Clear Creek TMDLs: Bacteria

- **Nine TMDLs Adopted September 2008**
  Approved by EPA March 2009
- **Four TMDLs Added by Addendum October 2012**
  Approved by EPA March 2013

(Publication follows this title sheet)

Prepared by the:
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Addendum One to Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries

Four Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries

For Segments 1101A, 1101C, 1101E, and 1102G
Assessment Units 1101A_01, 1101C_01, 1101E_01, and 1102G_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted the total maximum daily loads (TMDLs) *Nine Total Maximum Daily Loads for Bacteria in Clear Creek and Tributaries: Segments 1101, 1101B, 1101D, 1102, 1102A, 1102B, 1102C, 1102D, and 1102E* (TCEQ 2008) on 9/10/2008. The TMDLs were approved by the United States Environmental Protection Agency (EPA) on 3/6/2009. This document represents an addendum to the original TMDL document.

This addendum includes information specific to four additional segments located within the watershed of the approved TMDL project for bacteria in Clear Creek. Concentrations of indicator bacteria in these segments exceed the criteria used to evaluate attainment of the contact recreation standard. This addendum presents the new information associated with the four additional segments. For background or other explanatory information for these four segments, please refer to *Technical Support Document: Bacteria Total Maximum Daily Loads for the Clear Creek Watershed, Houston, Texas (1101A_01, 1101C_01, 1101E_01, and 1102G_01)* (University of Houston 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 all of these TMDLs. This addendum focuses on the subwatersheds of the additional segments. These areas, including permitted facilities within them, were addressed in the original TMDL. This addendum provides the details related to developing the TMDL allocations for these additional segments, which were not addressed individually in the original document. These segments are also covered by an implementation plan (I-Plan) that has been drafted by stakeholders in the greater Houston area. This I-Plan addresses many watersheds, including Clear Creek's.

Problem Definition

The TCEQ first identified the bacteria impairments to the segments and assessment units (AUs) included in this addendum in the year 2010 Texas Water Quality Inventory and 303(d) List (Table 1). The impaired AUs are Magnolia Creek (1101A_01), Cow Bay-

ou (110C_01), the Unnamed Tributary of Clear Creek Tidal (1101_01), and the Unnamed Tributary of Mary's Creek (1102G_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 all TMDLs 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, and Enterococci is the preferred indicator bacteria is saltwater.

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

Magnolia Creek (Segment 1101A_01): The single sample criteria for *E. coli* and Enterococci were exceeded in 55 percent and 100 percent of the samples, respectively at the only WQM station location within this subwatershed. The geometric mean criteria for both *E. coli* and Enterococci were also exceeded.

Cow Bayou (Segment 1101C_01): The single sample criteria for *E. coli* and Enterococci were exceeded in 50 percent of the samples at the only WQM station location within this subwatershed. The geometric mean criteria for both *E. coli* and Enterococci were also exceeded.

Unnamed Tributary of Clear Creek Tidal (Segment 1101E_01): The single sample criterion for Enterococci was exceeded in 100 percent of the samples at the only WQM station location within this subwatershed. The geometric mean criterion for Enterococci was also exceeded.

Unnamed Tributary of Mary's Creek (Segment 1102G_01): The single sample criterion for *E. coli* was exceeded in 33 percent of the samples collected at the only WQM station location within this subwatershed. The geometric mean criterion for *E. coli* was also exceeded.

Watershed Overview

The Clear Creek watershed encompasses approximately 180 square miles of land located just southeast of the City of Houston, Texas. The Clear Creek watershed is part of the San Jacinto-Brazos Coastal Basin. Based on data for the period 1999 to 2009, the entire watershed rainfall average is around 54.6 inches per year. Average values by subwatershed are summarized in Table 3.

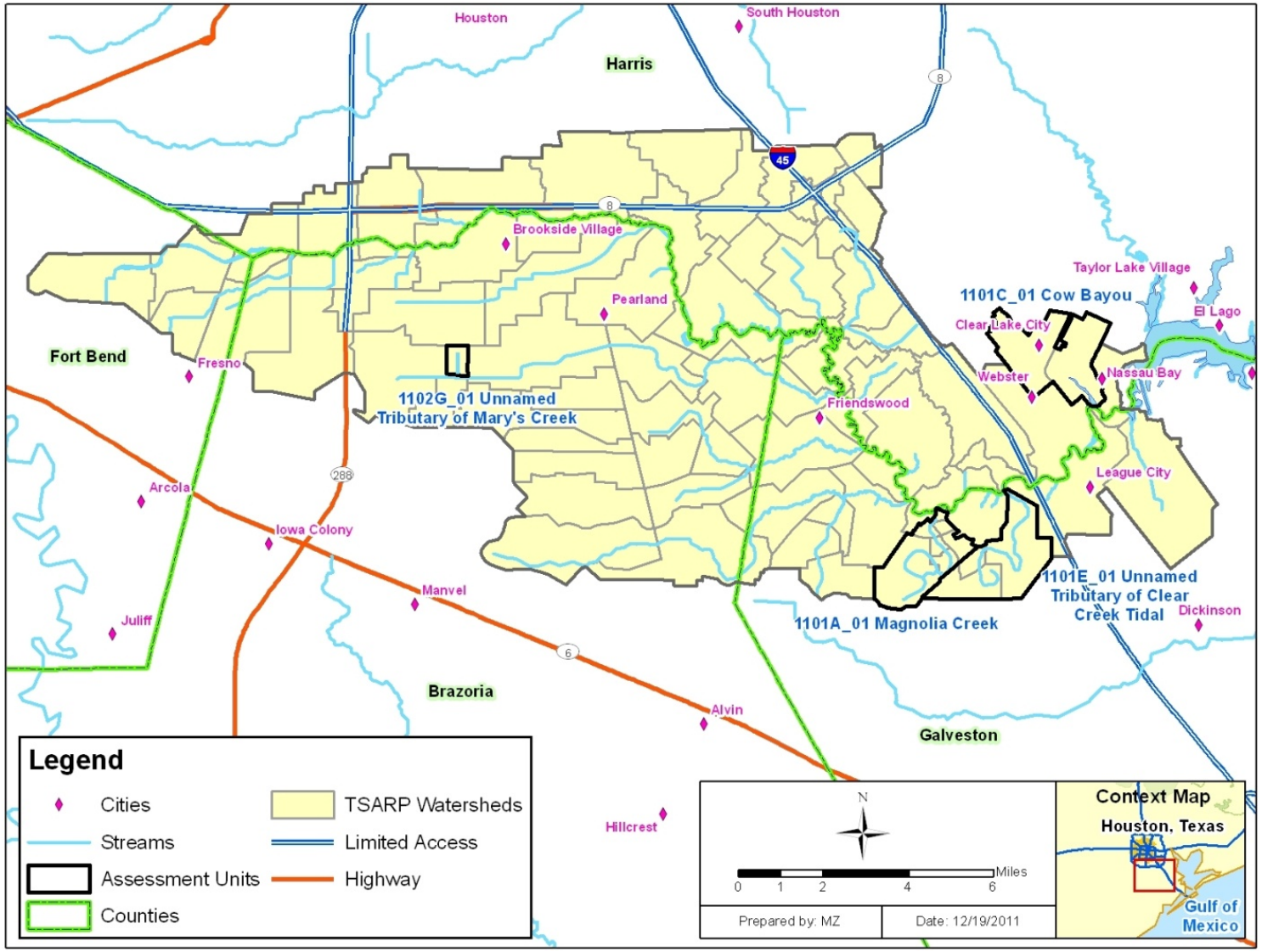


Figure 1. Clear Creek Watershed [a]

[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 Clear Creek Watershed

Segment ID	Segment Name	Parameter	Contact Recreation Use	Year Impaired	Category	Stream Length (miles)
1101A_01	Magnolia Creek	E. coli *	Nonsupport	2010	5a	4.8
1101C_01	Cow Bayou	ENT	Nonsupport	2010	5a	2
1101E_01	Unnamed tributary of Clear Creek Tidal	ENT	Nonsupport	2010	5a	1.9
1102G_01	Unnamed tributary of Mary's Creek	E. coli	Nonsupport	2010	5a	0.75

* *Magnolia Creek is tidally influenced, but has relatively low salinity levels— hence, the selection of* E. coli *as its bacteria indicator.*

Table 2. Water Quality Data for TCEQ Stations from 2002 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
1101A_01	16611	EC	548	31	17	55%
		ENT	2,721	26	26	100%
1101C_01	17928	EC	424	20	10	50%
		ENT	99	26	13	50%
1101E_01	18818	ENT	4,658	26	26	100%
1102G_01	18636	EC	326	15	5	33%

MPN: Most Probable Number; EC: E. coli, *ENT: Enterococci*

Geometric Mean Criteria: 126 MPN/100 ml for EC, 35 MPN/100 ml for ENT.

Single Sample Criteria: 399 MPN/100 ml for EC, 104 MPN/100 ml for ENT.

Green indicates the indicator bacteria selected as water quality target for each segment.

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

Segment Name	Segment ID	Average Annual (Inches)
Magnolia Creek	1101A_01	55.26
Cow Bayou	1101C_01	54.10
Unnamed Tributary of Clear Creek Tidal	1101E_01	55.20
Unnamed Tributary of Mary's Creek	1102G_01	50.25

Table 4 summarizes the acreages and the corresponding percentages of the land use categories for the contributing watershed associated with each subwatershed in the Clear Creek 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 each 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 these subwatersheds is developed land (between 54% and 99%) followed by pasture/hay (between 0% and 25%) and woody land (between 0% and 13%). Open water and bare/transitional land account for less than 3 percent of the subwatersheds.

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 TMDLs for freshwater segments is to maintain concentrations below the geometric mean criterion of 126 MPN/100 mL for *E. coli*. The freshwater segment is the Unnamed Tributary of Mary's Creek. The water quality target for the TMDLs for tidal (saltwater) segments is to achieve concentrations of Enterococci below the geometric mean criterion of 35 MPN/100 mL. The tidal segments are Magnolia Creek, Cow Bayou, and the Unnamed Tributary of Clear Creek Tidal. (While Magnolia Creek is tidally influenced, it has relatively low salinity levels and *E. coli* is its bacteria indicator.) Maintaining the geometric mean criterion for each 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. TMDLs will be based on bacteria allocations required to meet the geometric mean criterion.

Source Analysis

Regulated Sources

Two subwatersheds in the Study Area, Magnolia Creek (1101A_01) and the Unnamed Tributary of Mary's Creek (1102G_01), have National Pollutant Discharge Elimination System (NPDES)/Texas Pollutant Discharge Elimination System (TPDES)-permitted sources. A significant portion of the Study Area 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. There are no NPDES-permitted Concentrated Animal Feeding Operations (CAFOs) within the Study Area.

The two TPDES-permitted facilities that continuously discharge wastewater to surface waters addressed in these TMDLs are listed in Table 5 and shown in Figure 3. In addition, a third wastewater treatment facility (WWTF; City of League City, Southwest Water Reclamation Facility) has been permitted and is being built. There are no WWTFs located in Cow Bayou (1101C_01) or the Unnamed Tributary of Clear Creek Tidal (1101E_01) subwatersheds.

Table 4. Aggregated Land Use Summaries by Segment

Aggregated Land Use Category	1101A_01	1101C_01	1101E_01	1102G_01
Acres of Developed	1,018	2,030	1,873	222
Acres Cultivated Land	88	0	5	0
Acres Pasture/Hay	464	392	60	0
Acres Grassland/Herbaceous	48	70	80	1
Acres of Woody Land	254	92	229	0
Acres of Open Water	9	25	25	0
Acres of Wetland	13	3	67	0
Acres of Bare/Transitional	0	3	1	0
Watershed Area (acres)	1,894	2,614	2,340	224
Percent Developed	54%	78%	80%	99%
Percent Cultivated Land	5%	0%	0%	0%
Percent Pasture/Hay	25%	15%	3%	0%
Percent Grassland/Herbaceous	3%	3%	3%	0%
Percent Woody Land	13%	4%	10%	0%
Percent Open Water	0%	1%	1%	0%
Percent Wetland	1%	0%	3%	0%
Percent Bare/Transitional	0%	0%	0%	0%

Table 5. TPDES-Permitted Facilities in the Study Area

Segment	Receiving Water	TPDES Number	NPDES NUMBER	Facility Name	Facility Type	Permitted Flow (MGD)
1101A_01	Magnolia Creek	10568-003	TX0071447	City of League City	Sewerage Systems	0.66
1101A_01	Magnolia Creek	10568-008	TX0133043	City of League City; Southwest Water Reclamation Facility	Sewerage Systems	12
1102G_01	Unnamed Tributary of Mary's Creek	12332-001	TX0086118	Brazoria County Mud No. 3	Sewerage Systems	2.4

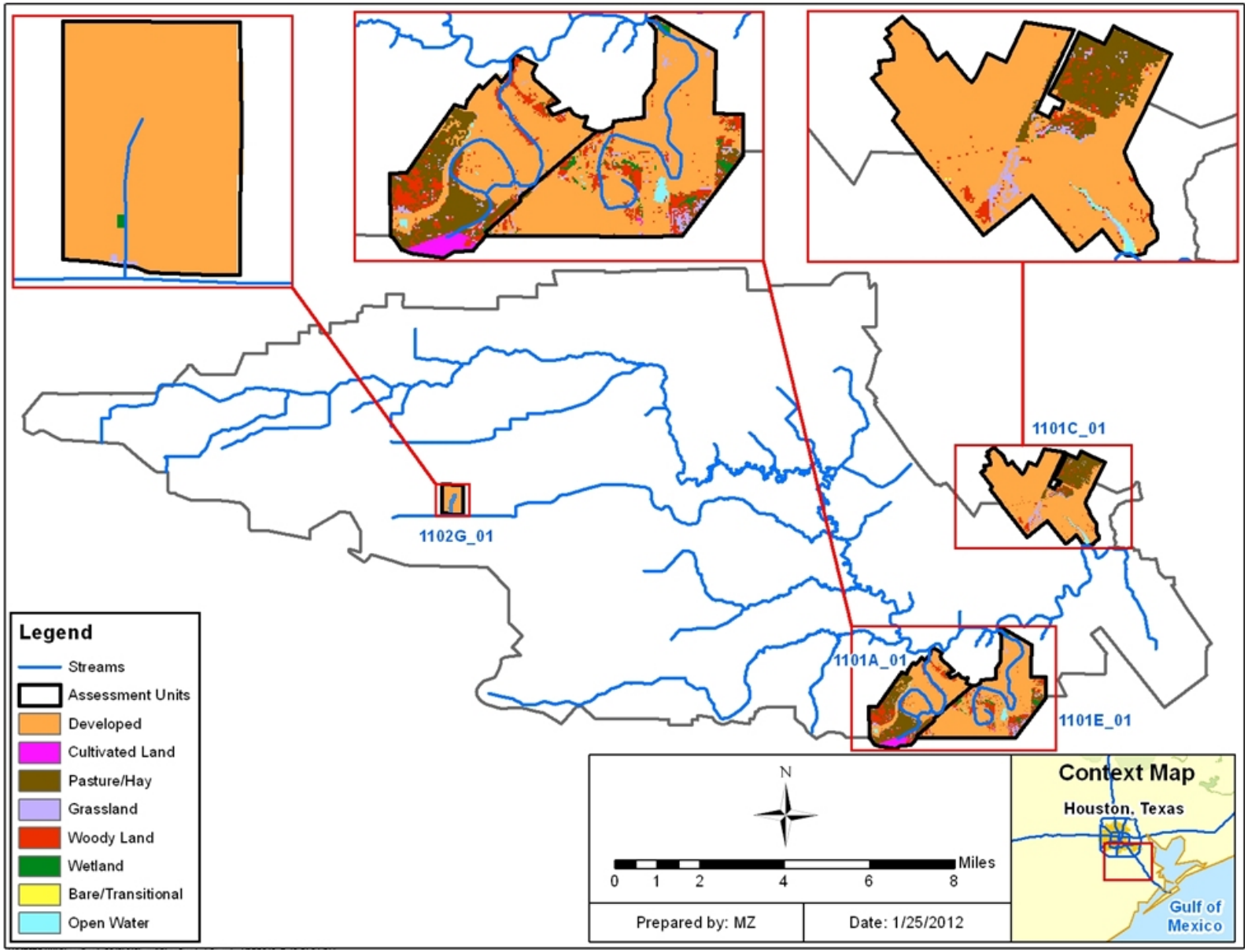
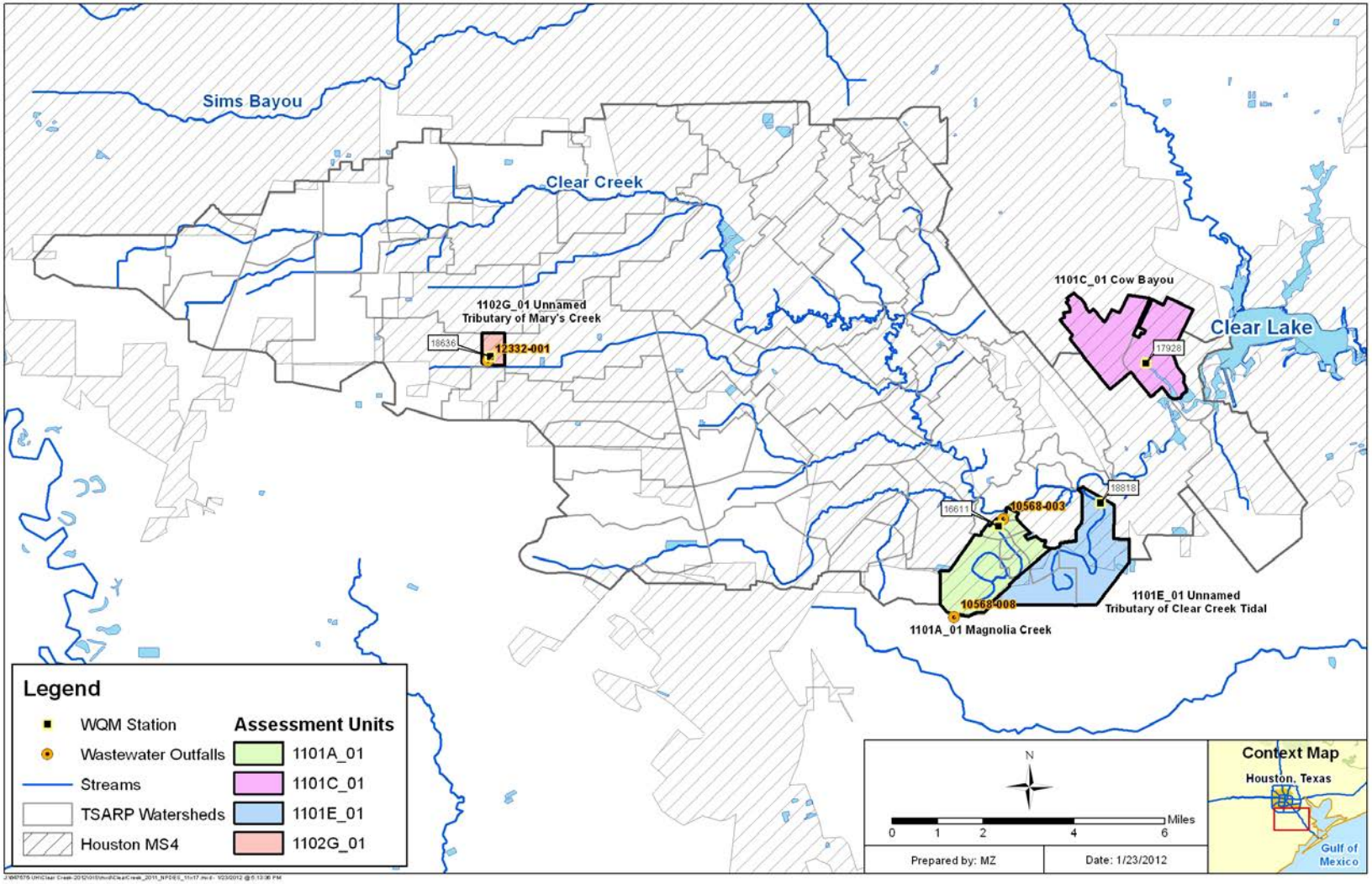


Figure 2. Land Use for Project Subwatersheds



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 Facilities in the Clear Creek Watershed

Sanitary Sewer Overflows

TCEQ Region 12-Houston provided two database queries for sanitary sew 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 Clear Creek watershed (Rice 2005). These data are included in Table 6. As can be seen from Table 6, there were three sanitary sewer overflows reported in the Unnamed Tributary of Clear Creek Tidal (1101E_01) in February 2004. The SSOs were caused by a collapsed line. 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 specific subwatersheds in this addendum.

Table 6. Sanitary Sewer Overflow (SSO) Summary

Facility Name	NPDES Permit No.	Facility ID	Date	Amount (Gallons)	Location
City of League City	TX0085618	10568-005	2/11/2004	500	2316 Colonial Ct. N
City of League City	TX0085618	10568-005	2/11/2004	600	2130 Savannah Ct N
City of League City	TX0085618	10568-005	2/11/2004	NA	1009 Newport

NA: Not Available

TPDES-Regulated Stormwater

Considerable portions of each subwatershed in the Study Area are covered under the City of Houston County municipal separate storm sewer system (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. Table 7 lists the percentage of area within each subwatershed covered under the Houston MS4 permit.

Table 7. Percentage of Permitted Stormwater in each Subwatershed

Segment	Receiving Stream	TPDES Number	Total Area (acres)	Area under MS4 Permit (Acres)	Percent of Subwatershed under MS4 Jurisdiction
1101A_01	Magnolia Creek	WQ0004685000	1,894	1,894	100%
1101C_01	Cow Bayou	WQ0004685000	2,613	2,613	100%
1101E_01	Unnamed Tributary of Clear Creek Tidal	WQ0004685000	2,340	990	42%
1102G_01	Unnamed Tributary of Mary's Creek	WQ0004685000	220	220	100%

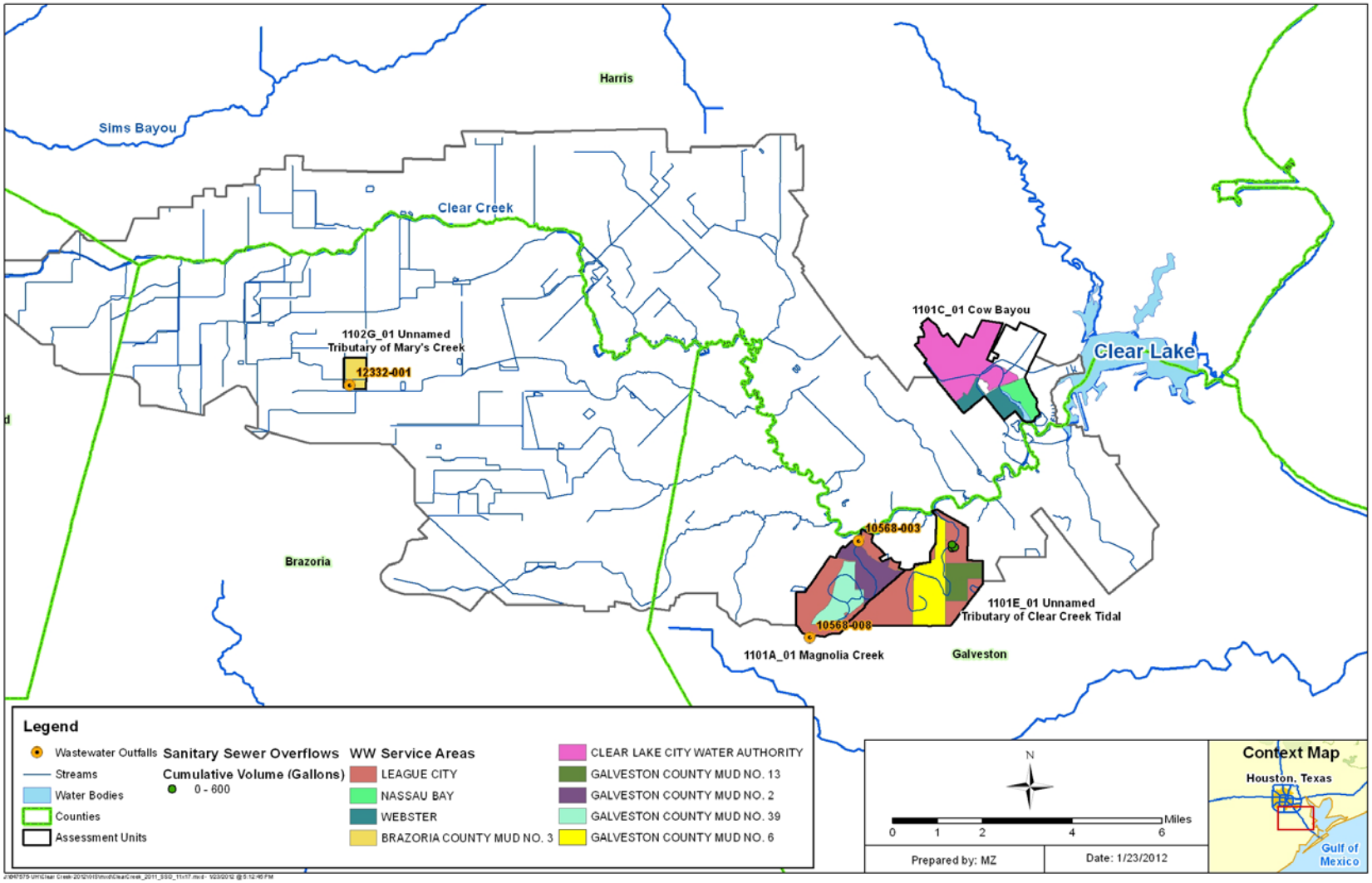


Figure 4. Locations of Sanitary Sewer Overflows

Stormwater runoff sampling was conducted in May and July 2006 to estimate the potential magnitude of loading from stormwater in the Study Area. Samples were collected at the mouths of the tributaries in response to significant rainfall in the project area. Significant rainfall events were defined as those that produced discharge of stormwater runoff into the study segments. Sampling was initiated as soon as possible on the rising limb of the hydrograph. Samples were collected during two storm events at nine locations, only two of which are located in the subwatersheds addressed in this addendum.

Detailed data from stormwater sampling are presented in Table 8. These data were used to estimate stormwater loads discharged from Magnolia Creek (Segment 1101A_01) and the Unnamed Tributary of Clear Creek Tidal (1101E_01). Table 8 summarizes the geometric mean of the bacteria loads at Stations 16611 and 18818. The loads for these stormwater sources were accounted for in the original TMDL document. They are being assigned to specific subwatersheds in this addendum.

Table 8. Bacteria Loading from Stormwater

WQM Station ID	Tributaries	1st Storm Sampling Geomean of Enterococci Load (Billion MPN/day)	2nd Storm Sampling Geomean of Enterococci Load (Billion MPN/day)
16611	Magnolia Creek	2,270	34,400
18818	Unnamed Tributary of Clear Creek Tidal	367	56.9

*Note: Orange (top row) indicates **maximum** load; Green (bottom row) indicates **minimum** load.*

Unregulated Sources

Pollutants from unregulated sources enter the impaired AUs 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.

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

Table 9 provides estimated numbers of selected livestock by subwatershed based on the 2002 USDA county agricultural census data (USDA 2002). The county-level estimated livestock populations were distributed among subwatersheds based on geographic information system (GIS) calculations of pasture land per subwatershed, based on the Texas 2005 C-CAP Land Cover Data (NOAA 2007). If subwatersheds were located in multiple counties, then the agricultural numbers were calculated separately by county and then summed for the entire subwatershed. Because the subwatersheds are generally much smaller than the counties, and livestock are not evenly distributed across counties or constant with time, these are estimates only. Cattle are the most abundant species of

livestock in the Study Area, and often have direct access to the water bodies or their tributaries. Livestock numbers and their contributions to bacteria loadings in the Clear Creek watershed are expected to decrease over time as more land is converted from grazing to developed, urban uses. The livestock number estimates were accounted for in the original TMDL document. They are being assigned to specific subwatersheds in this addendum.

Table 9. Livestock Estimates by Subwatershed

Segment	Stream Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chickens & Turkeys
1101A_01	Magnolia Creek	668	1	109	10	19	17	155
1101C_01	Cow Bayou	609	7	111	13	12	11	95*
1101E_01	Unnamed Tributary of Clear Creek Tidal	832	1	135	12	23	21	193
1102G_01	Unnamed Tributary of Mary's Creek	78	0	5	1	5	1	1*

**Chicken data incomplete due to county agricultural census data withheld to avoid disclosing data for individual farms.*

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 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 each subwatershed. Finally, the OSSFs for each unsewered area were then totaled by TMDL subwatershed. This approach gives an estimate of OSSFs in the subwatershed. Table 10 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 specific subwatersheds in this addendum.

H-GAC provided additional OSSF data for select portions of the Study Area (H-GAC 2005). There are three existing OSSFs in the Unnamed Tributary of Clear Creek Tidal subwatershed area and two existing OSSFs in the Magnolia Creek subwatershed, with low failure occurrences, as shown in Table 10. The subwatersheds that have been identified as having OSSFs are shown in Figure 5.

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 each subwatershed.

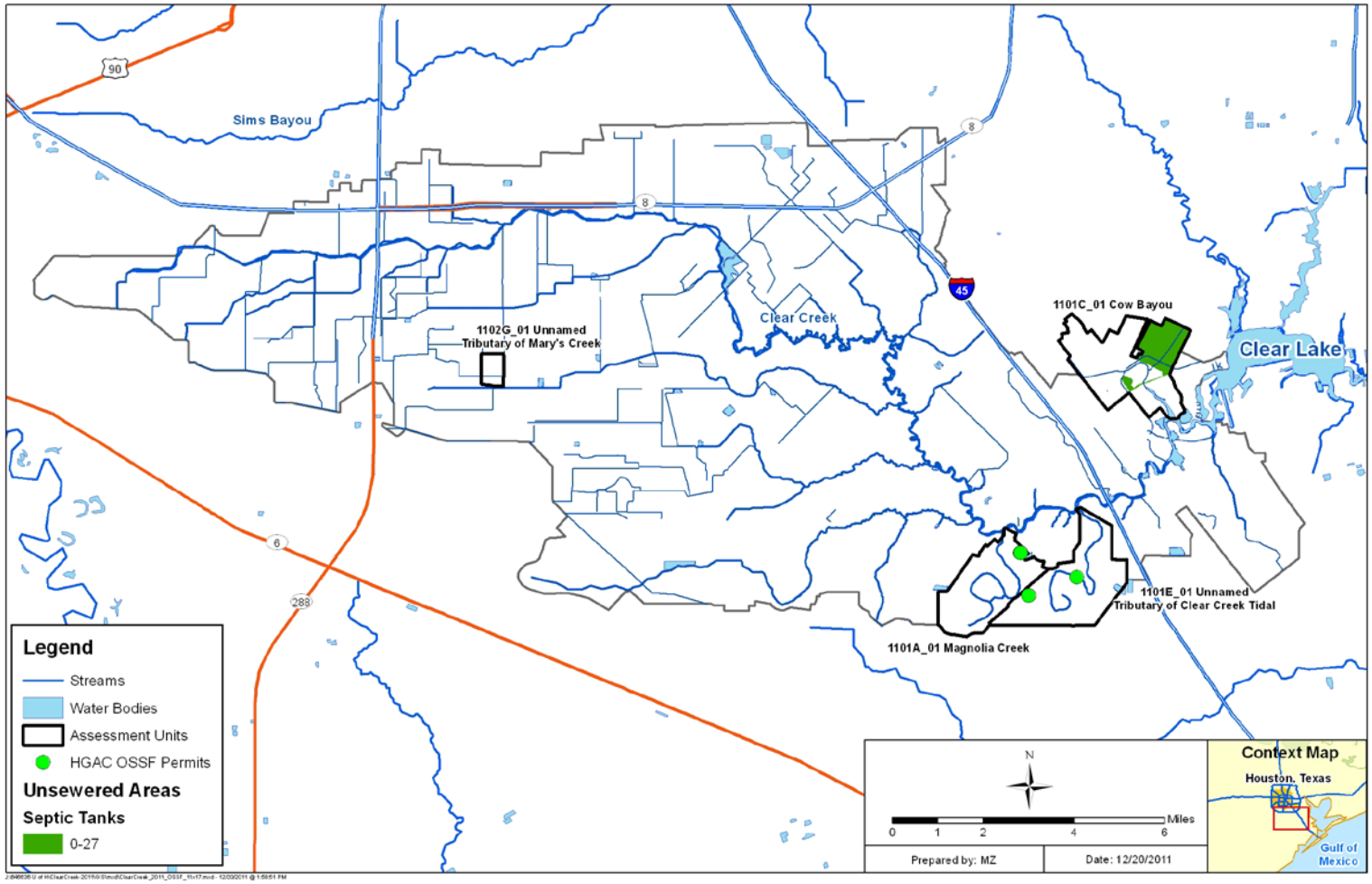


Figure 5. Unsewered Areas and Subdivisions with OSSFs

Fecal coliform loads were estimated using the following equation (USEPA 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 subwatersheds was summarized below in Table 10. 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 10. 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)
1101A_01	Magnolia Creek	0	2	0.24	2
1101C_01	Cow Bayou	27	0	3.24	24
1101E_01	Unnamed Tributary of Clear Creek Tidal	0	3	0.36	3
1102G_01	Unnamed Tributary of Mary's Creek	0	0	0	0

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 11 summarizes the estimated number of dogs and cats for the subwatersheds 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 specific subwatersheds in this addendum.

Table 11. Estimated Numbers of Pets

Segment	Stream Name	Dogs	Cats
1101A_01	Magnolia Creek	5,530	6,239
1101C_01	Cow Bayou	1,400	1579
1101E_01	Unnamed Tributary of Clear Creek Tidal	1,598	1,802
1102G_01	Unnamed Tributary of Mary's Creek	521	588

Linkage Analysis

Two methods of analysis were used for analyzing indicator bacteria loads and instream water quality. Load duration curve (LDC) analyses (including flow duration curve (FDC) analyses) were used for the freshwater segments. A mass balance analysis was used for the tidal segments. The Technical Support Document has details about these analyses.

Margin of Safety

The TMDL for the freshwater segment 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 explicit MOS was used because of the limited amount of data. 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 an MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced. The TMDL for the freshwater stream in this report incorporates an explicit MOS in the LDC by using 95 percent of the single sample criterion. For the tidal segments, the MOS was also explicit. But in this case, the MOS was based on allowable loading, not concentration. After the tidal prism model calculated the total assimilative capacity for Enterococci (the TMDL), 5 percent of the allowable load was computed as the MOS.

Pollutant Load Allocation

Pollutant load allocations for the tidally influenced segments were developed using the tidal prism (mass balance) method. Pollutant load allocations for the freshwater segments were developed using analysis of FDCs and the LDC method.

To establish the subwatershed targets, TMDL calculations and associated allocations are established for the most-downstream sampling locations in each subwatershed. This establishes a distinct TMDL for each 303(d) listed water body.

To calculate the bacteria load at the criterion for the freshwater segment (Unnamed Tributary of Mary's Creek (1102G_01)), 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.

For the tidal streams, the maximum allowable load at the criterion is calculated as the sum of the input loads that result in attainment of the water quality criteria for the reaches in the tidal prism model.

To estimate existing loading in the Unnamed Tributary of Mary's Creek (1102G_01), bacteria observations from 2000 to 2010 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 the Unnamed Tributary of Mary's Creek (1102G_01) 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 the Unnamed Tributary of Mary's Creek (1102G_01) and is based on *E. coli* bacteria measurements at sampling location 18636 (Unnamed Tributary Of Mary's Creek Downstream of Thalerfield Drive). The LDC indicates that *E. coli* levels exceed the instantaneous and geometric mean water quality criteria under highest flows and lowest flow conditions. Wet weather influenced *E. coli* observations are found under high and mid-ranged 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).

Existing Enterococci loads to the TMDL tidal segments are summarized in Table 12. The estimated existing loads are calculated as the sum of runoff, tributary, and WWTF loads to model reaches used in developing the TMDLs for the tidal segments. For Magnolia Creek, the Enterococci load was converted to *E. coli* using the tidal prism model, as that is the preferred bacteria indicator for this segment.

The pollutant load allocations for these subwatersheds were included in the allocations in the original TMDL document. They are being assigned to specific subwatersheds in this addendum.

Table 12. Estimated Existing Enterococci Loads to TMDL Tidal Segments

Segment	Receiving Stream	Enterococci Load (Billion MPN/day)
1101A_01	Magnolia Creek (Reach N and Magnolia Creek above Tidal)	2,880
1101E_01	Unnamed Tributary of Clear Creek Tidal (Reach Q and Non-tidal portion of Unnamed Tributary to Clear Creek Tidal)	2,340
1101C_01	Cow Bayou (Reach R and Cow Bayou above Tidal)	3,430

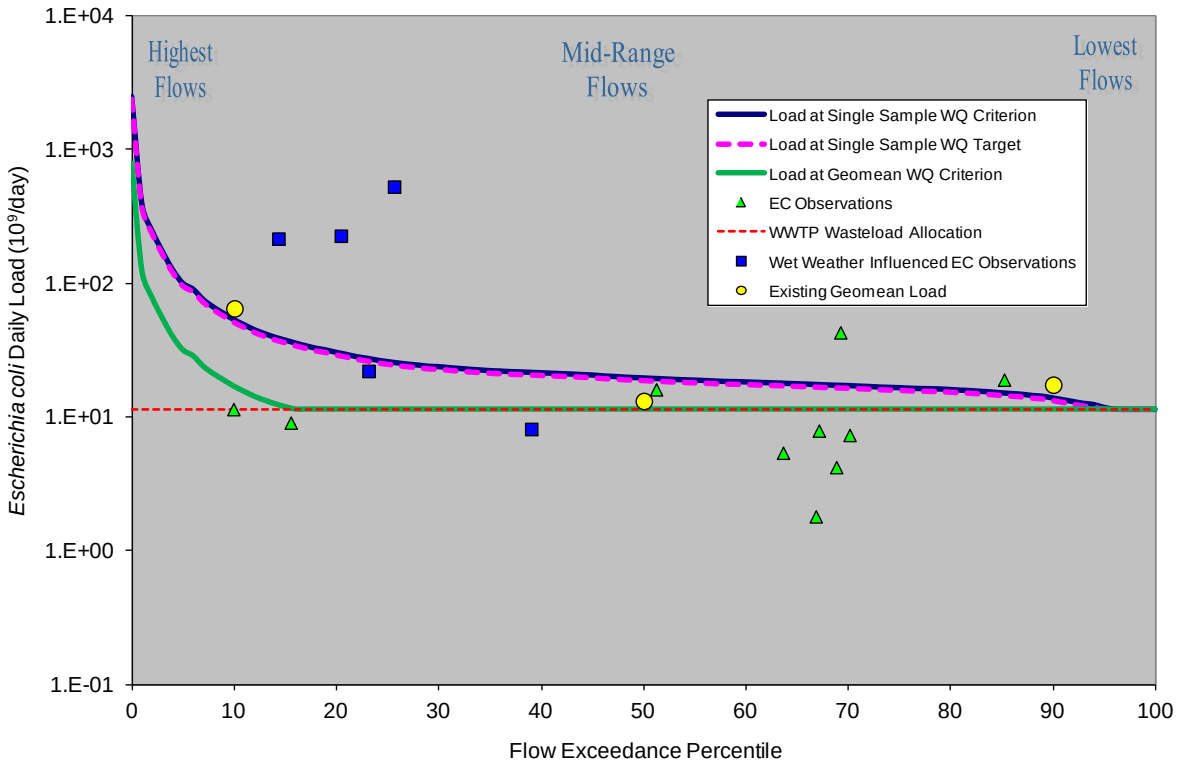


Figure 6. Load Duration Curve for the Unnamed Tributary of Mary's Creek (1102G_01)

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 the instream geometric mean water quality criterion. In other words, the facilities are required to meet instream criteria at their points of discharge.

Table 13 summarizes the WLA for the TPDES-permitted facilities within the Study Area. The WWTFs will not be subject to all listed indicator bacteria. WLAs were established for these facilities in the original TMDL document and its subsequent Water Quality Management Plan (WQMP) updates. They are being assigned to specific subwatersheds in this addendum.

Table 13. Wasteload Allocations for TPDES-Permitted Facilities

	Magnolia Creek (1101A_01)	Magnolia Creek (1101A_01)	Unnamed Tributary of Mary's Creek (1102G_01)
TPDES Number	10568-003	10568-008	12332-001
NPDES NUMBER	TX0071447	TX0133043	TX0086118
Facility Name	City of League City	City of League City, Southwest Water Reclamation WWTP	Brazoria County Mud No. 3
Final Permitted Flow (MGD)	0.66	12.0	2.4
***E. coli* (Billion MPN/day)**	3.15	57.2	11.4
Enterococci (Billion MPN/day)	0.874	15.9	N/A

N/A = not applicable

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 these TMDLs due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of each 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}.

Load Allocation

The LA is the sum of loads from unregulated sources.

Allowance for Future Growth

To account for the high probability that new additional flows from WWTF may occur in any of the segments, 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.

The three-tiered antidegradation policy in the Standards 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 14 summarizes the estimated maximum allowable load of *E. coli* for the freshwater AU included in this project.

For the tidal stream segments, Table 15 summarizes the estimated maximum allowable loads of Enterococci that will ensure the contact recreation standard is met. These are calculated from the tidal prism model using total existing loading (WWTFs, runoff and tributaries) to the water body (Table 12). Table 15 includes WLA, LA, and MOS calculations. Because the listing for Magnolia Creek is based on *E. coli*, the Enterococci allocations calculated using the tidal prism model were converted to *E. coli* using the 0.34 Enterococci/ *E. coli* ratio.

The final TMDL allocations required to comply with the requirements of 40 CFR 130.7 are summarized in Table 16. In this table, the future capacity for WWTF has been added to the WLA_{WWTF}.

TMDL values and allocations in Table 16 are derived from calculations using the existing water quality criteria for *E. coli* and Enterococci. However, designated uses and water quality criteria for these water bodies are subject to change through the TCEQ standards revision process. Figures 7 through 10 were 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 Figures 7 through 10 allow calculating new TMDLs and pollutant load allocations based on any potential new water quality criteria for *E. coli* and Enterococci.

Table 14. E. coli TMDL Summary Calculations for Unnamed Tributary of Mary's Creek (1102G_01)

All loads expressed as Billion MPN/day

TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$[c]	LA[d]	MOS[e]	Future Growth[f]
48.8	11.4	9.27	0	2.44	25.7

[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 (*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*conversion factor*

Table 15. TMDL Calculations for Tidal Segments

All loads expressed as Billion MPN/day

Segment	Stream Name	Indicator	TMDL[a]	WLA_{WWTF}[c]	$WLA_{STORMWATER}$[d]	LA[f]	MOS[g]	$TMDL_{Future}$[b]	$WLA_{WWTF-Future}$[e]
1101A_01	Magnolia Creek (Reach N)	ENT	95.0	16.8	73.5	0	4.75	99.4	4.41
	Magnolia Creek above Tidal)	*EC*[h]	*279*	*49.3*	*216*	*0*	*14.0*	*292*	*13.0*
1101E_01	Unnamed Tributary of Clear Creek Tidal (Reach Q and Non-tidal portion of Un-named Tributary to Clear Creek Tidal)	ENT	16.4	N/A*	6.54	9.04	0.82	16.4	N/A*
1101C_01	Cow Bayou (Reach R and Cow Bayou above Tidal)	ENT	720	N/A*	684	0	36.0	720	N/A*

[a] *Sum of WWTF, stormwater runoff, and tributary loads discharging directly to the WQ segment that result in attainment of the geometric mean criterion*

[b] *Sum of WWTF with projected permitted flows for 2050, stormwater runoff, and tributary loads discharging directly to the WQ segment that result in attainment of the geometric mean criterion*

[c] *Sum of loads from the WWTF discharging to the segment. Individual loads are calculated as permitted flow*35 counts/dL*conversion factor*

[d] $WLA_{STORMWATER} = (TMDL - MOS - WLA_{WWTF})$**percent of drainage area covered by MS4 permits*

[e] *Difference between* $TMDL_{Future}$ *and the TMDL*

[f] $LA = TMDL - MOS - WLA_{WWTF} - WLA_{STORMWATER}$

[g] *MOS = 0.05*TMDL*

[h] *Because the listing for segment 1101A_01 is based on* E. coli, *the ENT allocations calculated using the tidal prism model were converted to EC using the 0.34 ENT/EC ratio.*

* *N/A – Allocation not applicable at this time. New WWTF must comply with* WLA_{WW}

Table 16. Final TMDL Allocations

All loads expressed as Billion MPN/day

Assessment Unit	Indicator	TMDL[a]	WLA_{WWTF}[b]	$WLA_{STORMWATER}$	LA	MOS
1102G_01	EC	48.8	37.1	9.27	0	2.44
1101A_01	EC	292	62.3	216	0	14.0
1101E_01	ENT	16.4	N/A	6.54	9.04	0.82
1101C_01	ENT	720	N/A	684	0	36.0

[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 these TMDLs 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 available data for *E. coli* and Enterococci from two stations showed higher geometric mean concentrations for the cooler months than the warmer months.

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/WQmanagement_updates.html>.

Implementation and Reasonable Assurance

The four segments covered by this addendum are within the existing Clear Creek Bacteria TMDL project watershed. The Clear Creek watershed is within the area covered by the Implementation 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.

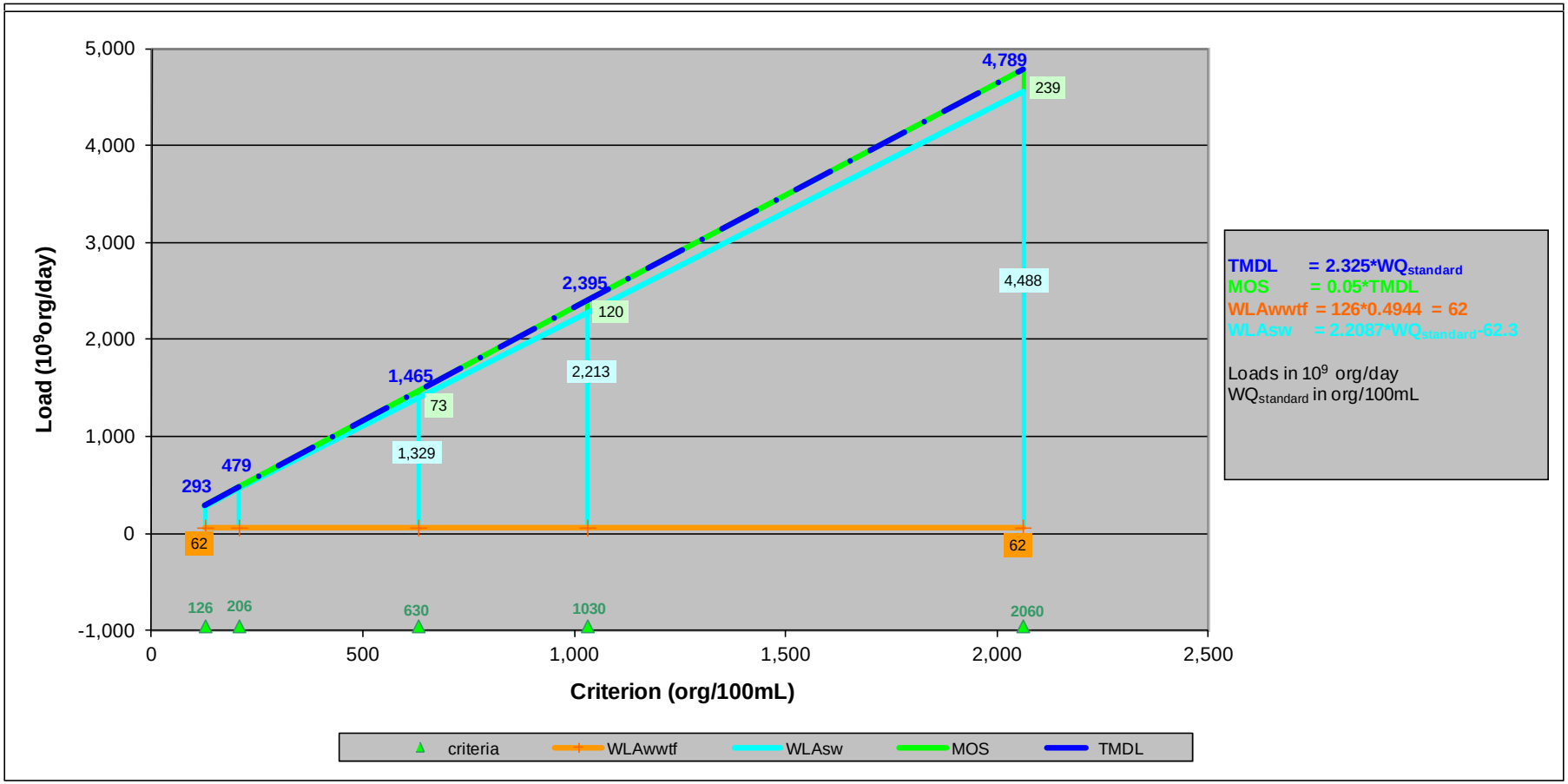


Figure 7. Allocation Loads for AU 1102G_01 as a Function of *E. coli* WQ Criteria

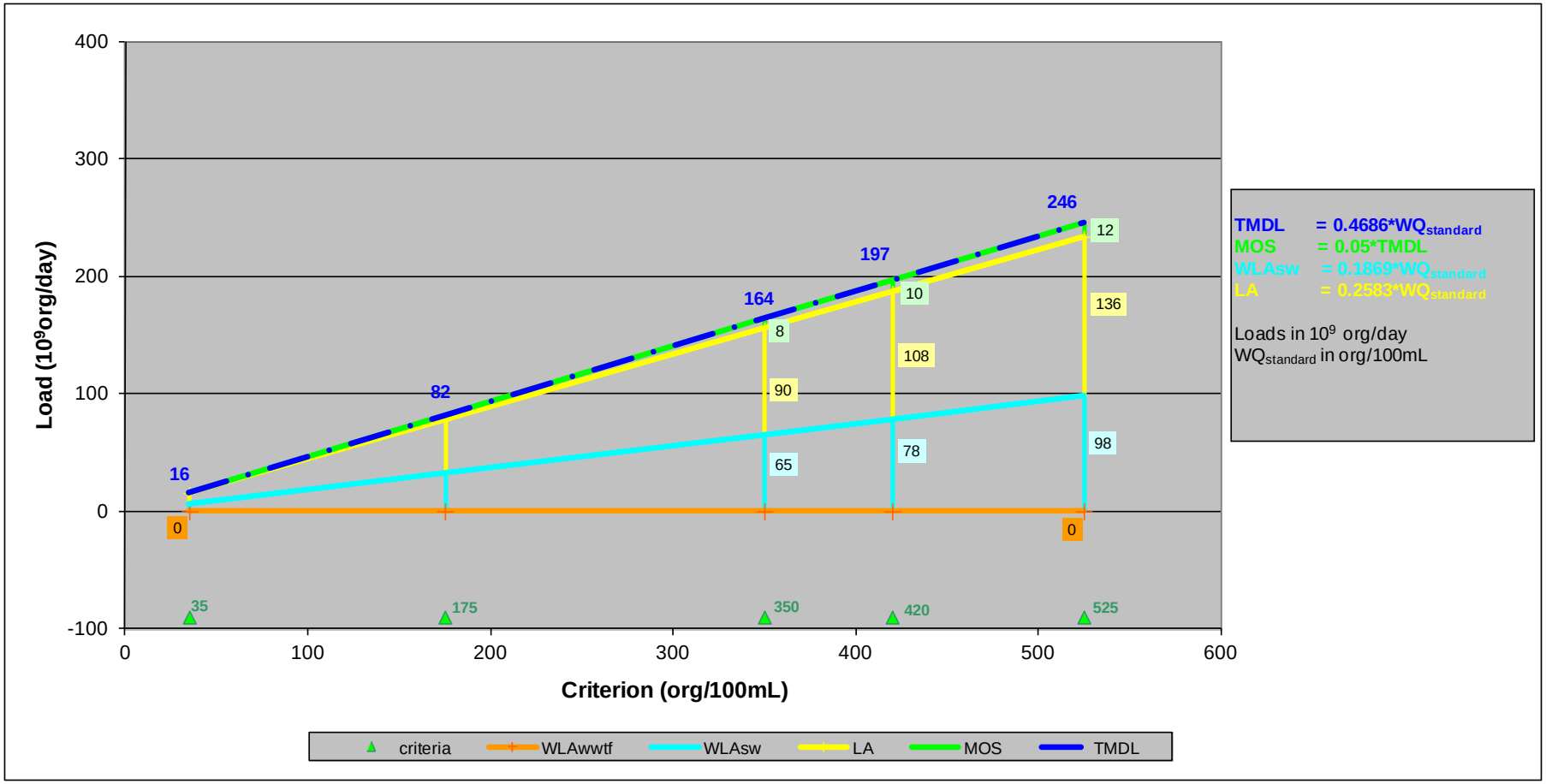


Figure 8. Allocation Loads for AU 1101A_01 as a Function of *E. coli* WQ Criteria

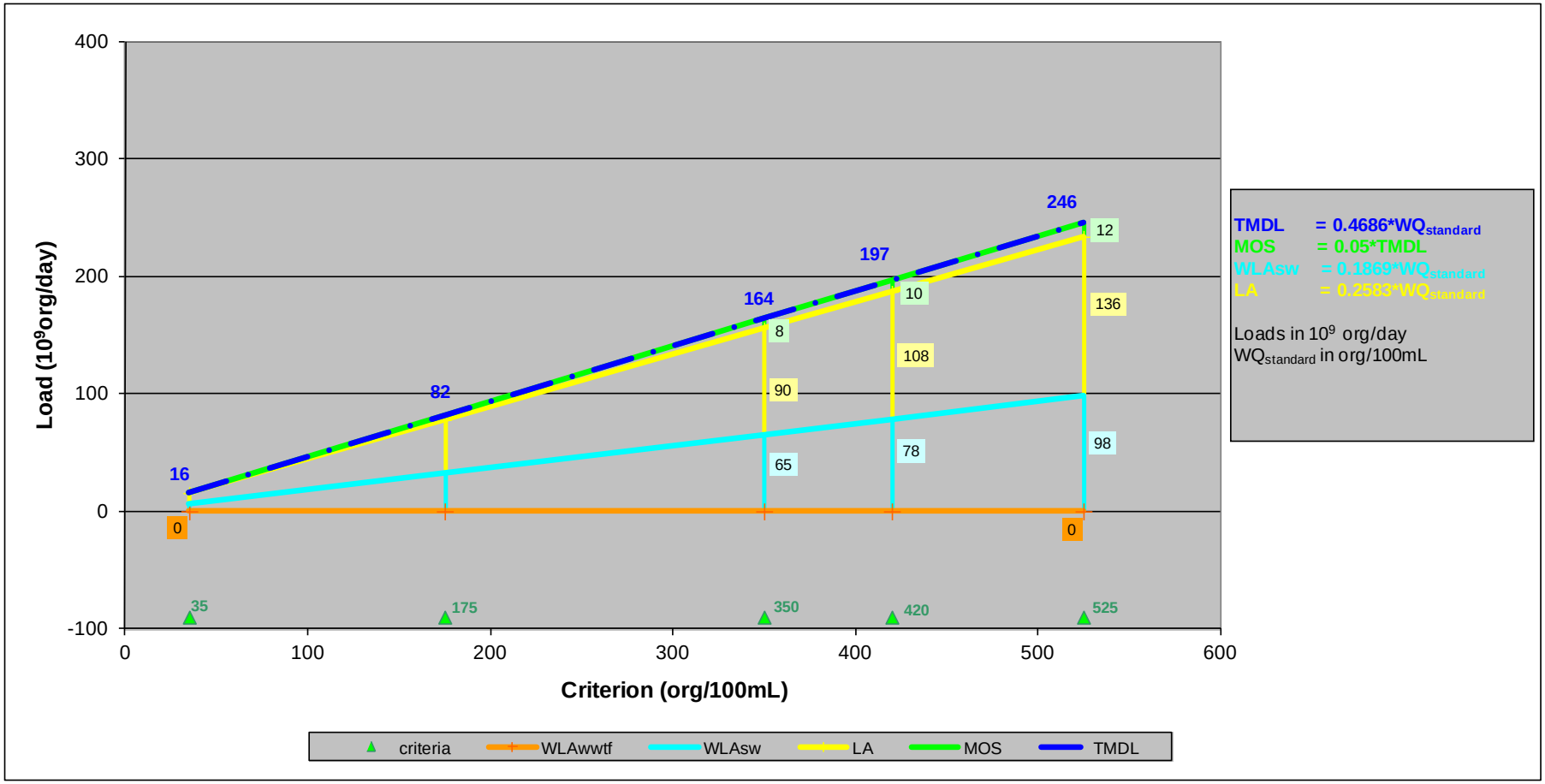


Figure 9. Allocation Loads for AU 1101E_01 as a Function of Enterococci WQ Criteria

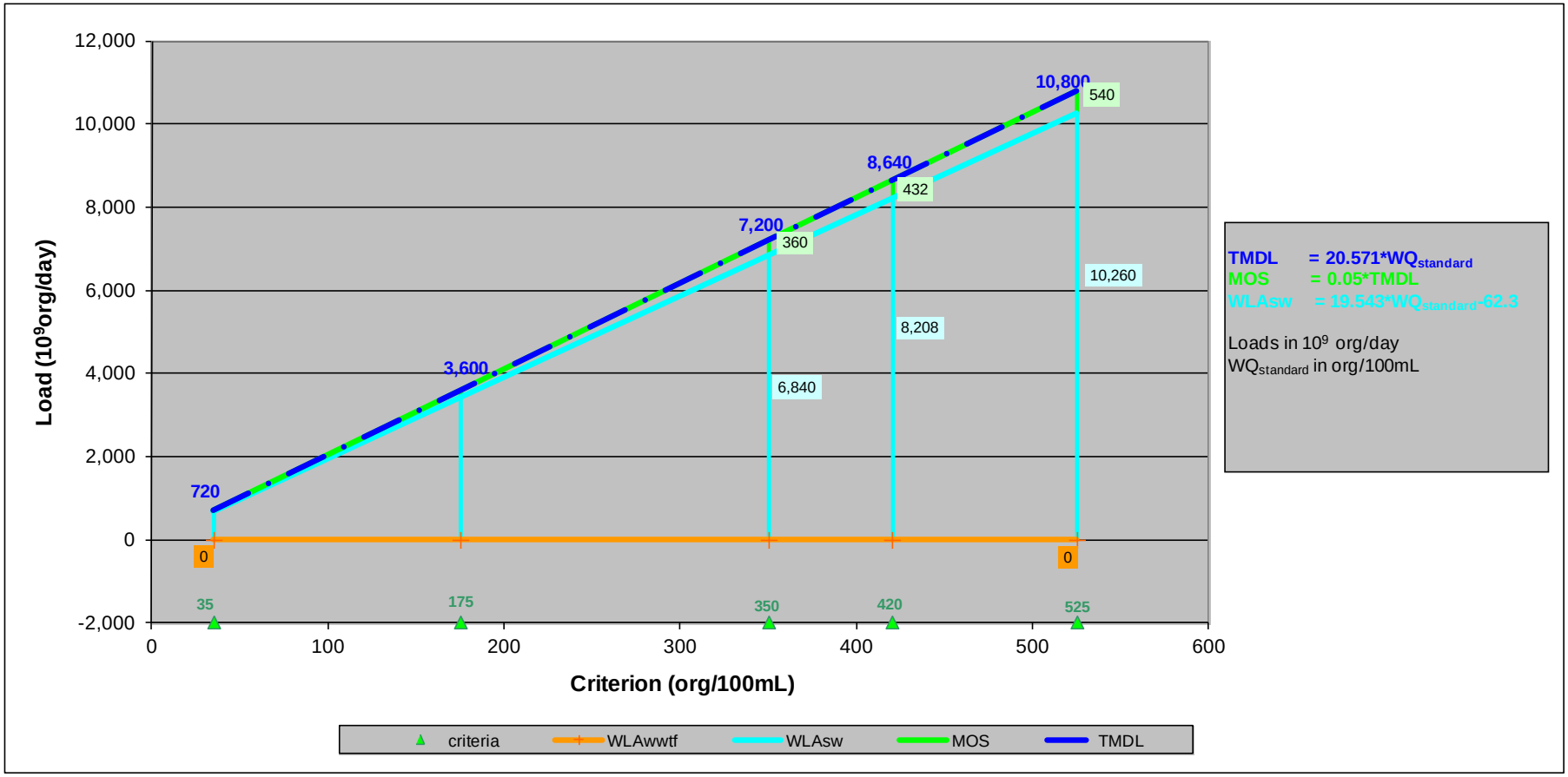


Figure 10. Allocation Loads for AU 1101C_01 as a Function of Enterococci WQ Criteria

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