Buffalo and Whiteoak Bayous and Tributaries: Bacteria in Waters Used for Contact Recreation

- **Eighteen TMDLs Adopted April 8, 2009**
  Approved by EPA June 11, 2009
- **One TMDL Added by Addendum April 2013**
  Approved by EPA August 28, 2013
- **One TMDL Added by Addendum April 2015**
  Approved by EPA July 27, 2015 (scroll to view or print this addendum)

TCEQ

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Addendum Two to Eighteen Total Maximum Daily Loads for Bacteria in Buffalo and Whiteoak Bayous and Tributaries

One Total Maximum Daily Load for Bacteria in Rolling Fork Creek

For Segment 1017F
Assessment Unit 1017F_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted the total maximum daily loads (TMDLs) *Eighteen Total Maximum Daily Loads for Bacteria in Buffalo and Whiteoak Bayous and Tributaries: Segments 1013, 1013A, 1013C, 1014, 1014A, 1014B, 1014E, 1014H, 1014K, 1014L, 1014M, 1014N, 1014O, 1017, 1017A, 1017B, 1017D, and 1017E* (TCEQ 2009) on 4/8/2009. The TMDLs were approved by the United States Environmental Protection Agency (EPA) on 6/11/2009. The public comment period for this TMDL was June 5, 2008 through July 5, 2008 and the public comment meeting was June 9, 2008. Additionally, an addendum to the original TMDL was submitted through the April 2013 Water Quality Management Plan (WQMP) update. This addendum added one additional segment (Vogel Creek, Segment 1017C), and had a public comment period from May 10, 2013 June 10, 2013, with no comments received. This document represents a second addendum to the original TMDL document.

This addendum includes information specific to one additional segment located within the watershed of the approved TMDL project for bacteria in the Buffalo and Whiteoak Bayous watershed. Concentrations of indicator bacteria in this segment exceed the criteria used to evaluate attainment of the contact recreation standard. This addendum presents the new information associated with the additional segment. For background or other explanatory information for this segment, please refer to *Technical Support Document: Bacteria Total Maximum Daily Loads for the Whiteoak Bayou Watershed, Houston, Texas (1017F_01)* (University of Houston 2014), which has additional details related to all aspects of this addendum.

Refer to the original, approved TMDL document for details related to the overall project watershed as well as the methods and assumptions used in developing this TMDL. This addendum focuses on the subwatershed of the additional segment. This addendum provides the details related to developing the TMDL allocation for the additional segment, which was not addressed individually in the original document. This segment is also covered by an implementation plan (I-Plan) developed by stakeholders in the greater

Houston area. The I-Plan addresses multiple watersheds, including those for Buffalo and Whiteoak Bayous.

Problem Definition

The TCEQ first identified the bacteria impairment to the segment and assessment unit (AU) included in this addendum in the year 2012 Texas Water Quality Inventory and 303(d) List (Table 1). The impaired AU is Rolling Fork Creek (1017F_01). See Figure 1 for a map of the watershed.

The Texas surface water quality standards (SWQSs; TCEQ 2012) provide numeric and narrative criteria to evaluate attainment of designated uses. The basis for water quality targets for the TMDL developed in this report will be the numeric criteria for bacterial indicators from the 2012 Texas SWQS. *E. coli* is the preferred indicator bacteria for assessing contact recreation use in freshwater.

Table 2 summarizes the ambient water quality data for the TCEQ water quality monitoring (WQM) station on the impaired water body.

Rolling Fork Creek (Segment 1017F_01): The single sample criterion for *E. coli* was exceeded in 65.22 percent of the samples at the only WQM station location at which *E. coli* data were collected within this subwatershed. The geometric mean criterion for *E. coli* was also exceeded.

Watershed Overview

The Buffalo and Whiteoak Bayous watershed encompasses approximately 492 square miles of land in portions of Harris, Fort Bend, and Waller counties, including the cities of Houston, Jersey Village, and Katy, Texas. The Buffalo and Whiteoak Bayous watershed is part of the San Jacinto River Basin. The entire watershed's rainfall average is approximately 50 inches per year. The average value for the Rolling Fork Creek subwatershed is summarized in Table 3.

The northern and southern portions of the Rolling Fork Creek subwatershed are heavily developed while the lower and middle regions are sparsely developed. Table 4 summarizes the acreages and the corresponding percentages of the land cover categories for the subwatershed, with Figure 2 showing this as a map. The land cover data were retrieved from the National Oceanic and Atmospheric Administration (2011) land cover database obtained from the Houston-Galveston Area Council. The total acreage of the segment in Table 4 corresponds to the watershed delineation in Figure 2. The predominant land cover category in this watershed is developed land (approximately 83%), with a moderate amount of forest types, and minimal other land uses.

Population estimates and future population projections were examined for counties and cities in the project area. These are discussed in the original TMDL document as well as the technical support document for this addendum.

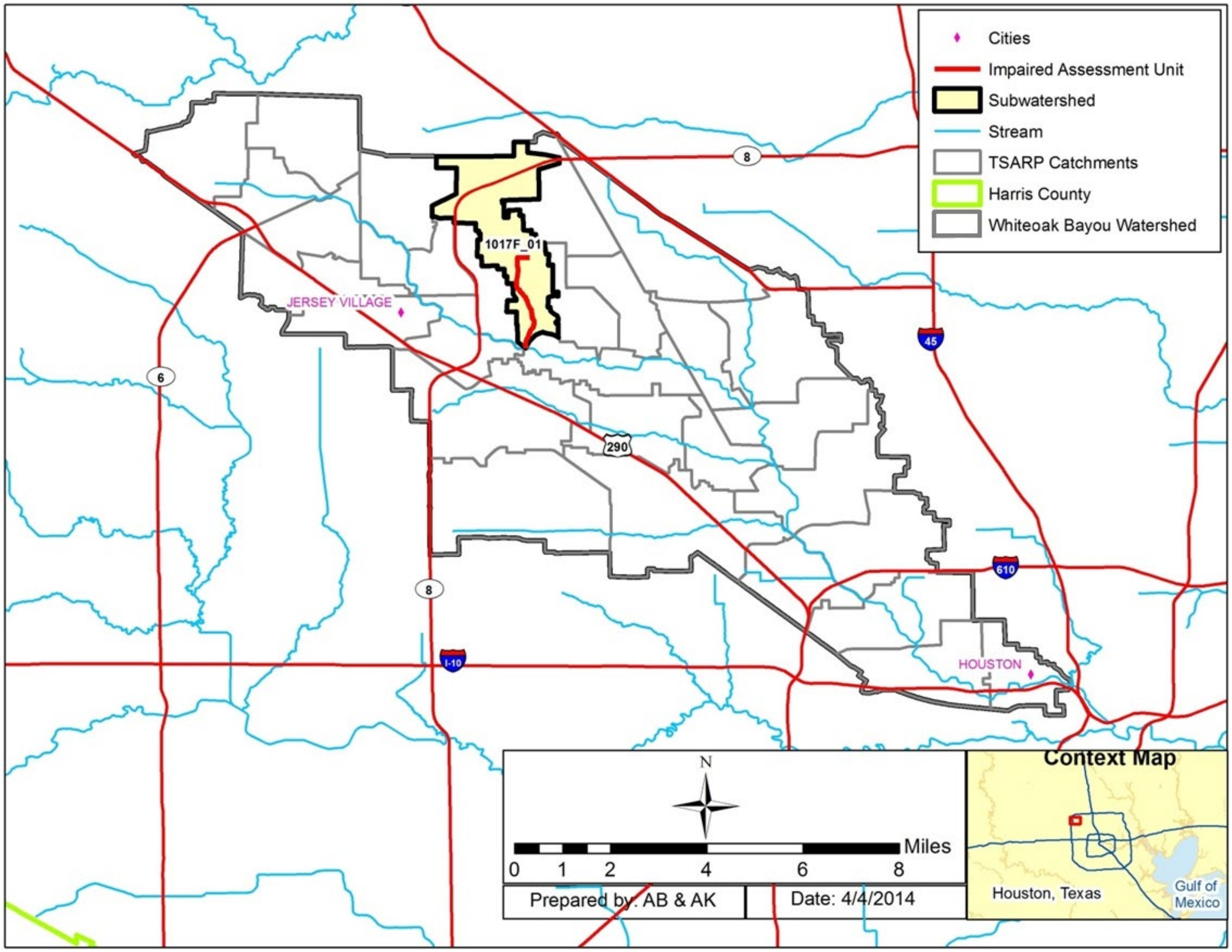

Figure 1. Buffalo and Whiteoak Bayous Watershed [a]

[a] All maps in this document were developed by the University of Houston and modified by the TMDL Program of the TCEQ. No claims are made to the accuracy or completeness of the data or to its suitability for a particular use. "TSARP" refers to the Tropical Storm Allison Recovery Project, for which some map delineations used in this project were originally created.

Table 1. Synopsis of Texas Integrated Report for Water Bodies in the Buffalo/Whiteoak Watershed

Assessment Unit	Segment Name	Parameter	Designated Use*				Year Impaired	Stream Length (miles)
			CR	AL	GU	FC		
1017F_01	Rolling Fork Creek (un-classified water body)	*E.coli*	NS	FS	CS	NA	2012	2.24

** CR: Contact recreation; AL: Aquatic Life; GU: General Use; FC: Fish Consumption, NS = Not Supporting; FS = Fully Supporting; CS= Screening Level Concern; NA= Not Assessed*

Table 2. Water Quality Data for TCEQ Stations from 2007 to 2012

Segment	Station ID	Indicator Bacteria	Geometric Mean Concentration (MPN/100ml)	Number of Samples	Number of Samples Exceeding Single Sample Criterion	% of Samples Exceeding
1017F_01	11157	*E. coli*	698.75	46	30	65.22%

MPN: Most Probable Number
Geometric Mean Criterion: 126 MPN/100 m.
Single Sample Criterion: 399 MPN/100 ml.

Table 3. Average Annual Precipitation in Rolling Fork Creek Subwatershed, 2000-2012 (in inches)

Segment Name	Segment ID	Average Annual (Inches)
Rolling Fork Creek	1017F_01	45.4

Table 4. Aggregated Land Use Summaries by Segment

Aggregated Land Cover Category	Area (ac)	Percent (%)
Open Water	18.0	0.6%
Developed, Open Space	595.3	21.3%
Developed, Low Intensity	682.1	24.4%
Developed, Medium Intensity	799.8	28.6%
Developed, High Intensity	236.2	8.4%
Barren Land	6.2	0.2%
Deciduous Forest	151.4	5.4%
Evergreen Forest	144.3	5.2%
Mixed Forest	29.3	1.0%
Shrub/Scrub	39.7	1.4%
Herbaceous	35.3	1.3%
Hay/Pasture	50.0	1.8%
Woody Wetlands	10.9	0.4%

Endpoint Identification

The water quality target for the TMDL for this freshwater segment is to maintain concentrations below the geometric mean criterion of 126 MPN/100 mL for *E. coli*. The TMDL will be based on bacteria allocations required to meet the geometric mean criterion.

Source Analysis

Regulated Sources

The subwatershed (1017F_01) has five Nation Pollution Discharge Elimination System (NPDES)/Texas Pollution Discharge Elimination System (TPDES)-permitted sources. A significant portion of the subwatershed is regulated under the TPDES stormwater discharge permit jointly held by Harris County, Harris County Flood Control District (HCFCD), City of Houston, and Texas Department of Transportation (TPDES Permit No. WQ0004685000, NPDES Permit No. TXS001201). There are no NPDES-permitted concentrated animal feeding operations (CAFOs) within the subwatershed. The location of all five TPDES-permitted facilities is shown in Figure 3 with additional details on each provided in Table 5.

TPDES-permitted facilities that discharge treated wastewater are required by their permit to monitor their effluent for certain parameters. A summary of the discharge monitoring report (DMR) data for the facilities in the subwatershed is shown in Table 6. In addition, all five TPDES facilities in the subwatershed: 13433-001, 13623-001, 12342-001, 11188-001, and 15040-001 collect fecal indicator bacteria data. Facility 15040-001 was part of the WQMP Update from July 2012, with the public comment period from August 3, 2012 through September 4, 2012, and no comments were received. Table 7 lists the number of reported monthly exceedances of the daily average concentration of 126 cfu/100 mL, and the number of reported daily exceedances of the daily maximum of 399 cfu/100 mL. As shown in the tables, Facility 13433-001 exceeded the *E.coli* permit limit once during the monitoring time frame (approximately 2002-2012).

Table 5. TPDES-Permitted Facilities in the subwatershed

Assess-ment Unit	Receiving Water	TPDES Number	NPDES Number	Facility Name	Facility Type	TYPE	Permitted Flow (MGD)	Average Monthly Flow (MGD)
1017F_01	Rolling Fork Creek	13433-001	TX0103705	Heron Lakes WWTP	Sewerage sys-tems	D	0.5	0.13
1017F_01	Rolling Fork Creek	13623-001	TX0109126	West Harris County MUD 21 WWTF	Sewerage sys-tems	D	0.12	0.06
1017F_01	Rolling Fork Creek	12342-001	TX0085821	Maple Leaf Gardens WWTP	Sewerage sys-tems	D	0.045	0.01
1017F_01	Rolling Fork Creek	11188-001	TX0026697	Rolling Fork PUD WWTP	Sewerage sys-tems	D	0.49	0.22
1017F_01	Rolling Fork Creek	15040-001	TX0133582	Windfern MHP WWTP	Sewerage sys-tems	D	0.04	0.01

Table 6. DMR Data for Permitted Wastewater Discharges (January 2002-December 2012)

TPDES Number	NPDES Number	Facility Name	Assessment Unit	Stream Name	Dates Monitored		# of Records	Monthly Average Flow (MGD)*	Permit-ted Flow (MGD)
					Start	End			
13433-001	TX0103705	Heron Lakes WWTP	1017F_01	Rolling Fork Creek	6/30/2002	12/31/2012	162	0.13	0.5
13623-001	TX0109126	West Harris County MUD 21 WWTF	1017F_01	Rolling Fork Creek	10/31/2002	12/31/2012	116	0.06	0.12
12342-001	TX0085821	Maple Leaf Gardens WWTP	1017F_01	Rolling Fork Creek	1/31/2004	12/31/2012	107	0.01	0.045
11188-001	TX0026697	Rolling Fork PUD WWTP	1017F_01	Rolling Fork Creek	6/30/2002	12/31/2012	126	0.22	0.49
15040-001	TX0133582	Windfern MHP WWTP	1017F_01	Rolling Fork Creek	1/31/2004	12/31/2012	99	0.01	0.04

Source: EPA, ICIS monitoring data search August 2013
*Notes: n/a = Not Available, MGD = Millions of Gallons per Day, cfu = Colony Forming Unit; *there were several missing monthly flow data points; these gaps were filled by taking the average of flows for the previous and subsequent months.*

Table 7. *E.coli* Data for Permitted Wastewater Discharges (April 2012 - December 2012)

Facility Name	TPDES Number	NPDES Number	No. Records	Avg Daily Average (cfu/100 mL)	Avg Monthly Maximum (cfu/100 mL)	Exceedances of Maximum Permit Limit (399 cfu/100 mL)		Exceedances of Average Permit Limit (126 cfu/100 mL)	
						Number	%	Number	%
Heron Lakes WWTP	13433-001	TX0103705	*9*	*120*	*n/a*	1	11.10%	1	11.10%
West Harris County MUD 21 WWTF	13623-001	TX0109126	9	2.4	*n/a*	0	0	0	0
Maple Leaf Gardens WWTP	12342-001	TX0085821	2	0.5	*n/a*	0	0	0	0
Rolling Fork PUD WWTP	11188-001	TX0026697	9	2.2	*n/a*	0	0	0	0
Wind-fern MHP WWTP	15040-001	TX0133582	No data	No data	No data	No data	No data	No data	No data

Source: EPA, ICIS monitoring data search August 2013
Notes: MCMX = Measurement: Concentration Maximum, MCAV = Measurement: Concentration Average, n/a = Not Available

Note on Windfern facility: This facility started reporting E. coli data on 10/13/13. Between that time and 4/30/15, there were six records of E. coli submissions, with an average of the daily average of 0.8 cfu/100 mL, and no exceedances reported for the daily average or maximum.

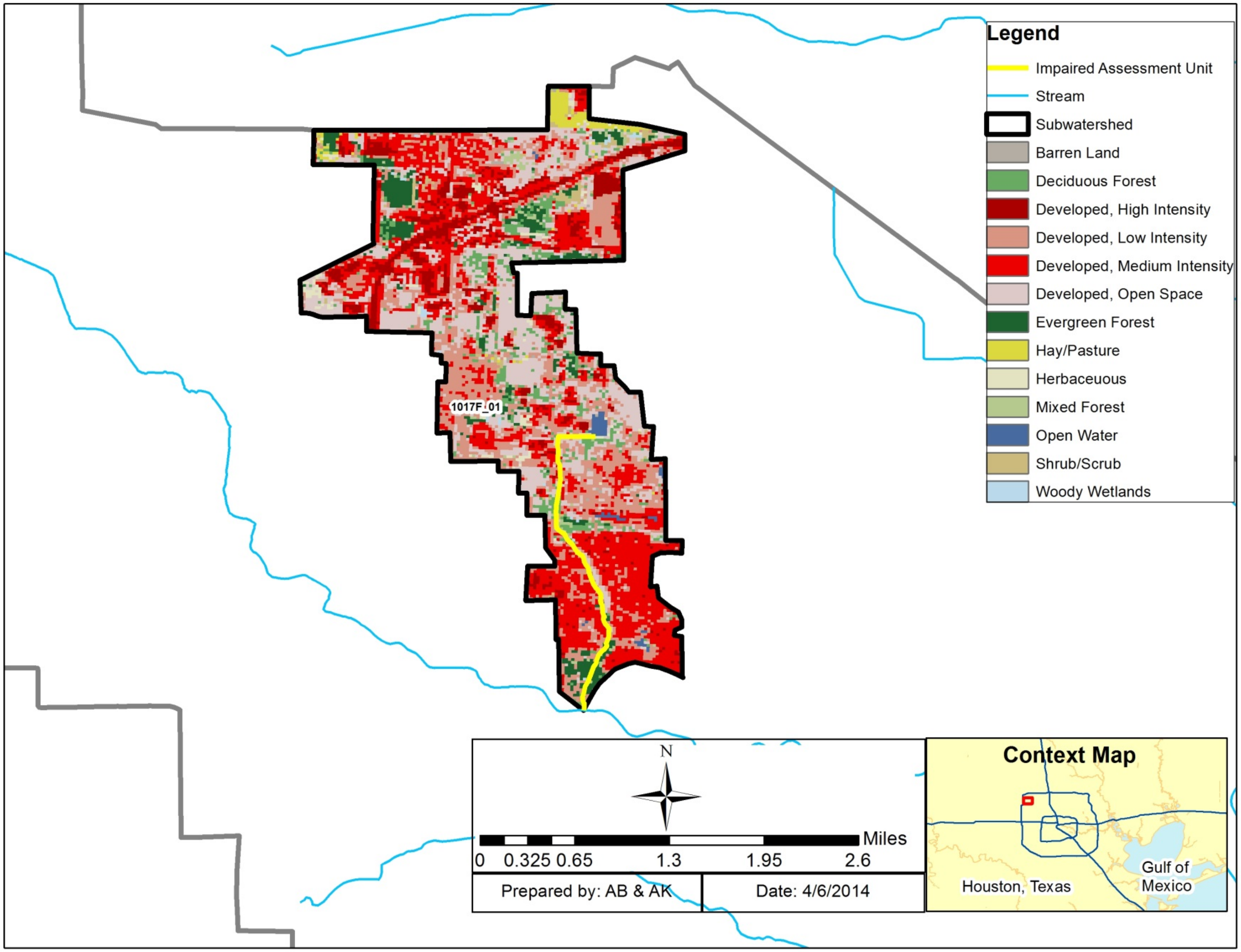

Figure 2. Land Cover Map

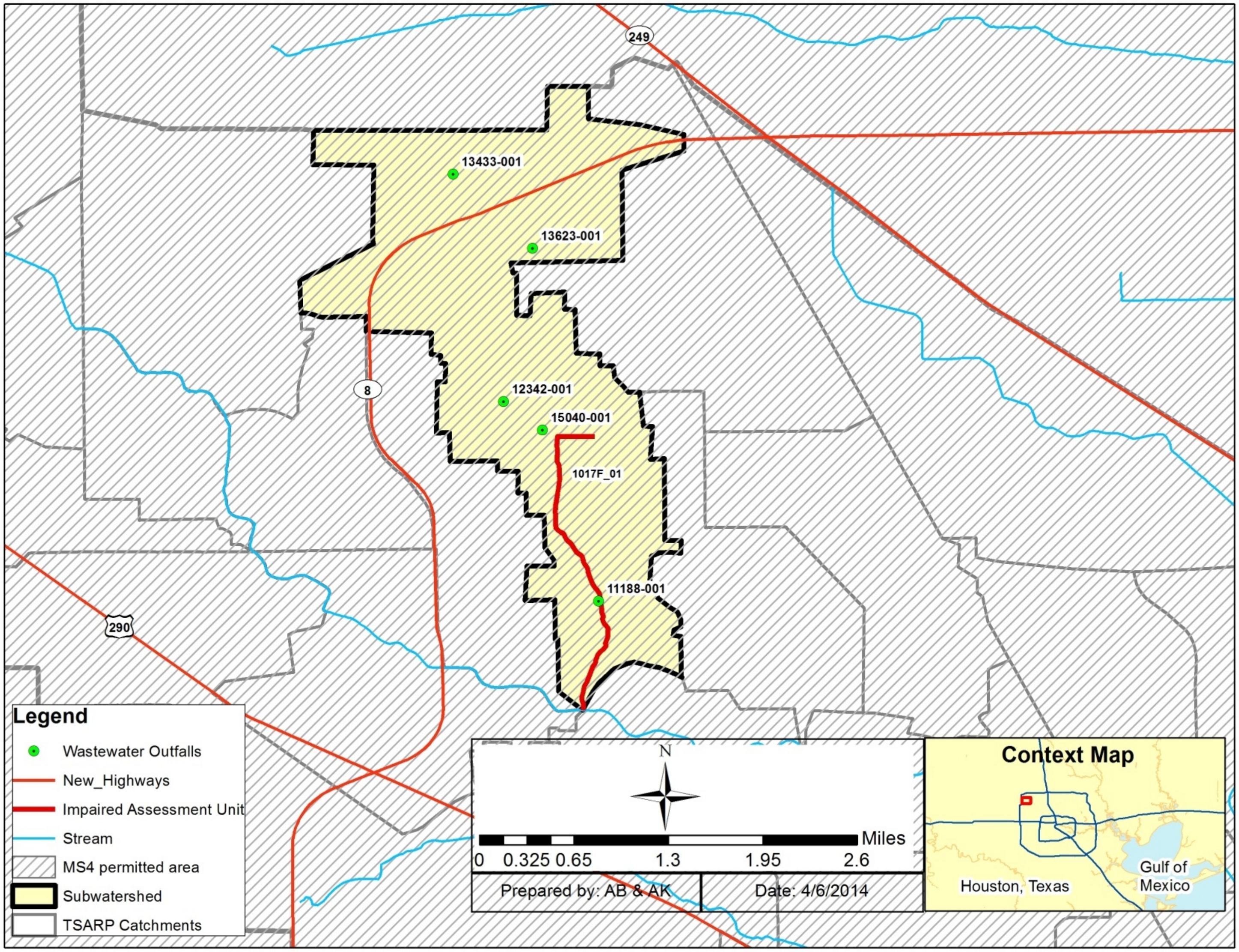

Figure 3. TPDES-Permitted Facility, WQM Stations, and MS4 Coverage Area in the Rolling Fork Creek Subwatershed

Source: The jurisdictional boundary of the Houston MS4 permit is derived from Urbanized Area Map Results for Texas which can be found at the USEPA website <cfpub.epa.gov/npdes/stormwater/urbanmapresult.cfm?state=TX>.

Sanitary Sewer Overflows

The TCEQ maintains a database of sanitary sewer overflow (SSO) data collected from wastewater operators in the Rolling Fork Creek watershed. TCEQ Region 12-Houston provided a database for SSO data in the subwatershed (Laird 2013). These data are included in Table 8.

The locations and magnitudes of all the reported SSOs within the subwatershed are displayed in Figure 4. It is important to note that some facilities provide wastewater service within the boundary of the subwatershed, but the facilities themselves do not discharge to Rolling Fork Creek.

As can be seen from Table 8, there have been approximately 19 sanitary sewer overflows reported in the Rolling Fork Creek subwatershed since November 2001. The reported SSOs averaged at 2,455 gallons per event.

Table 8. Sanitary Sewer Overflow (SSO) Summary

Facility Name	NPDES Permit No.	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
				From	To	Min	Max
Heron Lakes WWTP	TX0103705	13433-001	5	4/24/02	11/27/07	5	10,000
West Harris County MUD 21 WWTF	TX0109126	13623-001	6	8/23/02	9/14/07	30	5,000
Maple Leaf Gardens WWTP	TX0085821	12342-001	1	6/15/11	6/15/11	500	500
Rolling Fork PUD WWTP	TX0026697	11188-001	7	11/21/01	11/12/11	5	3,600
Windfern MHP WWTP	TX0133582	15040-001	0	1/1/98	5/28/15	0	0

Note on Windfern facility: This facility was previously under facility ID number 13509-001. The plant has been in operation since at least 1998 and has never reported any SSOs.

TPDES-Regulated Stormwater

The entirety of the subwatershed is covered under the City of Houston County municipal separate storm sewer system (MS4) permit (TPDES Permit No. WQ0004685000, NPDES Permit No. TXS001201). Under the City of Houston/Harris County discharge permit, Harris County, HCFCD, City of Houston, and Texas Department of Transportation are designated as co-permittees.

Unregulated Sources

Pollutants from unregulated sources enter the impaired AU through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities and animals, land application fields, failing onsite sewage facilities (OSSFs), and domestic pets.

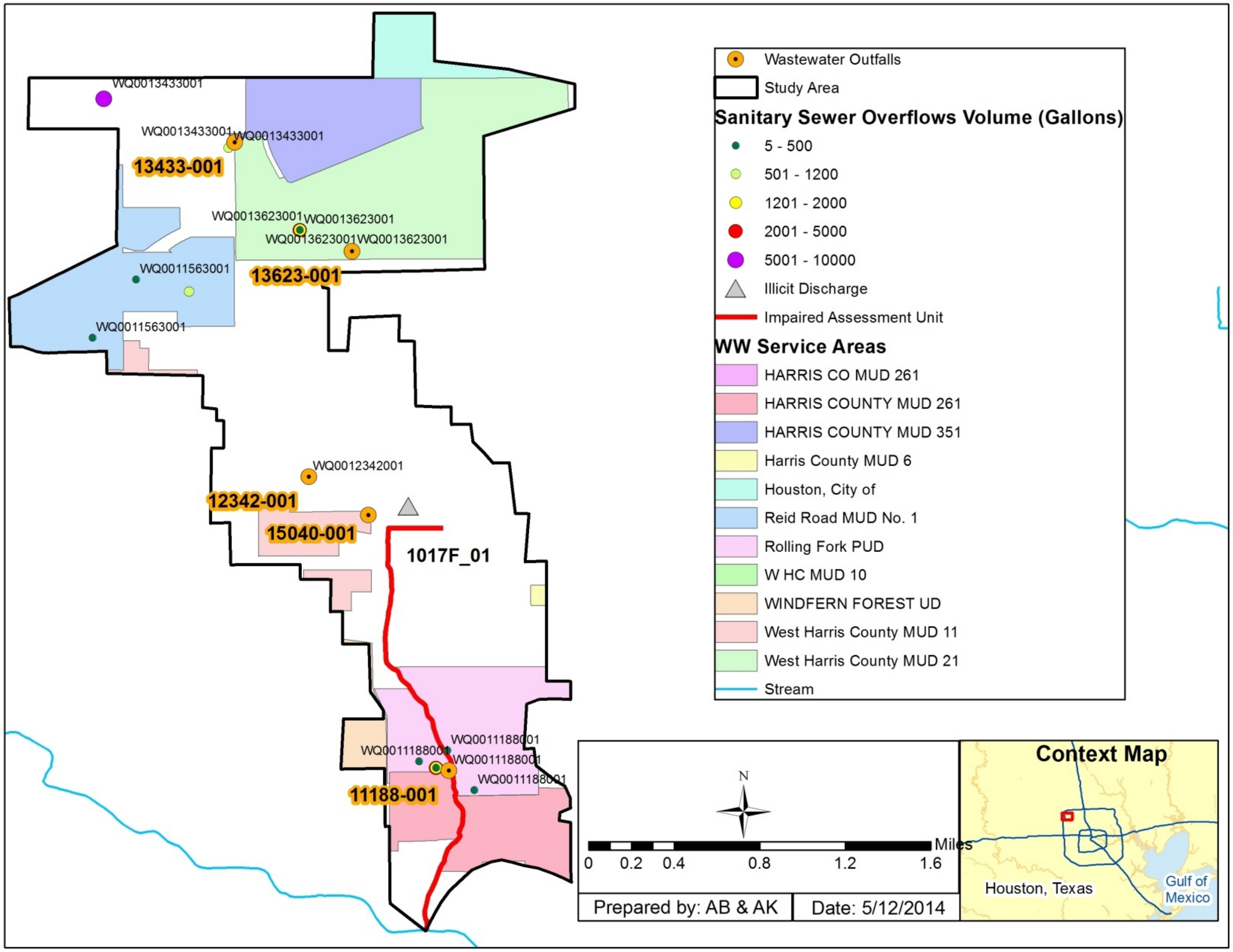

Figure 4. Locations of Sanitary Sewer Overflows

Wildlife and Unmanaged Animal Contributions

Currently there are insufficient data available to estimate populations and spatial distribution of wildlife and avian species by subwatershed. Consequently, it is difficult to assess the magnitude of bacteria contributions from wildlife species as a general category.

Unregulated Agricultural Activities and Domesticated Animals

There are a number of unregulated agricultural activities that can also be sources of fecal bacteria loading. Agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002).

The estimated numbers of selected livestock by watershed were calculated based on the 2007 USDA county agricultural census data (USDA 2007). The county-level estimated livestock populations were distributed throughout the subwatershed based on GIS calculations of pasture land per watershed, based on the National Land Cover Database (NOAA 2011). It should be noted that these are planning level livestock and are not evenly distributed across counties or constant with time.

As shown in Table 9, cattle are estimated to be the most abundant species of livestock in the Rolling Fork Creek subwatershed. These livestock numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Failing On-site Sewage Facilities

OSSFs can be a source of bacteria loading to streams and rivers. Bacteria loading from failing OSSFs can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Indicator bacteria-contaminated groundwater can also be discharged to creeks through springs and seeps.

Over time, most OSSFs operating at full capacity will fail if not properly maintained. The 1995 American Housing Survey conducted by the U.S. Census Bureau estimates that, nationwide, 10 percent of occupied homes with OSSFs experience malfunctions during the year (U.S. Census Bureau 1995). A statewide study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12 percent of the OSSFs in Harris County were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSSFs per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1985).

Table 9. Livestock and Manure Estimates in the Subwatershed

Type of Animal	Total Animals
Cattle and Calves	13
Horses and Ponies	3
Goats	1
Hogs and Pigs	1
Sheep and Lambs	1
Bison	0
Captive Deer	1
Donkey	1
Rabbits	1
Llamas	0
Pullets	1
Broilers	1
Layers	2
Turkeys	1
Ducks	1
Geese	0
Other Poultry	1
Total Animals	29

Only permitted OSSF systems are recorded by authorized county or city agents; therefore, it is difficult to estimate the exact number of OSSFs in use in the subwatershed. Table 10 lists the OSSF totals based on GIS data information provided by H-GAC. Figure 5 displays unsewered areas that do not fall under the wastewater service areas and may be expected to have septic systems serving households in these areas.

For the purpose of estimating fecal coliform loading in watersheds, the OSSF failure rate of 12 percent from the Reed, Stowe & Yanke, LLC (2001) report for Texas On-Site Wastewater Region 4 was used. Using this 12 percent failure rate, calculations were made to characterize fecal coliform loads in each watershed.

Fecal coliform loads were estimated using the following equation (USEPA 2001), modified to use 60 gallons per person per day (TCEQ standard) instead of 70 gallons per person per day (original EPA equation)

$$\#\frac{counts}{day} = (\#Failing\_systems) \times \left(\frac{10^6 counts}{100ml}\right) \times \left(\frac{60gal}{personday}\right) \times \left(\#\frac{person}{household}\right) \times \left(3785.2\frac{ml}{gal}\right)$$

The average of number of people per household was calculated to be 2.75 for the subwatershed (U.S. Census Bureau 2010) based on an average household density for Houston, and Jersey Village. Approximately 60 gallons of wastewater were estimated to be produced on average per person per day. The fecal coliform concentration in failing septic tank effluent was estimated to be 106 per 100 mL of effluent based on reported concentrations from a number of published reports (Metcalf and Eddy 1991; Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the subwatershed was calculated and is summarized in Table 10. Based on this data, it was determined that the estimated fecal coliform loading from OSSFs in the subwatershed could be a significant source as a considerable area of the subwatershed was unsewered.

Table 10. Estimated Number of OSSFs per Watershed and Fecal Coliform Load

Segment	Stream Name	Number of OSSFs	# of Failing OSSFs	Estimated Loads from OSSFs (x 10^9 counts/day)
1017F_01	Rolling Fork Creek	98	11.76	73.45

Domestic Pets

Fecal matter from dogs and cats is transported to streams by runoff from urban and suburban areas and can be a potential source of bacteria loading. On average nationally, there are 0.58 dogs per household and 0.66 cats per household (American Veterinary Medical Association 2002). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each watershed. Table 11 summarizes the estimated number of dogs and cats for the subwatershed.

Table 11. Estimated Numbers of Pets

Segment	Stream Name	Dogs	Cats
1017F_01	Rolling Fork Creek	1883	2143

Only a small portion of these loads is expected to reach water bodies, through wash-off of land surfaces and conveyance in runoff, since many cats dispose of their waste indoors and many pet owners clean up after their dogs outside.

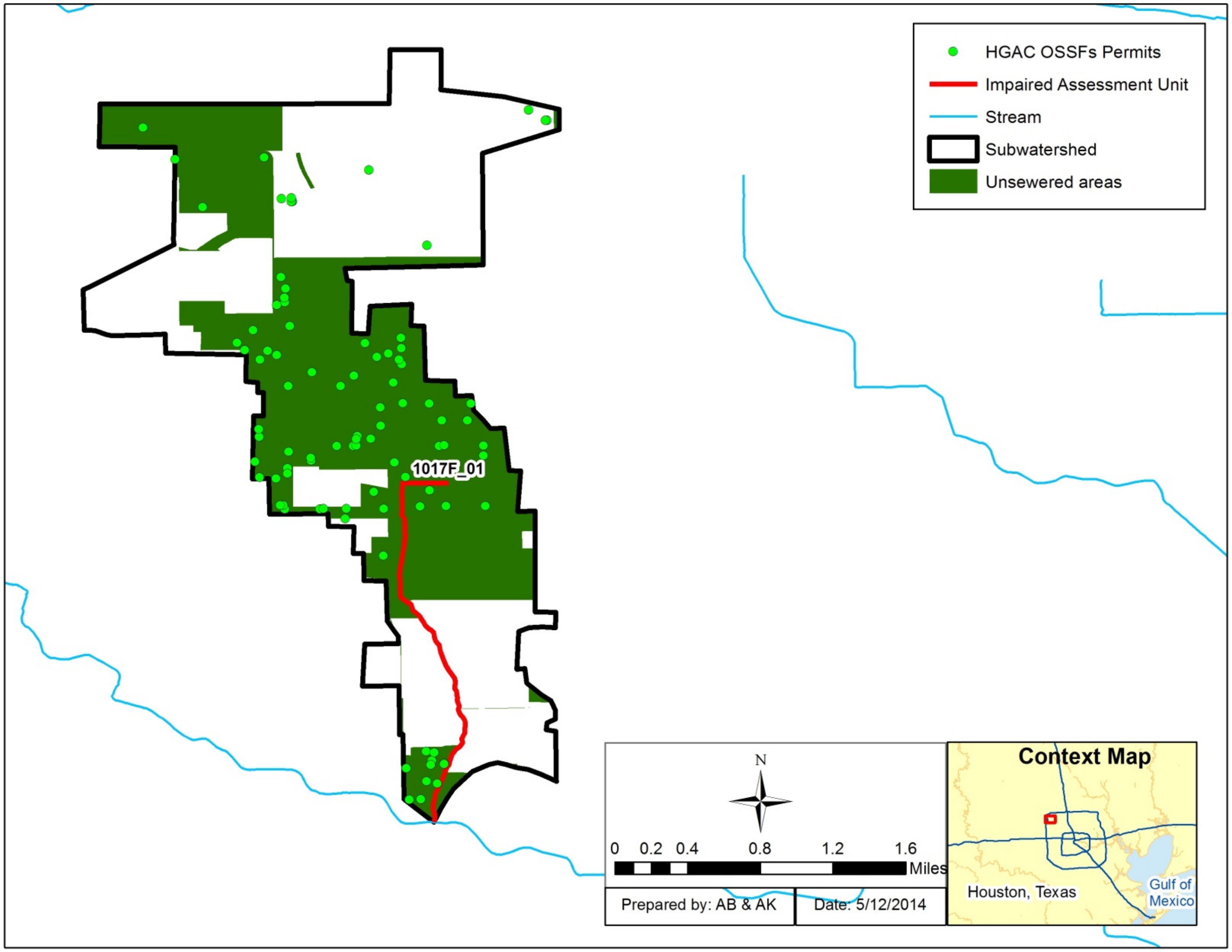

Figure 5. Unsewered Areas and Subdivisions with OSSF

Linkage Analysis

Load duration curve (LDC) analysis (including flow duration curve (FDC) analysis) was used for analyzing indicator bacteria load and instream water quality for the segment in this project. The Technical Support Document has details about this analysis.

Margin of Safety

The TMDL covered by this report incorporates an explicit margin of safety (MOS) by setting a target for indicator bacteria loads that is 5 percent lower than the single sample criterion. The MOS was used because of the limited amount of data available for the sampling station. For contact recreation, using this MOS equates to a single sample target of 379 MPN/100mL for *E. coli* and a geometric mean target of 120 MPN/100mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of the water body is slightly reduced. The TMDL covered by this report incorporates an explicit MOS in each LDC by using 95 percent of the single sample criterion.

Pollutant Load Allocation

Pollutant load allocations were developed using analysis of the FDC and the LDC method. To establish the subwatershed targets, TMDL calculations and associated allocations are established for the most-downstream sampling location in the subwatershed. This establishes a distinct TMDL for the 303(d) listed water body.

To calculate the bacteria load at the criterion for the segment, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,755 dL/ft3 * seconds/day*) and the *E. coli* criterion. This calculation produces the maximum bacteria load in the stream without exceeding the instantaneous standard over the range of flow conditions. *E. coli* loads are plotted versus flow exceedance percentiles as an LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacteria load.

To estimate existing loading in Rolling Fork Creek, two USGS gages outside the subwatershed, Whiteoak Bayou at Alabonson Road, Houston, TX (USGS gage number: 08074020), and Whiteoak Bayou at Houston, TX (USGS gage number: 08074500), were chosen to conduct flow projections. The period of record for flow data used from these stations was 2002 through 2012. Pollutant loads were then calculated by multiplying the measured bacteria concentration by the flow rate and the unit conversion factor of *24,465,755 dL/ft3 * seconds/day*. The associated flow exceedance percentile is then matched with the measured flow. The observed bacteria loads are added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the criterion.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and loads that meet the TMDL water quality target can also be calculated under different flow conditions.

The load allocation goal for Rolling Fork Creek is based on data analysis using the geometric mean criterion since it is anticipated that achieving the geometric mean over an extended period of time will likely ensure that the single sample criterion will also be achieved.

Figure 6 represents the LDC for Rolling Fork Creek and is based on *E. coli* bacteria measurements at sampling location 11157. The LDC indicates that *E. coli* levels exceed the instantaneous and geometric mean water quality criteria under all flow conditions. Wet weather influenced *E. coli* observations are found under all flow conditions. The allocation goal for the segment used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–20th percentile).

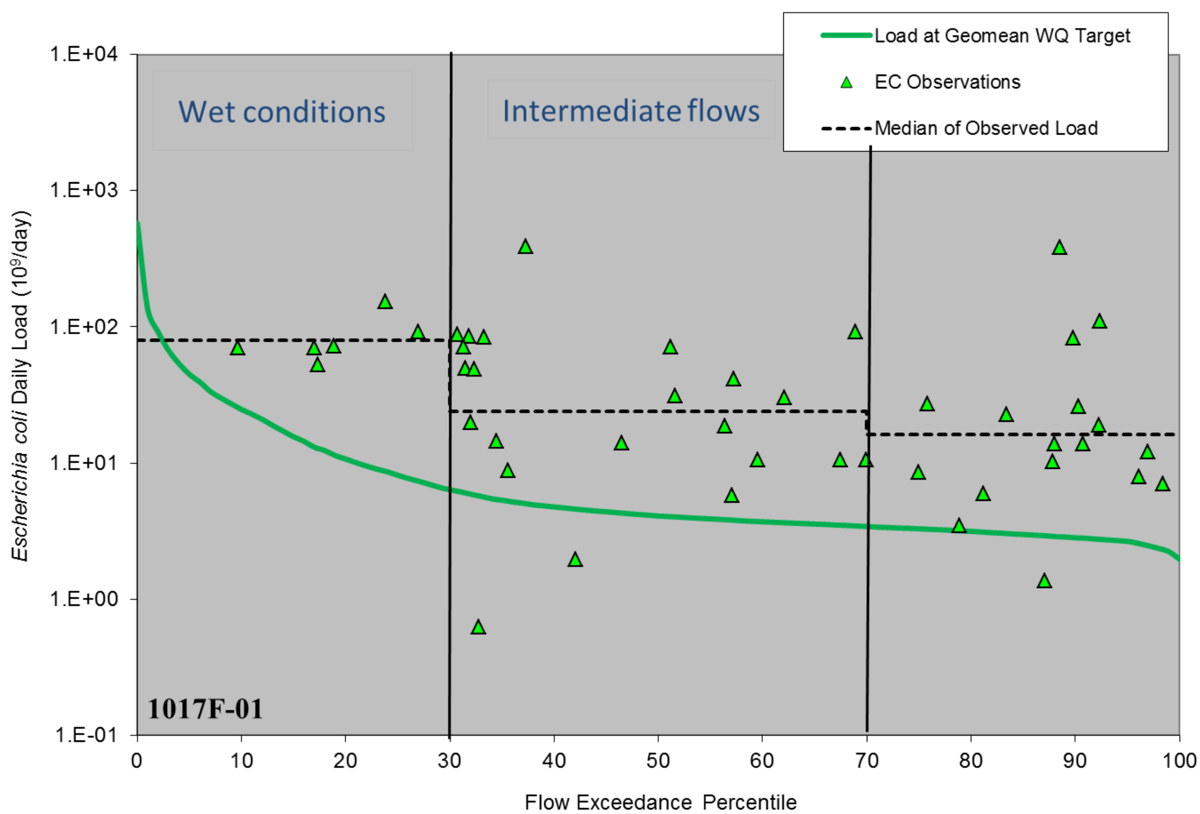

Figure 6. Load Duration Curve for Rolling Fork Creek (1017F_01)

Wasteload Allocation

TPDES-permitted facilities are allocated a daily wasteload calculated as their permitted discharge flow rate multiplied by one half of the instream geometric mean water quality criterion. Table 12 summarizes the waste load allocation (WLA) for the TPDES-permitted facilities within the subwatershed. The WLA for each facility (WLA_{WWTF}) is derived from the following equation:

*WLA_{WWTF} = criterion/2 * flow * unit conversion factor (#/day)*

Where:
criterion = 126 counts/dL for E coli
flow (10^6 gal/day) = permitted flow
unit conversion factor = 37,854,120/10^6gal/day

When multiple TPDES facilities occur within a watershed, loads from individual WWTFs are summed and the total load for continuous point sources is included as part of the WLA_{WWTF} component of the TMDL calculation for the corresponding segment. When there are no TPDES WWTFs discharging into the contributing watershed of a WQM station, then WWTF WLA is zero. Compliance with the WLA_{WWTF} will be achieved by adhering to the discharge limits and disinfection requirements of TPDES permits.

Table 12. Wasteload Allocations for TPDES-Permitted Facilities

TPDES Number	NPDES Number	Facility Name	Final Permitted Flow (MGD)	*E. coli* (Billion MPN/day)
13433-001	TX0103705	Heron Lakes WWTP	0.5	1.19
13623-001	TX0109126	West Harris County MUD 21 WWTF	0.25	0.6
12342-001	TX0085821	Maple Leaf Gardens WWTP	0.045	0.107
11188-001	TX0026697	Rolling Fork PUD WWTP	0.49	1.17
15040-001	TX0133582	Windfern MHP WWTP	0.04	0.095

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered permitted or regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges ($WLA_{Stormwater}$). A simplified approach for estimating the WLA for these areas was used in the development of the TMDL due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of the subwatershed that is under the jurisdiction of stormwater permits (i.e., defined as the area designated as urbanized area in the 2000 US Census) is used to estimate the amount of the overall runoff load to be allocated as the regulated stormwater contribution in the $WLA_{Stormwater}$ component of the TMDL. The load allocation (LA) component of the TMDL corresponds to direct nonpoint source runoff and is the difference between the total load from stormwater runoff and the portion allocated to $WLA_{Stormwater}$. For the subwatershed addressed in this TMDL, 100 percent of the area is within the urbanized area.

Load Allocation

The LA is the sum of loads from unregulated sources. Since the entirety of the subwatershed is within the urbanized area, there is no LA for this TMDL.

Allowance for Future Growth

As described in the original TMDL document, future growth of existing or new point sources is not limited by this TMDL as long as the sources do not cause indicator bacteria to exceed the limits. The assimilative capacity of streams increases as the amount of flow increases. Consequently, increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard. New or amended permits for wastewater discharge facilities will be evaluated case by case.

To account for the high probability that new additional flows from WWTFs may occur in this segment, a provision for future growth was included in the TMDL calculations by estimating permitted flows to year 2050 using population projections completed by the Texas Water Development Board. A summary of the methodology used to predict waste water flow capacity based on population growth is included in the Technical Support Document for reference.

The three-tiered antidegradation policy in the SWQSs prohibits an increase in loading that would cause or contribute to degradation of an existing use. The antidegradation policy applies to both point and nonpoint source pollutant discharges. In general, antidegradation procedures establish a process for reviewing individual proposed actions to determine if the activity will degrade water quality. The TMDL in this document will result in protection of existing beneficial uses and conform to Texas's antidegradation policy.

TMDL Calculations

Table 13 summarizes the estimated maximum allowable load of *E. coli* for the freshwater AU in this project.

The final TMDL allocation required to comply with the requirements of 40 Code of Federal Regulations (CFR) 130.7 is summarized in Table 14. In this table, the future capacity for WWTF has been added to the WLA_{WWTF}.

TMDL values and allocations in Table 14 are derived from calculations using the existing water quality criteria for *E. coli*. Figure 6 shows these allocations graphically. Designated uses and water quality criteria for this water body are subject to change through the TCEQ SWQS revision process. Figure 7 was developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant load allocations change in relation to a number of hypothetical water quality criteria. The equations provided along with Figure 7 allow the calculation of new TMDLs and pollutant load allocations based on any potential new water quality criteria for *E. coli*.

Table 13. *E. coli* TMDL Summary Calculations for Rolling Fork Creek (1017F_01)

Assessment Unit	Stream Name	Indicator Bacteria	TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$[c]	LA[d]	MOS[e]	Future Growth[f]
			(Billion MPN/day)					
1017F_01	Rolling Fork Creek	*E. coli*	17.4	3.16	12.4	0.0	0.87	0.94

[a] *Maximum allowable load for the highest flow range (0 to 30th percentile flows)*

[b] *Sum of loads from the WWTF discharging upstream of the TMDL station. Individual loads are calculated as permitted flow*126/2 (E.coli) MPN/100mL*conversion factor*

[c] *$WLA_{STORMWATER}$ = (TMDL – MOS - WLA_{WWTF})*(percent of drainage area covered by stormwater permits)*

[d] *LA= TMDL – MOS – WLA_{WWTF} – $WLA_{STORMWATER}$ – Future Growth*

[e] *MOS= TMDL x 0.05*

[f] *Projected increase in WWTF permitted flows*126/2*conversion factor*

Table 14. Final TMDL Allocations

Assessment Unit	TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$	LA	MOS
	(Billion MPN/day)				
1017F_01	17.4	4.10	12.4	0.0	0.87

[a] *TMDL= WLA_{WWTF} + $WLA_{STORMWATER}$ + LA + MOS*

[b] *WLA_{WWTF}= WLA_{WWTF} + Future Growth*

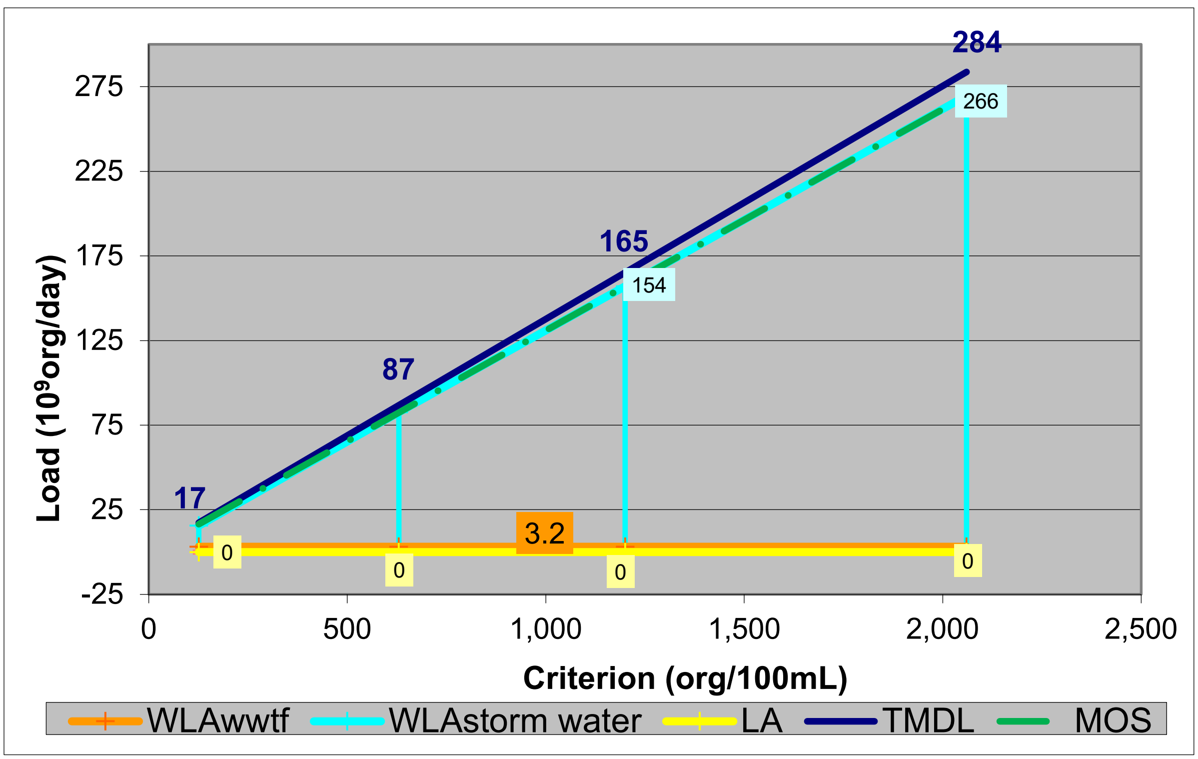

Figure 7. Allocation Loads for AU 1017C_01 as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations

$$TMDL = 0.1377 * Std - 0.59$$
$$LA = 0.0$$
$$WLA_{WWTF} = 3.16$$
$$WLA_{Stormwater} = 0.1313 * Std - 3.75$$
$$MOS = 0.05 * TMDL$$

Where:

WLA_{WWTF} = waste load allocation (permitted WWTF)
$WLA_{Stormwater}$ = waste load allocation (permitted storm water)
LA = load allocation (non-permitted source contributions)
Std = revised contact recreation standard
MOS = margin of safety

Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in these TMDLs by using more than 5 years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

Though the analysis of the available data for *E. coli* in Table 15 showed significance in the data at the monitoring station for warmer and/or cooler months, this cannot be confirmed as the number of samples was very small. Also, in the Buffalo and Whiteoak Bayou TMDL published in 2008 (texasnetdmr.org/assets/public/waterquality/tmdl/22buffalobayou/22-finalreport_dec06.pdf), a larger area was sampled and it was concluded in that report that there was no difference in *E. coli* concentration between the warmer and colder months.

Table 15. Seasonal Differences for *E. coli* Concentrations

Segment	Station ID	Indicator	Warm Months		Cold Months		*p*-value
			n	Geomean (MPN/100 ml)	n	Geomean (MPN/100 ml)	
1017F_01	11157	EC	15	989.07	19	426.07	0.043

EC: E. coli, n = number of samples
p-value is based on a t-test conducted at each station using single sample concentrations.

Public Participation

A presentation on this addendum was given at the annual meeting of the Bacteria Implementation Group (BIG) in Houston on May 22, 2012. The public will have an opportunity to comment on this document during a 30-day WQMP comment period. Notice of the public comment period will be sent to the BIG group and posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement _comment.html>, and the document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanage

ment_updates.html>. The technical support document for this project is posted on the TMDL project page at <www.tceq.texas.gov/waterquality/tmdl/nav/42-houstonbacteria/42-houstonareabacteria-library>.

Implementation and Reasonable Assurance

The segment covered by this addendum is within the existing Buffalo and Whiteoak Bayous bacteria TMDL project watershed. This watershed is within the area covered by the I-Plan developed by the BIG for bacteria TMDLs throughout the greater Houston area. Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

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