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 (scroll to view or print this addendum)

Water Quality Planning Division, Office of Water
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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

One Total Maximum Daily Load for Bacteria in Vogel Creek

For Segment 1017C
Assessment Unit 1017C_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. This document represents an 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 New/Additional Listings in the Houston Metro Area, Houston, Texas (1007T_01, 1007U_01, 1007S_01, 1007V_01, 1017C_01, and 1007A_01)* (University of Houston and Parsons 2012), 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 subwatershed, including permitted facilities within it, was addressed in the original TMDL. 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) that has been drafted 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 2010 Texas Water Quality Inventory and 303(d) List (Table 1). The impaired AU is Vogel Creek (1017C_01). See Figure 1 for a map of the watershed.

The Texas surface water quality standards (SWQSs; TCEQ 2010) 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 2010 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.

Vogel Creek (Segment 1017C_01): The single sample criterion for *E. coli* was exceeded in 41 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 subwatershed is summarized in Table 3.

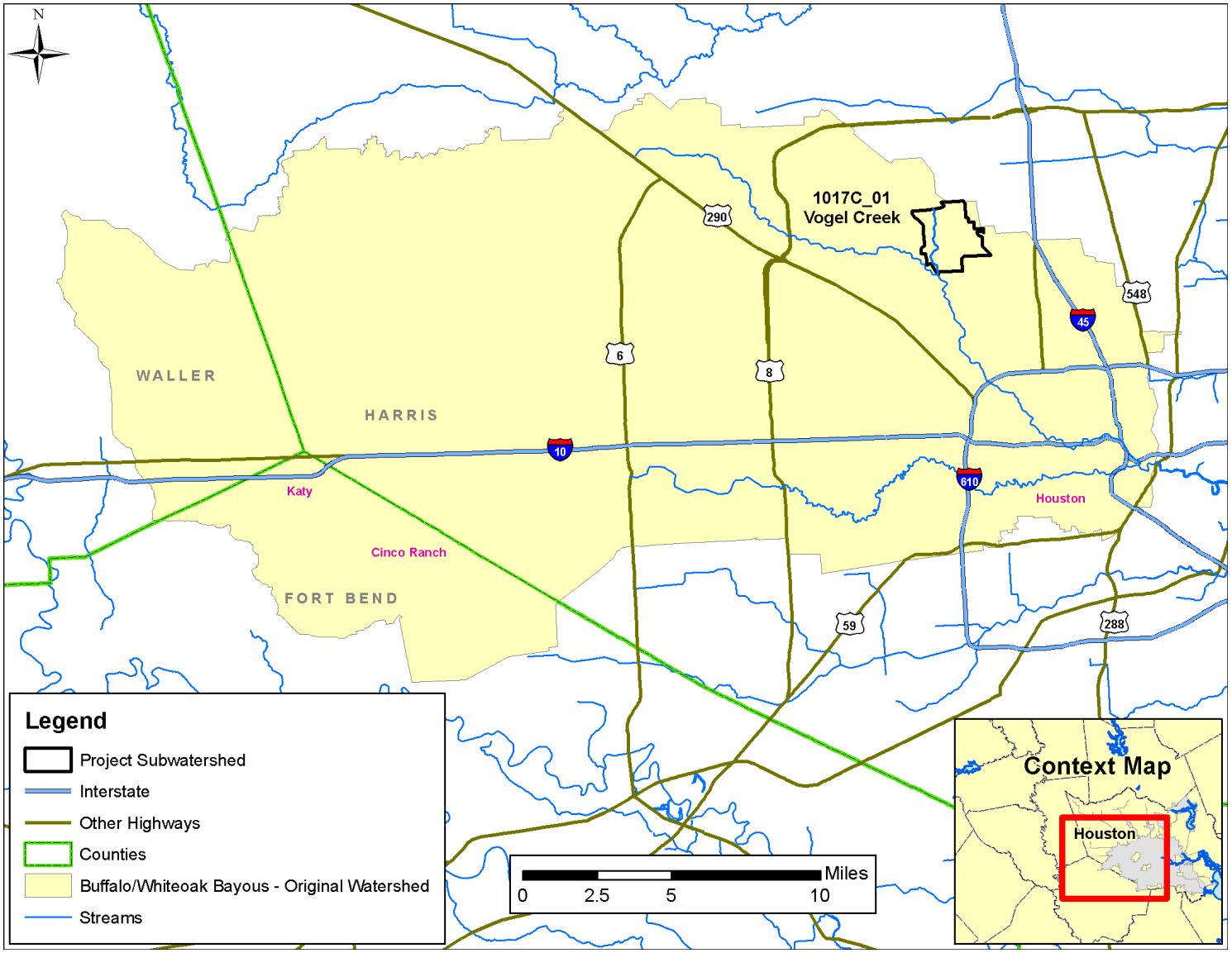


Figure 1. Buffalo and Whiteoak Bayous Watershed [a]

[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

Segment ID	Segment Name	Parameter	Contact Recreation Use	Year Impaired	Category	Stream Length (miles)
1017C_01	Vogel Creek	*E. coli*	Nonsupport	2010	5a	2.0

Table 2. Water Quality Data for TCEQ Stations from 1999 to 2011

Segment	Station ID	Indicator Bacteria	Geometric Mean Concentration (MPN/100ml)	Number of Samples	Number of Samples Exceeding Single Sample Criterion	% of Samples Exceeding
1017C_01	11155	*E. coli*	386	69	28	41%

MPN: Most Probable Number

Geometric Mean Criterion: 126 MPN/100 m.

Single Sample Criterion: 399 MPN/100 ml.

Table 3. Average Annual Precipitation in Study Area Subwatershed, 1988-2007 (in inches)

Segment Name	Segment ID	Average Annual (Inches)
Vogel Creek	1017C_01	52.17

Table 4 summarizes the acreages and the corresponding percentages of the land use categories associated with the project subwatershed in the Buffalo and Whiteoak Bayous watershed. The land use/land cover data were retrieved from the National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center. The specific land use/land cover data files were derived from the Coastal Change Analysis Program (C-CAP), Texas 2005 Land Cover Data (NOAA 2007). The total acreage of the segment in Table 4 corresponds to the watershed delineation in Figure 2. Based on the data sources that were used, the predominant land use category in this subwatershed is developed land (90%) followed by woody land (8.5%).

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.

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*. Maintaining the geometric mean criterion for indicator bacteria is expected to be protective of the single sample criterion also and therefore will ultimately result in the attainment of the contact recreation use. The TMDL will be based on bacteria allocations required to meet the geometric mean criterion.

Source Analysis

Regulated Sources

There is one National Pollutant Discharge Elimination System (NPDES)/Texas Pollutant Discharge Elimination System (TPDES)-permitted facility within the project's subwatershed. In addition, the entire Study Area is regulated under the TPDES municipal separate storm sewer system (MS4) discharge permit jointly held by Harris County, Harris County Flood Control District (HCFCD), City of Houston, and Texas Department of Transportation. There are no NPDES-permitted Concentrated Animal Feeding Operations (CAFOs) within the Study Area.

The TPDES-permitted facility that continuously discharges wastewater to surface waters addressed in this TMDL is listed in Table 5 and shown in Figure 3. Figure 3 also shows water quality monitoring (WQM) stations and the MS4 coverage area.

Table 4. Aggregated Land Use Summaries by Segment

Aggregated Land Use Category	1017C_01
Acres of Developed	2,150
Acres Cultivated Land	0
Acres Pasture/Hay	5.6
Acres Grassland/Herbaceous	19
Acres of Woody Land	203
Acres of Open Water	0
Acres of Wetland	9.1
Acres of Bare/Transitional	8.0
Watershed Area (acres)	**2,394**
Percent Developed	89.8%
Percent Cultivated Land	0%
Percent Pasture/Hay	0.2%
Percent Grassland/Herbaceous	0.8%
Percent Woody Land	8.5%
Percent Open Water	0%
Percent Wetland	0.38%
Percent Bare/Transitional	0.33%

Table 5. TPDES-Permitted Facilities in the Study Area

Segment	Receiving Water	TPDES Number	NPDES NUMBER	Facility Name	Facility Type	Permitted Flow (MGD)
1017C_01	Vogel Creek	11005-001	TX0020095	Champ's Water Company,W. Montgomery Subdivision-WWTP	Sewerage Systems	0.28

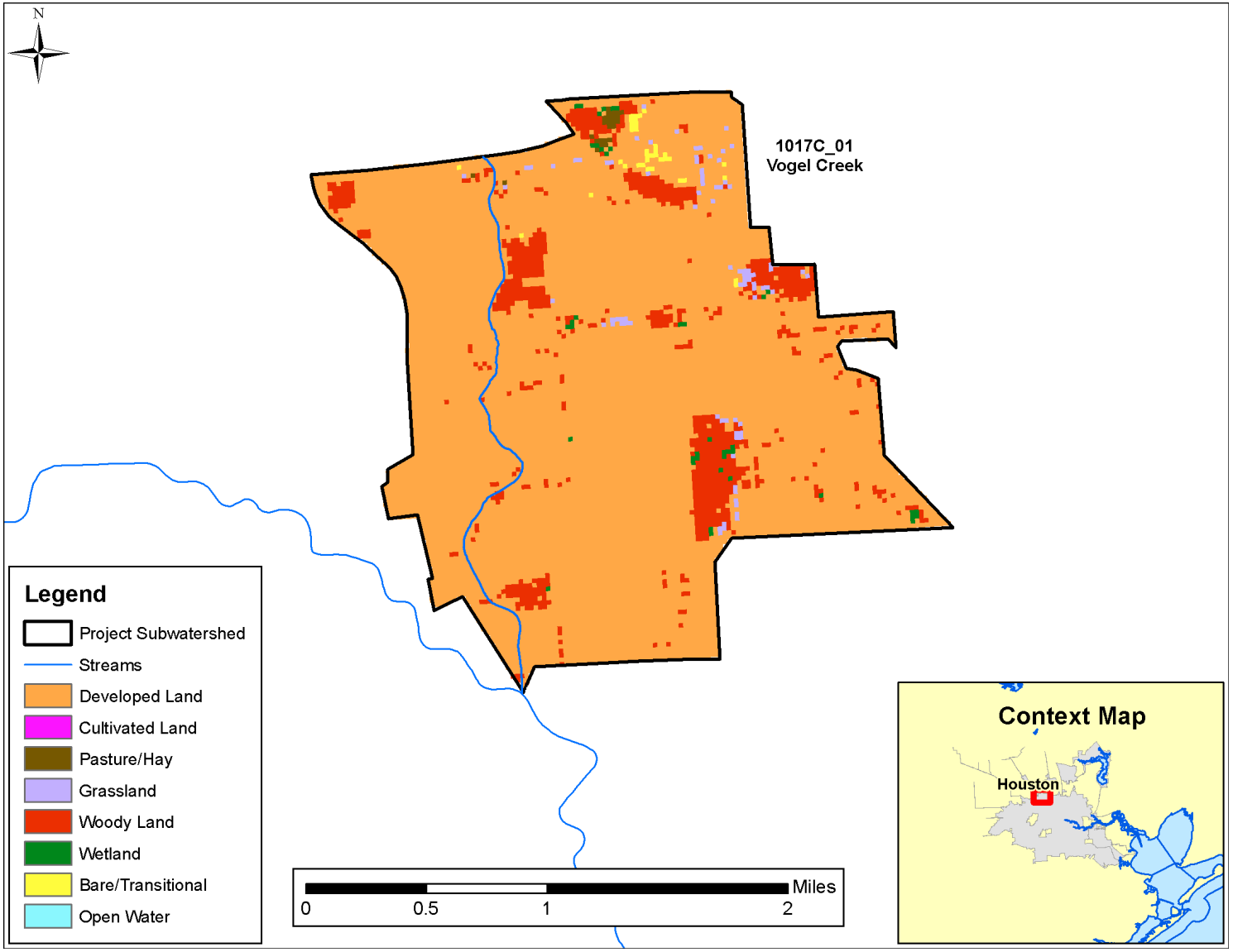
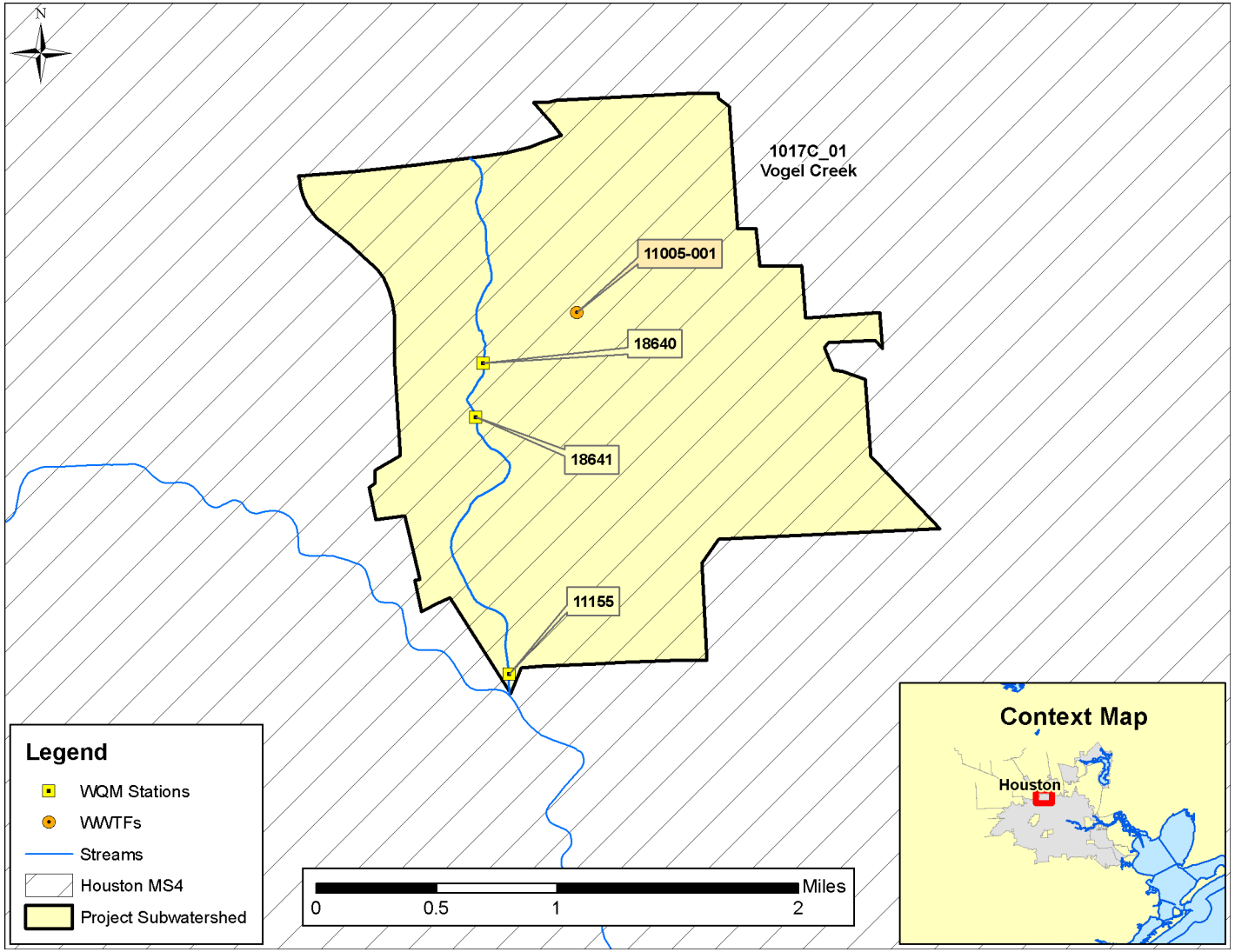


Figure 2. Land Use for Project Subwatersheds



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>.

Figure 3. TPDES-Permitted Facility, WQM Stations, and MS4 Coverage Area in the Buffalo and Whiteoak Bayous Subwatershed

Sanitary Sewer Overflows

TCEQ Region 12-Houston provided two database queries for sanitary sewer overflow (SSO) data – one is collected by the City of Houston and the other is compiled from the remainder of the wastewater dischargers in the Study Area (Rice 2005). These data are included in Table 6. The locations and magnitudes of the reported SSOs are displayed in Figure 4. The WWTF service area boundaries are also shown in Figure 4. The loads from these SSOs were accounted for in the original TMDL document. They are being assigned to the specific subwatershed in this addendum.

Table 6. Sanitary Sewer Overflow (SSO) Summary

Facility Name	NPDES Permit No.	TPDES Permit No.	# of Occur-rences	Date Range – From	Date Range – To	Gal-lons (Min)	Gal-lons (Max)	Gal-lons (Avg.)	Segment
City of Houston - North West Plant	TX0063011	10495-076	18	03/13/01	10/16/03	40	18514	2545	1017C_01

TPDES-Regulated Stormwater

The entirety of the subwatershed in the Study Area is covered under the City of Houston County MS4 permit (TPDES Permit No. WQ0004685000). 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.

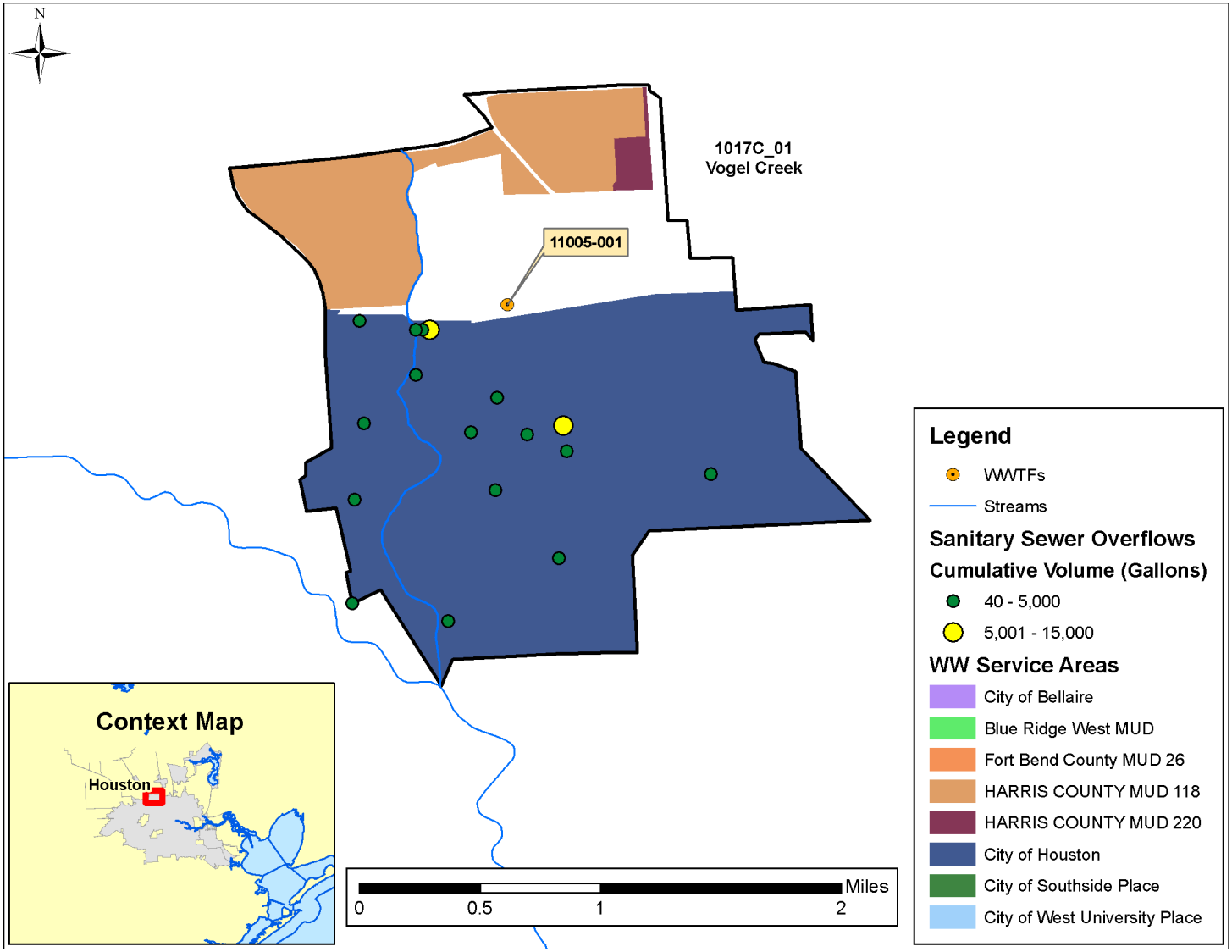


Figure 4. Locations of Sanitary Sewer Overflows

Unregulated Sources

Pollutants from unregulated sources enter the impaired AU through distributed, non-specific 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.

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

A number of agricultural activities that do not require permits can also be sources of fecal bacteria loading. Given the fact that the TMDL Study Area is highly urbanized, livestock and other domesticated animals are either not found in the watershed or exist in small numbers. Therefore, livestock and other domesticated animals are not considered as a contributor of bacteria loads.

Failing On-site Sewage Facilities

To estimate the potential magnitude of fecal bacteria loading from OSSFs, the number of OSSFs was estimated for each subwatershed. The estimate of OSSFs was derived by using data from the 1990 U.S. Census (U.S. Census Bureau 2000) and a GIS shape file obtained from Houston-Galveston Area Council (H-GAC) showing all areas where wastewater service currently exists. Figure 5 displays unsewered areas that did not fall under the wastewater service areas. OSSFs were calculated using spatial GIS queries for areas not covered by wastewater service areas. OSSFs were assigned proportionally based on the percentage of the area falling outside a wastewater service area within the project subwatershed. Finally, the OSSFs for each unsewered area were then totaled for the TMDL subwatershed. This approach gives an estimate of OSSFs in the subwatershed. Table 7 shows the estimated number of OSSFs calculated using this GIS method. The estimated OSSF numbers and loads were accounted for in the original TMDL document. They are being assigned to the specific project subwatershed in this addendum.

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

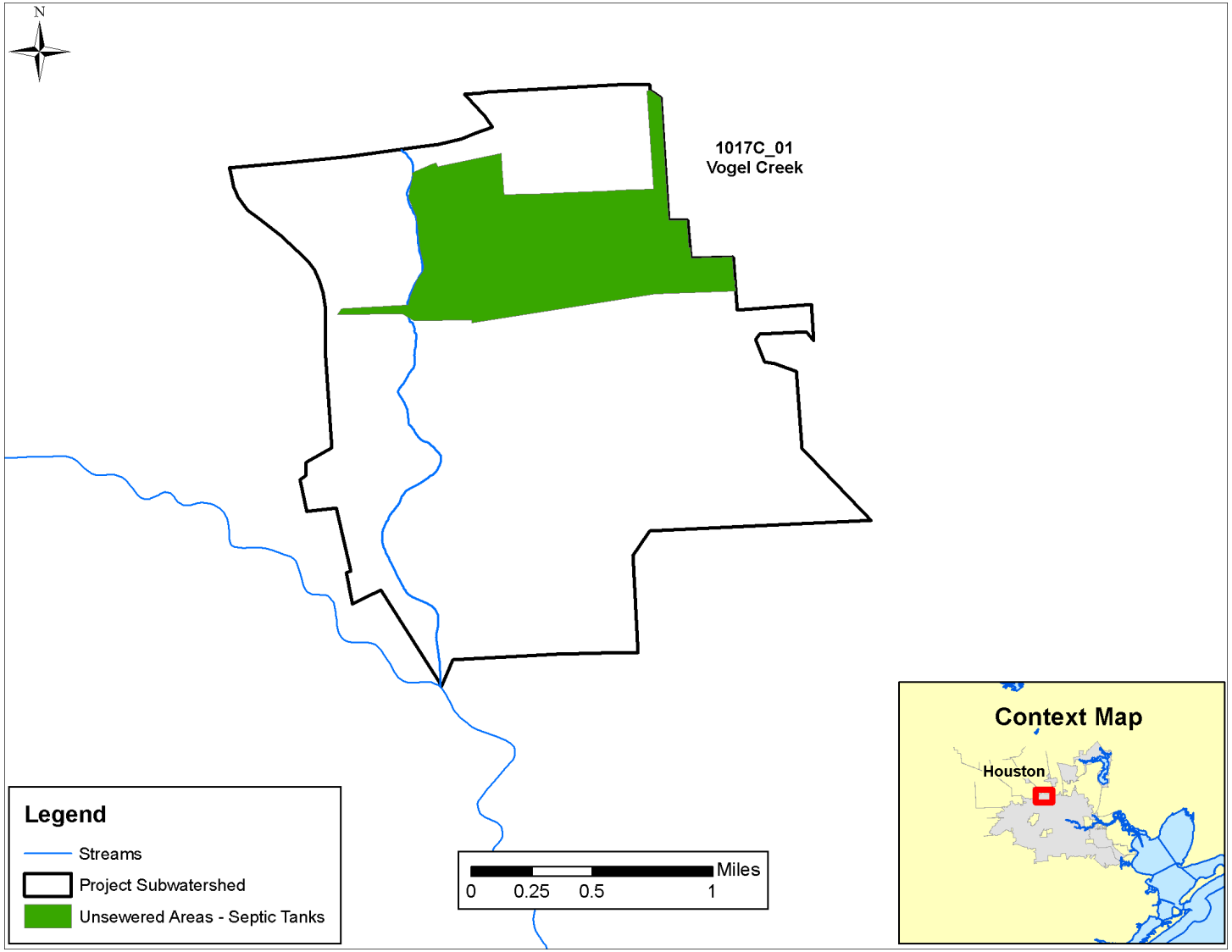


Figure 5. Unsewered Areas

Fecal coliform loads were estimated using the following equation (EPA 2001):

$$\#\frac{counts}{day} = \left(\#\,Failing\_systems\right) \times \left(\frac{10^6\,counts}{100ml}\right) \times \left(\frac{70gal}{personday}\right) \times \left(\#\frac{person}{household}\right) \times \left(3785.2\frac{ml}{gal}\right)$$

The average of number of people per household was calculated to be 2.78 for counties in the Study Area (U.S. Census Bureau 2000). Approximately 70 gallons of wastewater were estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per dL 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 summarized below in Table 7. Based on this data, it was determined that the estimated fecal coliform loading from OSSFs in the Study Area was found to be negligible.

Table 7. Estimated Number of OSSFs per Subwatershed, and Their Fecal Coliform Loads

Segment	Stream Name	OSSF Estimate using 1990 Census method	OSSF data from HGAC	# of Failing OSSFs	Estimated Loads from OSSFs (Billion MPN/day)
1017C_01	Vogel Creek	39	0	4.72	35

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 2007). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each subwatershed. Table 8 summarizes the estimated number of dogs and cats for the subwatershed of the Study Area. Only a small portion of the bacteria load from pets is expected to reach water bodies, through wash-off of land surfaces and conveyance in runoff. The pet number estimates were accounted for in the original TMDL document. They are being assigned to the specific subwatershed in this addendum.

Table 8. Estimated Numbers of Pets

Segment	Stream Name	Dogs	Cats
1017C_01	Vogel Creek	3,796	4,282

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 locations. For contact recreation, this 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 Vogel Creek, bacteria observations from 1999 to 2011 are paired with the flows measured or estimated in that segment on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and a 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 Vogel 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 Vogel Creek and is based on *E. coli* bacteria measurements at sampling location 11155 (Vogel Creek at Little York Road). The LDC indicates that *E. coli* levels exceed the instantaneous and geometric mean water quality criteria under high and mid-range 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).

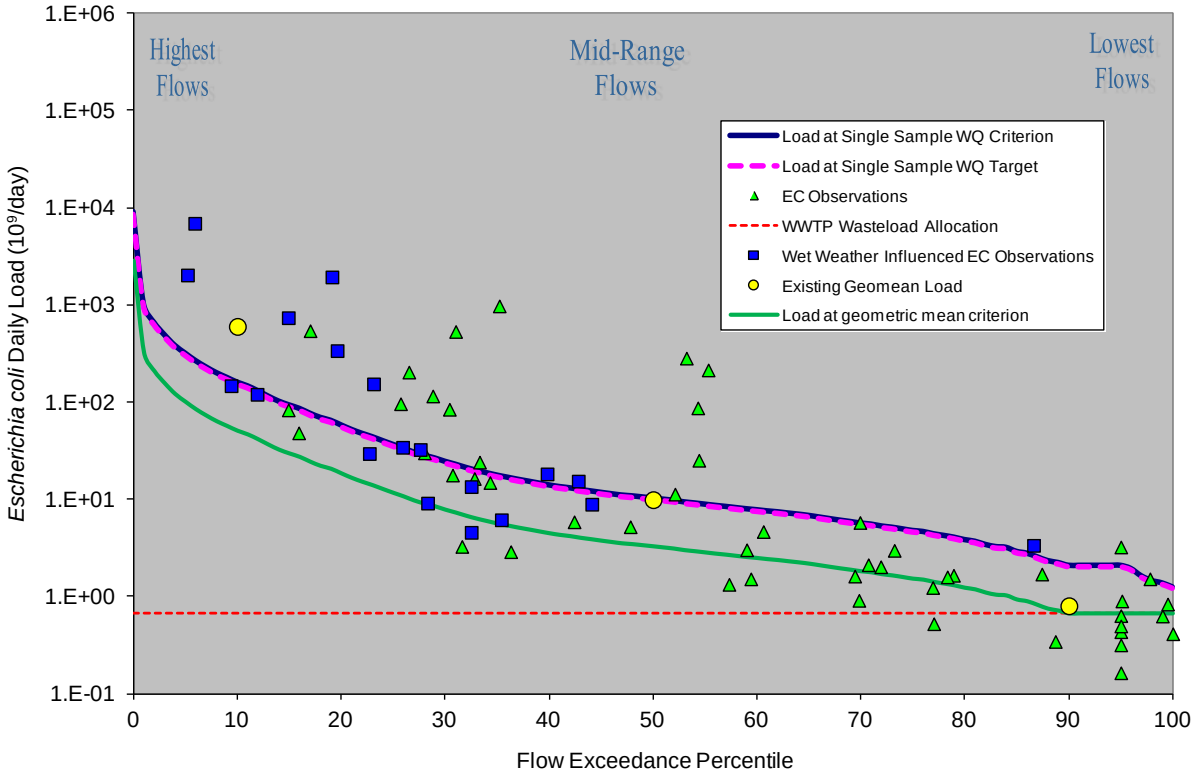


Figure 6. Load Duration Curve for Vogel Creek (1017C_01)

Wasteload Allocation

The wasteload allocation (WLA) is the sum of loads from regulated sources.

WWTFs

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their permitted discharge flow rate multiplied by one-half the instream geometric mean water quality criterion. One-half of the water quality criterion is used as the target to provide instream and downstream load capacity, and to provide consistency with other TMDLs developed in the Houston area.

Table 9 summarizes the WLA for the TPDES-permitted facility within the Study Area. WLAs were established for the facilities throughout the Buffalo and White-oak Bayous watersheds in the original TMDL document and its subsequent Water Quality Management Plan (WQMP) updates. This facility is being assigned to a specific subwatershed in this addendum.

Table 9. Wasteload Allocations for TPDES-Permitted Facilities

Assess-ment Unit	Stream Name	TPDES Number	NPDES Number	Facility Name	Final Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/day)
1017C_01	Vogel Creek	11005-001	TX0020095	Champ's Water Company, W. Montgomery Subdivision-WWTP	0.28	0.668

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_{SW}). 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_{SW} 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_{SW}. 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 probability that increased or additional flows from WWTFs may occur in Vogel Creek, a provision for future growth was included in the

TMDL calculations by estimating permitted flows to year 2035 using population projections completed by H-GAC.

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 TMDLs in this document will result in protection of existing beneficial uses and conform to Texas's antidegradation policy.

TMDL Calculations

Table 10 summarizes the estimated maximum allowable load of *E. coli* for the AU included in this project.

The final TMDL allocation required to comply with the requirements of 40 CFR 130.7 is summarized in Table 11. In this table, the future capacity for WWTF has been added to the WLA_{WWTF}.

TMDL values and allocations in Table 11 are derived from calculations using the existing water quality criteria for *E. coli*. However, designated uses and water quality criteria for these water bodies 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 10. *E. coli* TMDL Summary Calculations for Vogel Creek (1017C_01)

All loads expressed as Billion MPN/day

TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$[c]	LA[d]	MOS[e]	Future Growth[f]
51.4	0.668	48.1	0	2.57	0.0534

[a] *Maximum allowable load for the highest flow range (0 to 20th 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 11. Final TMDL Allocations

All loads expressed as Billion MPN/day

Assessment Unit	TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$	LA	MOS
1017C_01	51.4	0.721	48.1	0	2.57

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

[b] $WLA_{WWTF} = WLA_{WWTF} + Future\ Growth$

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 the TMDL by using more than five years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing historical bacteria concentrations collected in the warmer months against those collected during the cooler months. Analysis of available *E. coli* data showed no significant difference.

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 <http://www.tceq.texas.gov/permitting/wqmp/WQmanagement_comment.html>, and the document will be posted at <http://www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. The technical support document for this project is posted on the TMDL project page at <http://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.

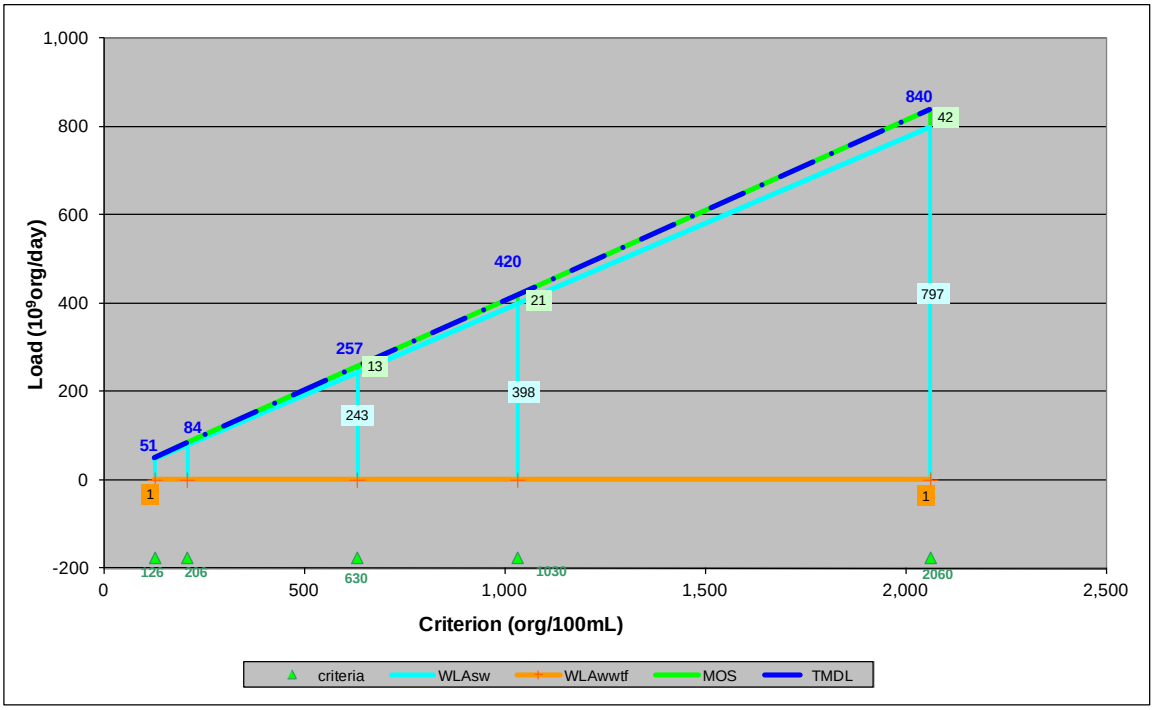


Figure 7. Allocation Loads for AU 1017C_01 as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations

$$TMDL = 0.4079*Std$$
$$LA = 0$$
$$WLA_{WWTF} = 63*0.011 = 1$$
$$WLA_{STORM\ WATER} = 0.3875*Std-0.7212$$
$$MOS = 0.05*TMDL$$

Where:

WLA_{WWTF} = waste load allocation (permitted WWTF)
$WLA_{STORM\ WATER}$ = waste load allocation (permitted storm water)
LA = load allocation (non-permitted source contributions)
Std = Revised Contact Recreation Standard
MOS = Margin of Safety

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