind Intensity	Calm	Calm
Water Surface	Calm	Ripples
Flow Severity	High	Normal

Little White Oak Bayou (1013A_01)

Little White Oak Bayou, TCEQ segment AU 1013A_01, is located in a highly urbanized area of central Houston in Harris County. The waterway is located at the intersection of the IH-610 North Loop and I-45 with a watershed area of 7.29 square miles. Significant amounts of litter and debris was commonly observed throughout the watershed area, especially in portions of the waterway that are difficult to access. Primary land uses are residential and commercial with much of the area under transition from older homes and neighborhoods to updated real estate and new development of upscale apartment complexes.

Little White Oak Bayou has been on TCEQ's 303(d) list of impaired waterways for bacteria since 2002. It is also included as the ninth AU on the BIG's Top 10 Most Impaired Water Bodies list from 2015. With a seven-year *E.coli* geometric mean value of 1,975 MPN/100mL, this AU is far from meeting the state water quality standard of 126 MPN/100mL. Figure 29 shows the wet weather and dry weather bacteria concentrations from the Phase II Little White Oak Bayou surveys by sample number and figure 30 illustrates the location of Phase II sample stations.

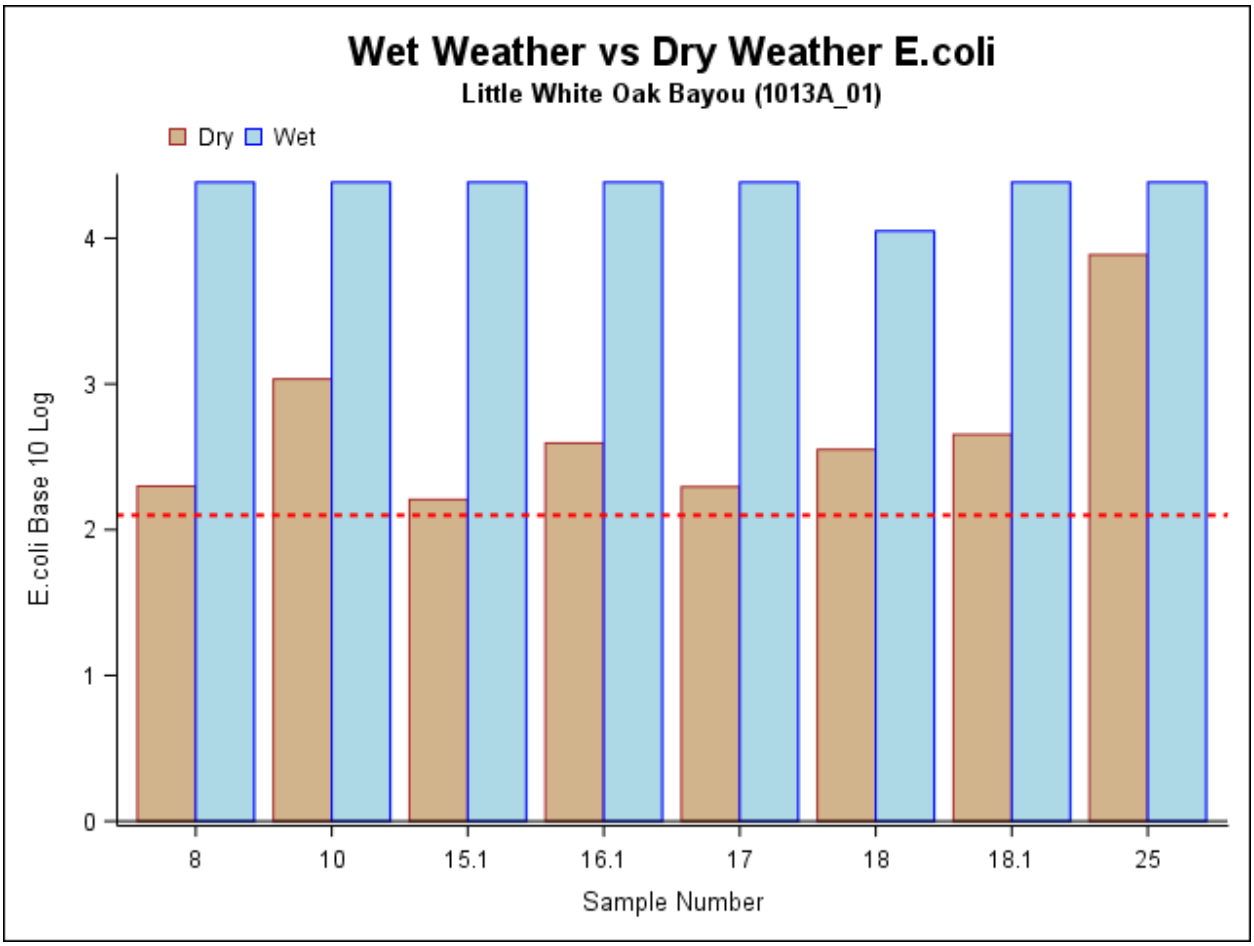

FIGURE 36. WET WEATHER AND DRY WEATHER *E.COLI* CONCENTRATIONS FROM PHASE II LITTLE WHITE OAK BAYOU SURVEYS. RED DOTTED LINE REPRESENTS THE STATE WATER QUALITY STANDARD FOR BACTERIA.

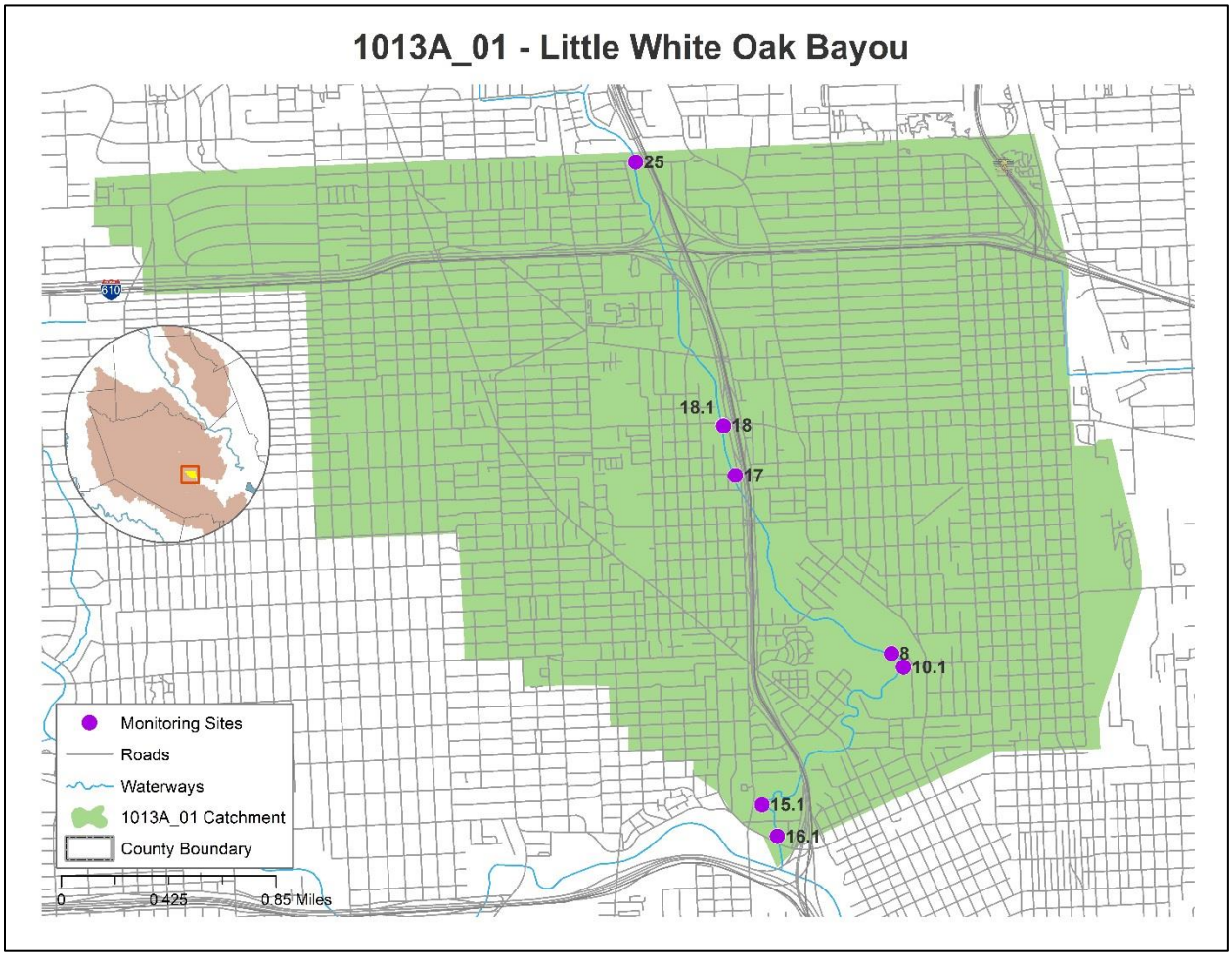

FIGURE 37. PHASE II LITTLE WHITE OAK BAYOU MONITORING STATIONS

Station 8

Station 8 is a large outfall located at the southern end of Moody Park adjacent to a parking lot off Fulton Street. The outfall was consistently discharging large volumes of water into Little White Oak Bayou during all Phase I and II investigations (Figures 31-32). Homeless activity was commonly observed at this location.

Samples were collected directly downstream of the outfall during Phase II investigations (Figure 33). The dry weather sample collected on October 11, 2016 was just over the state water quality standard for bacteria measuring at 199 MPN/100mL (Table 16). However, the wet weather sample collected on February 15, 2017 resulted in the much higher bacteria concentration of 24,200 MPN/100mL.

Figure 38

Figure 39

Figure 40

TABLE 23. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 8.

Parameter	Wet Weather	Dry Weather
Latitude	29.79033	
Longitude	-95.36252	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.19	0.43
Temperature (°C)	17.57	24.95
Specific Conductance (µs/cm)	414.8	772.9
pH (standard units)	7.72	7.59
Dissolved Oxygen (mg/L)	7.62	6.42
E.coli (MPN/100mL)	24,200	199
Turbidity (ntu)	0.45	0.85
Observed Turbidity	Medium	Low
Water Clarity	Fair	Good
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Slight
Water Surface	Ripples	Calm
Flow Severity	Normal	Normal

Station 10.1

Figure 41

Station 10 is a large storm drain located at Hays Street next to an apartment complex (Figure 34). Litter and debris build up is significant at this location, especially after rain events, with trash from upstream getting trapped at the bend in Little White Oak Bayou located at this station (Figure 35-36).

Samples were collected directly downstream of the storm drain during Phase II investigations. The dry weather sample collected on October 11, 2016 resulted in an *E.coli* concentration of 1,080 MPN/100mL, making it one of the highest bacteria sources to Little White Oak Bayou during

the dry weather event (Table 17). However, the wet weather sample collected on February 15, 2017 resulted in a much higher bacteria concentration of 24,200 MPN/100mL.

Figure 43

Figure 42

TABLE 24. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 10.1

Parameter	Wet Weather	Dry Weather
Latitude	29.78984	
Longitude	-95.36163	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.28	0.24
Temperature (°C)	16.46	25.13
Specific Conductance (µs/cm)	309.5	761.0
pH (standard units)	7.62	7.56
Dissolved Oxygen (mg/L)	8.35	6.83
E.coli (MPN/100mL)	24,200	1,080
Turbidity (ntu)	0.47	0.75
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Good
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	Normal	Normal

Station 15.1

Station 15.1 is located approximately 110 meters upstream of Wrightwood Street. A sewer system junction box is located at Wrightwood Street at Little White Oak Bayou that has had several overflow incidents during wet weather events. Stations 15.1 and 16.1 were investigated to identify the extent of contamination originating from this junction box (Figure 37).

The dry weather sample collected at this location on October 11, 2016 (Figure 38) resulted in an *E.coli* concentration of 161 MPN/100mL, slightly exceeding the state water quality standard. The wet weather was sample collected approximately 20 minutes after a significant rain event on February 14, 2017. The water level was high and large amounts of trash and debris were flowing with the water downstream (Figure 39). The *E.coli* concentration for the wet weather event was 24,200 MPN/100 mL, significantly higher than the dry weather concentration (Table 18).

Figure 44

Figure 45

Figure 46

TABLE 25. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 15.1

Parameter	Wet Weather	Dry Weather
Latitude	29.78194	
Longitude	-95.37144	
Survey Date	2/14/2017	10/11/2016
Days Since Last Rain	<1	16
Total Depth (m)	0.53	0.41
Temperature (°C)	18.32	24.86
Specific Conductance (µs/cm)	150.6	741.7
pH (standard units)	7.81	7.82
Dissolved Oxygen (mg/L)	9.11	7.62
E.coli (MPN/100mL)	24,200	161
Turbidity (ntu)	0.07	0.46
Observed Turbidity	High	Medium
Water Clarity	Poor	Fair
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Slight
Water Surface	Ripples	Calm
Flow Severity	High	Normal

Station 16.1

Station 16.1 is located approximately 85 meters downstream of the faulty sewer junction box at Wrightwood Street. The station is also adjacent to the White Oak walking and biking trail and a new up-scale apartment complex is currently under construction directly to the east of Little White Oak Bayou at this location.

The dry weather sample collected on October 11, 2016 (Figure 40) resulted in an *E.coli* concentration of 393 MPN/100mL. This concentration is more than twice the concentration observed upstream of the junction box. However, the wet weather sample collected on February 14, 2017 (Figure 41) had the same bacteria concentration as the sample collected upstream of the junction box (Table 19).

Figure 47

Figure 48

TABLE 26. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 16.1

Parameter	Wet Weather	Dry Weather
Latitude	29.78012	
Longitude	-95.37051	
Survey Date	2/14/2017	10/11/2016
Days Since Last Rain	<1	16
Total Depth (m)	0.71	0.15
Temperature (°C)	18.14	25.13
Specific Conductance (µs/cm)	125.9	738.7
pH (standard units)	7.98	7.76
Dissolved Oxygen (mg/L)	9.36	6.89
E.coli (MPN/100mL)	24,200	393
Turbidity (ntu)	0.05	0.25
Observed Turbidity	High	Medium
Water Clarity	Poor	Fair
Water Color	Brownish	Brownish
Water Odor	Musky	Chlorine
Present Weather	Cloudy	Cloudy
Wind Intensity	Calm	Slight
Water Surface	Ripples	Calm
Flow Severity	High	Normal

Station 17

Station 17 is located at Vincent Street and Coronado Avenue directly upstream of where the waterway goes underground at I-45 (Figure 42). A faulty manhole was observed on the right bank approximately 52 meters upstream of this station. The manhole was about 6 feet above ground and the cement casing had a large hole. A hole in the ground was also observed next to the manhole with evidence of recent sewage overflows visible (Figure 43).

The dry weather sample collected on October 11, 2016 had an *E.coli* concentration of 197 MPN/100mL. The wet weather sample collected on February 15, 2017 was significantly higher at 24,200 MPN/100mL (Table 20).

Figure 49

Figure 50

TABLE 27. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 17.

Parameter	Wet Weather	Dry Weather
Latitude	29.80083	
Longitude	-95.37273	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.46	0.55
Temperature (°C)	15.05	24.05
Specific Conductance (µs/cm)	311.4	792.0
pH (standard units)	7.51	7.46
Dissolved Oxygen (mg/L)	10.3	6.09
E.coli (MPN/100mL)	24,200	197
Turbidity (ntu)	0.55	0.35
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Fair
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Partly Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	Normal	Normal

Station 18

Station 18 is an outfall located on the left bank of Little White Oak Bayou to the south of the Cavalcade Street bridge (Figure 44). Homeless activity is common at this location with furniture and other debris observed on the bank (Figure 45). Alligator gar and other large fish species were observed at the mouth of this outfall during Phase I and Phase II investigations.

The dry weather sample collected on October 11, 2016 resulted in a bacteria concentration of 355 MPN/100mL. The wet weather sample collected on February 15, 2017 was significantly higher measuring at 11,200 MPN/100mL (Table 21). Although the wet weather sample concentration was slightly lower than the surface water samples collected upstream of this location, this outfall is still considered to be contributing a consistent amount of bacteria into Little White Oak Bayou regardless of weather conditions.

Figure 51

TABLE 28. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 18.

Parameter	Wet Weather	Dry Weather
Latitude	29.80274	
Longitude	-95.37321	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.60	0.59
Temperature (°C)	19.0	25.71
Specific Conductance (µs/cm)	884.5	1080.0
pH (standard units)	7.66	7.43
Dissolved Oxygen (mg/L)	7.69	7.08
E.coli (MPN/100mL)	11,200	355
Turbidity (ntu)	0.82	>1.2
Observed Turbidity	Low	Low
Water Clarity	Good	Excellent
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Partly Cloudy	Partly Cloudy
Wind Intensity	Calm	Slight
Water Surface	Ripples	Calm
Flow Severity	Normal	Normal

Station 18.1

Station 18.1 is located directly upstream of outfall station 18 south of the Cavalcade Street bridge. A surface water sample was collected at this location to compare upstream bacteria levels to concentrations found at outfall 18.

Both the dry weather (Figure 46) and wet weather (Figure 47) bacteria concentrations were greater than levels found at outfall station 18.1 (Table 22) indicating that a more significant source of bacteria is located upstream of this location.

Figure 53

Figure 54

TABLE 29. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 18.1.

Parameter	Wet Weather	Dry Weather
Latitude	29.80374	
Longitude	-95.37321	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.58	0.77
Temperature (°C)	15.17	24.04
Specific Conductance (µs/cm)	317.1	763.0
pH (standard units)	7.52	7.38
Dissolved Oxygen (mg/L)	8.17	6.53
E.coli (MPN/100mL)	24,200	450
Turbidity (ntu)	0.19	0.35
Observed Turbidity	Medium	Medium
Water Clarity	Fair	Fair
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Slight	Calm
Water Surface	Calm	Calm
Flow Severity	Normal	Normal

Station 25

Station 25 is located directly downstream of the Stokes Street bridge at the upstream boundary of the Little White Oak Bayou watershed. This station was considered the largest contributor of bacteria to the waterway during the Phase I and Phase II investigations.

A dry weather sample was collected on October 11, 2016. At the time of sample collection, a strong odor of diesel was detected and an oily sheen was observed on the surface of the water (Figure 48). The *E.coli* concentration was 7,700 MPN/100mL which was the highest bacteria concentration collected during the dry weather event at Little White Oak Bayou. The wet weather sample collected on February 15, 2017 (Figure 49) resulted in a significantly higher bacteria concentration of 24,200 MPN/100mL. The same *E.coli* concentration was detected for all surface water samples collected on February 15, 2017 that were located downstream of this station. Further investigation upstream of this location is recommended to better evaluate specific bacteria sources impacting Little White Oak Bayou.

Figure 56

Figure 55

TABLE 30. WATER QUALITY DATA FOR LITTLE WHITE OAK BAYOU STATION 25.

Parameter	Wet Weather	Dry Weather
Latitude	29.818995	
Longitude	-95.378497	
Survey Date	2/15/2017	10/11/2016
Days Since Last Rain	1	16
Total Depth (m)	0.58	0.15
Temperature (°C)	15.17	24.46
Specific Conductance (µs/cm)	317.1	825.4
pH (standard units)	7.52	7.47
Dissolved Oxygen (mg/L)	8.17	7.76
E.coli (MPN/100mL)	24,200	7,700
Turbidity (ntu)	0.19	0.91
Observed Turbidity	Medium	Low
Water Clarity	Fair	Good
Water Color	Brownish	Oily/Chemical
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Slight	Calm
Water Surface	Calm	Ripples
Flow Severity	Normal	Normal

Rummel Creek (1014N_01)

Rummel Creek, TCEQ segment AU 1014N_01, is located in west Houston in Harris County at the intersection of I-10 and the Beltway. Primary land uses in the 4.62 square mile watershed area are residential and commercial with hospitals and manufacturing facilities present along the I-10 corridor. The Edith L Moore Nature Sanctuary is also located in the southern portion of the watershed at Memorial Drive and Wilchester Boulevard.

Rummel Creek has been listed as impaired for bacteria on the Texas Integrated Report (IR) since 2002. It is also included as the tenth AU on the BIG's Top 10 Most Impaired Water Bodies list from 2015. With a seven-year *E.coli* geometric mean value of 1,960 MPN/100mL, this AU is far from meeting the state water quality standard of 126 MPN/100mL. Figure 50 shows the wet weather and dry weather bacteria concentrations from the Phase II Rummel Creek surveys by sample number and figure 51 illustrates the location of Phase II sample stations.

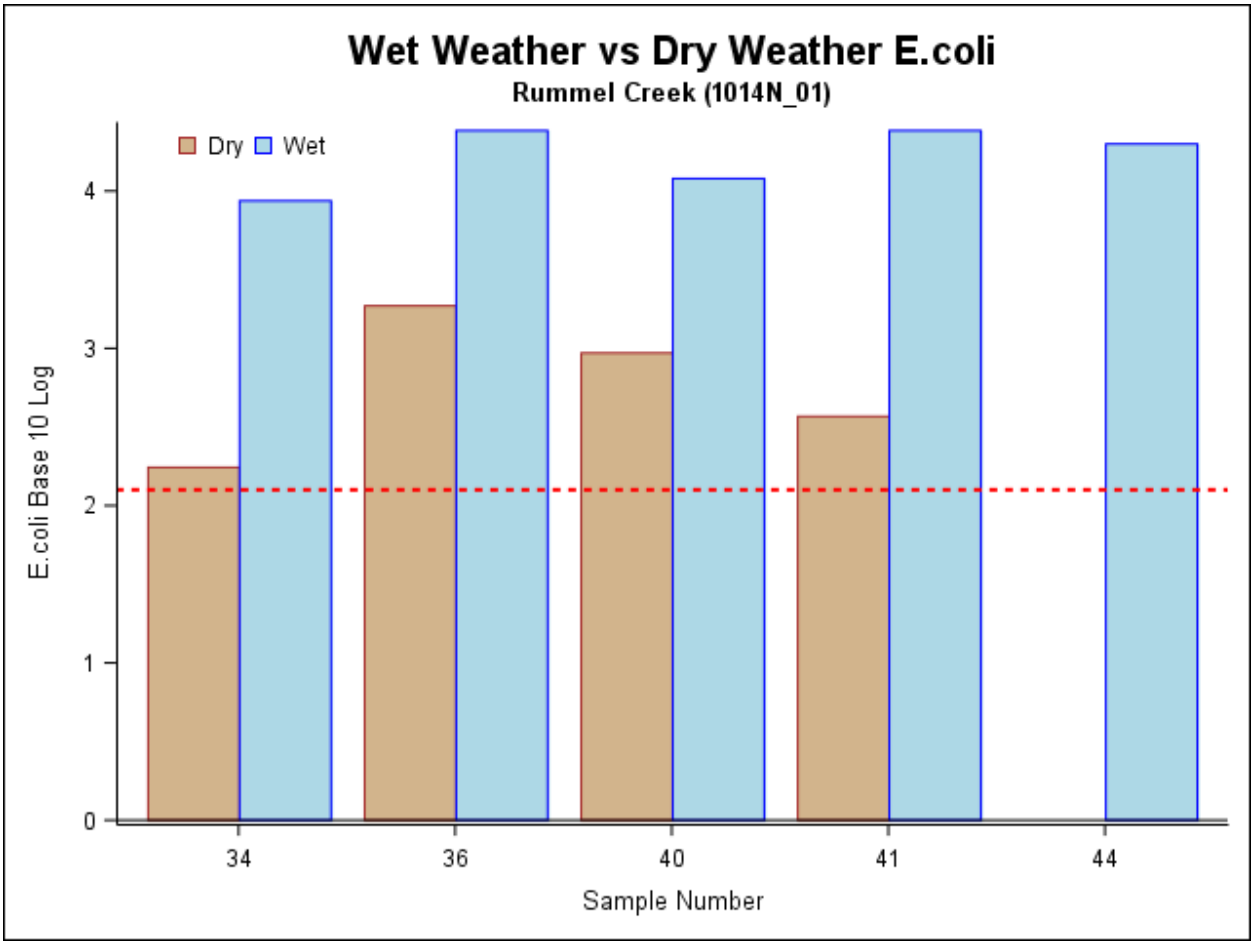

FIGURE 57. WET WEATHER AND DRY WEATHER *E.COLI* CONCENTRATIONS FROM PHASE II RUMMEL CREEK SURVEYS. RED DOTTED LINE REPRESENTS THE STATE WATER QUALITY STANDARD FOR BACTERIA.

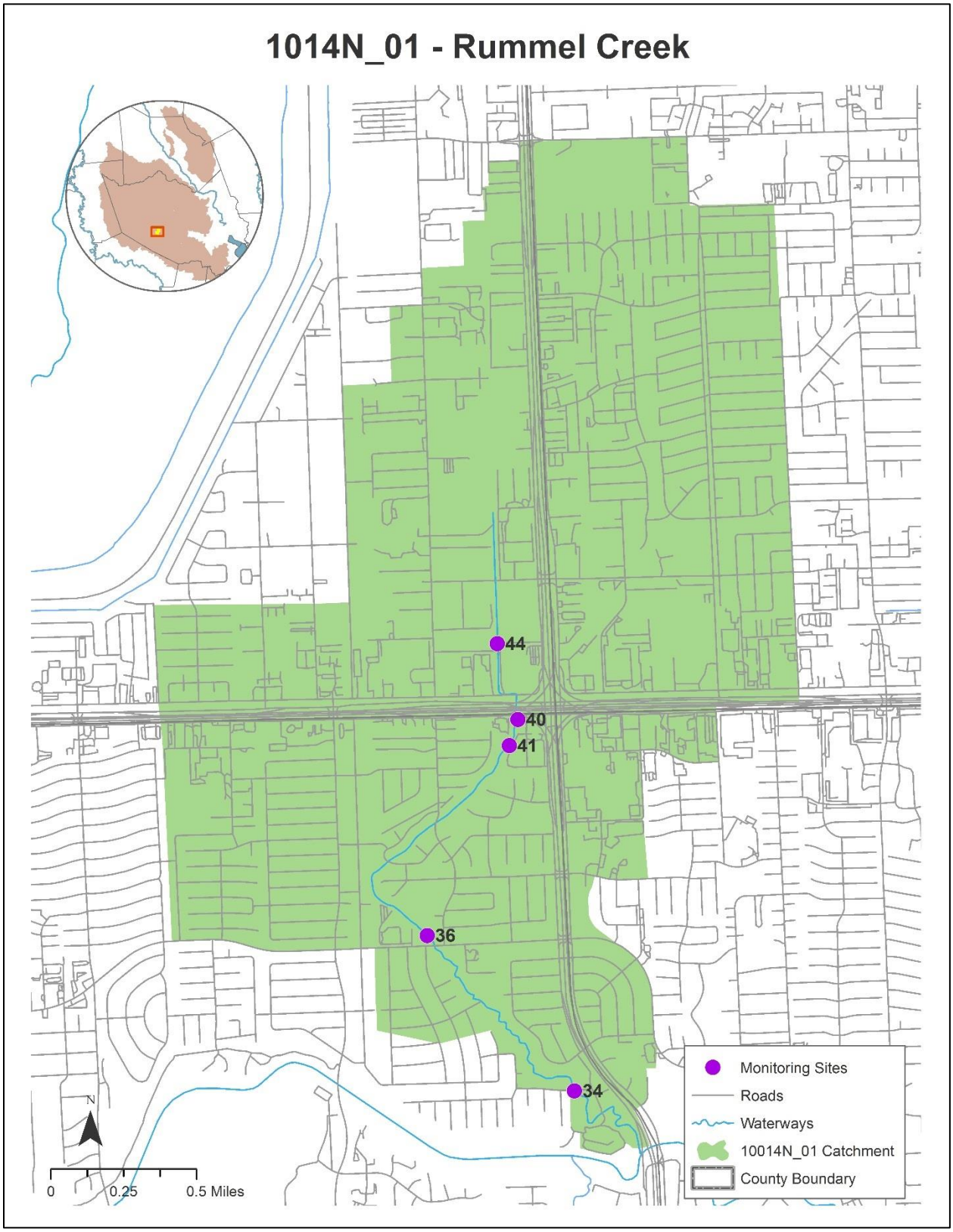

FIGURE 58. PHASE II RUMMEL CREEK MONITORING STATIONS

Station 34

Station 34 is located at the southern end of the Rummel Creek watershed boundary downstream of the Edith L Jones Nature Conservancy. The station can be accessed through dense vegetation at the end of Hermitage Lane in a residential neighborhood. Old pipelines were observed along the stream bottom, although it was unclear if they were still operating or not (Figure 52).

A dry weather sample was collected on December 14, 2016 resulting in a bacteria concentration slightly exceeding the state water quality standard (Table 24). The wet weather sample was collected on February 14, 2017 immediately following a significant rain event (Figure 53). The bacteria concentration for the wet weather sample was 8,660 MPN/100mL which was significantly higher than the dry weather sample, but was the lowest wet weather concentration observed in Rummel Creek.

Figure 59

Figure 60

TABLE 31. WATER QUALITY DATA FOR RUMMEL CREEK STATION 34.

Parameter	Wet Weather	Dry Weather
Latitude	29.76526	
Longitude	-95.56252	
Survey Date	2/14/2017	12/14/2016
Days Since Last Rain	<1	7
Total Depth (m)	0.88	0.11
Temperature (°C)	17.83	18.1
Specific Conductance (µs/cm)	96.8	526.5
pH (standard units)	8.07	7.23
Dissolved Oxygen (mg/L)	8.86	5.26
E.coli (MPN/100mL)	8,660	175
Turbidity (ntu)	0.175	>1.2
Observed Turbidity	High	Low
Water Clarity	Poor	Excellent
Water Color	Brownish	Clear
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Ripples
Flow Severity	High	Normal

Station 36

Station 36 is an outfall located downstream of Rummel Creek Elementary directly upstream of the bridge at Memorial Drive (Figure 54). This station is one of the highest contributors of bacteria into Rummel Creek during both Phase I and Phase II investigations. The outfall was discharging during all station visits, regardless of weather conditions.

The dry weather sample collected on December 14, 2016 resulted in an *E.coli* concentration of 1,860 MPN/100mL. The wet weather sample collected immediately following a significant rain event on February 14, 2017 (Figure 55) was significantly higher measuring at 24,200 MPN/100mL.

Figure 61

Figure 62

TABLE 32. WATER QUALITY DATA FOR RUMMEL CREEK STATION 36.

Parameter	Wet Weather	Dry Weather
Latitude	29.77316	
Longitude	-95.57065	
Survey Date	2/14/2017	12/14/2016
Days Since Last Rain	<1	7
Total Depth (m)	0.36	0.23
Temperature (°C)	17.69	18.49
Specific Conductance (µs/cm)	148.4	534.9
pH (standard units)	8.04	7.45
Dissolved Oxygen (mg/L)	10.02	7.18
E.coli (MPN/100mL)	24,200	1,860
Turbidity (ntu)	0.54	>1.2
Observed Turbidity	Medium	Low
Water Clarity	Fair	Excellent
Water Color	Brownish	Clear
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Moderate	Calm
Water Surface	Ripples	Calm
Flow Severity	High	Low

Station 40

Station 40 is located directly downstream of where Rummel Creek emerges from I-10 underground. This portion of Rummel Creek is concrete lined but sediment has settled on the surface of the concrete downstream where vegetation is now growing (Figure 56). Additionally, a plant nursery and large detention basin are located on either side of the concrete lined canal at this location.

The dry weather sample collected on December 14, 2016 resulted in a bacteria concentration of 933 MPN/100mL, making this station one of the highest contributors of bacteria to Rummel Creek during dry weather conditions. At the time of the wet weather survey on February 14, 2017, the water discharging from the left bank was darker in color whereas water discharging on the right bank looked brown and cloudy, likely from heavy sediment loads from the recent rains (Figure 57). The wet weather *E.coli* concentration was significantly greater than the dry weather sample measuring at 12,000 MPN/100mL (Table 26).

Figure 64

Figure 63

TABLE 33. WATER QUALITY DATA FOR RUMMEL CREEK STATION 40.

Parameter	Wet Weather	Dry Weather
Latitude	29.78378	
Longitude	-95.56508	
Survey Date	2/14/2017	12/14/2016
Days Since Last Rain	<1	7
Total Depth (m)	0.72	0.08
Temperature (°C)	17.85	17.92
Specific Conductance (µs/cm)	141	504.2
pH (standard units)	7.64	7.56
Dissolved Oxygen (mg/L)	8.29	6.54
E.coli (MPN/100mL)	12,000	933
Turbidity (ntu)	0.2	1.09
Observed Turbidity	High	Low
Water Clarity	Poor	Excellent
Water Color	Brownish	Brownish
Water Odor	None	None
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	High	Low

Station 41

Station 41 is located approximately 160 meters downstream of station 40 near where the concrete lining ends (Figure 58). There are several outfalls located between stations 40 and 41, most of which are storm water outfalls originating from the detention basin to the east of Rummel Creek at this location. There is also a weather emergency alert facility located adjacent to the detention basin that has some type of on-site sewage facility (OSSF) on location.

During the dry weather event conducted on December 14, 2016, a strong odor of sewage was detected at one of the large outfalls directly upstream of station 41. Toilet paper was also observed at the outfall, although no water was discharging at that time. The dry weather sample resulted in a bacteria concentration of 369 MPN/100mL. The wet weather sample collected on February 14, 2017 was 24,200 MPN/100mL making station 41 one of the highest contributors of bacteria during wet weather conditions.

Figure 65

TABLE 34. WATER QUALITY DATA FROM RUMMEL CREEK STATION 41.

Parameter	Wet Weather	Dry Weather
Latitude	29.78247	
Longitude	-95.56562	
Survey Date	2/14/2017	12/14/2016
Days Since Last Rain	<1	7
Total Depth (m)	0.47	0.13
Temperature (°C)	17.82	18.12
Specific Conductance (µs/cm)	100.7	493
pH (standard units)	7.94	8.12
Dissolved Oxygen (mg/L)	9.39	7.62
E.coli (MPN/100mL)	24,200	369
Turbidity (ntu)	0.19	>1.2
Observed Turbidity	High	Low
Water Clarity	Poor	Excellent
Water Color	Brownish	Clear
Water Odor	None	None
Present Weather	Partly Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	High	Low

Station 44

Station 44 is located approximately 260 meters upstream of I-10 right before Rummel Creek goes back underground. This is the most upstream station in the Rummel Creek watershed investigated during Phase I and II of this project. This portion of the stream normally runs dry except after significant rain events. A hospital and multiple flooring and manufacturing facilities are located along Rummel Creek at this location (Figure 59).

No sample was collected during the dry weather event on December 14, 2016 due to no flowing water at this station. The wet weather sample collected on February 14, 2017 resulted in an *E.coli* concentration of 19,900 MPN/100mL (Figure 60).

Figure 66

Figure 67

TABLE 35. WATER QUALITY DATA FOR RUMMEL CREEK STATION 44.

Parameter	Wet Weather	Dry Weather
Latitude	29.78763	
Longitude	-95.566144	
Survey Date	2/14/2017	12/14/2016
Days Since Last Rain	<1	7
Total Depth (m)	0.3	-
Temperature (°C)	18.07	-
Specific Conductance (µs/cm)	169.4	-
pH (standard units)	7.83	-
Dissolved Oxygen (mg/L)	7.91	-
E.coli (MPN/100mL)	19,900	-
Turbidity (ntu)	0.06	-
Observed Turbidity	High	-
Water Clarity	Poor	-
Water Color	Brownish	-
Water Odor	None	-
Present Weather	Cloudy	Partly Cloudy
Wind Intensity	Calm	Calm
Water Surface	Ripples	Calm
Flow Severity	High	Dry

Significant Bacteria Sources

Canal C-147 (1007A_01)

Table 29 lists the most significant bacteria sources to Canal C-147 identified during Phase I and Phase II of this project. Potential causes for these sources are also listed. Further investigation is recommended at these locations.

TABLE 36. SUMMARY OF BACTERIA SOURCES TO CANAL C-147

Station	Description	Latitude/Longitude	Potential Causes
8.1	Metal outfall located directly under the Tiffany Street bridge	29.61612, -95.45970	Illicit discharges; improper pet waste disposal (dogs, chickens)
13	Large concrete storm drain on the right bank of Canal C-147 at South Post Oak Street.	29.61142, -95.46475	Sewer system leaks; runoff or discharges from nearby auto body shops and car dealerships
14	Large concrete storm drain on the left bank of Canal C-147 at South Post Oak Street.	29.61145, -95.46475	Sewer system leaks; runoff or discharges from nearby auto body shops and car dealerships
17	Tributary of Canal C-147 at the Beltway 8 bridge	29.60601, -95.47043	Illicit discharges; improper pet waste disposal (dogs, chickens)
27	Metal outfall located adjacent to residential neighborhood off Ohara Drive.	29.60384, -95.48948	Sewer system leaks; runoff or discharges from neighborhood recreation center; stormwater runoff

Upper Panther Branch (1008B_02)

The most significant finding during the Phase I and Phase II investigations at Upper Panther Branch was the detection of high chlorine levels throughout the waterway during dry weather conditions. The majority of dry weather samples were in compliance with state water quality standards for bacteria, but these results may be impacted by the observed high chlorine concentrations. Further investigation into the source of chlorine is recommended.

All wet weather samples resulted in extremely high *E.coli* concentrations likely due to runoff of pet waste and other wildlife sources such as deer and feral hogs. Refer to Table 30 for more information about other significant bacteria sources to Upper Panther Branch.

TABLE 37. SUMMARY OF BACTERIA SOURCES TO UPPER PANTHER BRANCH

Station	Description	Latitude/Longitude	Potential Causes
9	Tributary of Upper Panther Branch	30.19107, -95.47797	Malfunctioning OSSFs or grease traps; runoff from sporting facility; improper pet waste disposal (dogs, horses); wildlife

Little White Oak Bayou (1013A_01)

The bacteria sources impacting Little White Oak Bayou are widespread and significant. Table 31 lists information about a few of the most significant sources detected during Phase I and II of this project. However, further investigation is recommended throughout the entire watershed as conditions seems to be degrading and bacteria concentrations are increasing based on the data collected.

Station 25 was detected as one of the most significant sources of bacteria to Little White Oak Bayou and is located at the upstream boundary of the watershed. Further investigation of upstream watersheds is recommended to better identify bacteria sources impacting Little White Oak Bayou.

TABLE 38. SUMMARY OF BACTERIA SOURCES TO LITTLE WHITE OAK BAYOU

Station	Description	Latitude/Longitude	Potential Causes
N/A	Sewer system junction box located at Wrightwood Street and Little White Oak Bayou	29.781074, -95.370219	Constructed stormwater controls failing; malfunctioning wastewater collection systems; overflows
N/A	Manhole located upstream of station 17 off Vincent Street and Coronado Avenue	29.80126, -95.37309	Constructed stormwater controls failing; malfunctioning wastewater collection systems; overflows
10	Large storm drain located at Little White Oak Bayou at Hays Street	29.78984, -95.36163	Constructed stormwater controls failing; sewer system leaks; illicit discharges
25	Little White Oak Bayou at Stokes Street bridge	29.818995, -95.378497	Rapid urbanization and impervious cover; illicit discharges; runoff of pet waste; homeless activity

Rummel Creek (1014N_01)

Table 32 lists the most significant bacteria sources to Rummel Creek identified during Phase I and Phase II of this project. Potential causes for these sources are also listed. Further investigation is recommended at these locations.

TABLE 39. SUMMARY OF BACTERIA SOURCES TO RUMMEL CREEK

Station	Description	Latitude/Longitude	Potential Causes
36	Metal outfall located downstream of Rummel Creek Elementary	29.77316, -95.57065	Leaking sewer systems; stormwater runoff
40	Concrete lined portion of Rummel Creek directly downstream of I-10 underground	29.78378, -95.56508	Runoff from plant nursery; Leaking sewer and stormwater systems; stormwater runoff
41	Concrete lined portion of Rummel Creek 160 meters downstream of station 40	29.78247, -95.56562	Runoff from plant nursery; malfunctioning OSSF; sewer overflows; stormwater runoff

Next Steps

Phase III of this project involves meeting with local jurisdictions to review Phase II results and discuss what corrective actions, if any, will be taken to address the sources of bacteria identified in this report. Follow up monitoring will take place in areas where corrective actions are implemented. A Final Report summarizing Phases I, II, and III of this project will be published in spring of 2017.