Adopted August 14, 2019

Two Total Maximum Daily Loads for Indicator Bacteria in Lavaca River Above Tidal and Rocky Creek

Segments 1602 and 1602B

Assessment Units 1602_03 and 1602B_01

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Texas Commission on Environmental Quality
MC-203
P.O. Box 13087
Austin, Texas 78711-3087
E-mail: tmdl@tceq.texas.gov

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"Technical Support Document for Total Maximum Daily Loads for Indicator Bacteria in the Lavaca River Above Tidal and Rocky Creek"
prepared by the Texas Water Resources Institute.

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Abbreviations

AU	assessment unit
BMP	best management practice
CFR	Code of Federal Regulations
cfu	colony-forming units
cfs	cubic feet per second
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
FDC	flow duration curve
FG	future growth
I&I	inflow and infiltration
I-Plan	implementation plan
IRNR	Institute of Renewable Natural Resources
GIS	Geographic Information System
LA	load allocation
LDC	load duration curve
mL	milliliter
MGD	million gallons per day
MOS	margin of safety
MPN	most probable number
MS4	municipal separate storm sewer system
MSGP	Multi-Sector General Permit
NASS	National Agriculture Statistic Service
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
RMU	Resource Management Unit
SSO	sanitary sewer overflow
SSURGO	Soil Survey Geographic
SWQM	surface water quality monitoring
TAC	Texas Administrative Code

TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USCB	United States Census Bureau
USDA	United State Department of Agriculture
USGS	United States Geological Survey
WCID	Water Control and Improvement District
WLA	wasteload allocation
WQBEL	water quality-based effluent limits
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Two TMDLs for Indicator Bacteria in the Lavaca River Above Tidal and Rocky Creek

Executive Summary

This document describes total maximum daily loads (TMDLs) for the freshwater segments Lavaca River Above Tidal and Rocky Creek (Segments 1602 and 1602B), where concentrations of indicator bacteria exceed the criteria used to evaluate attainment of the contact recreation use standard. The Texas Commission on Environmental Quality (TCEQ) first identified the impairments to the Lavaca River Above Tidal (Segment 1602) in the *2008 Texas Water Quality Inventory and 303(d) List* and Rocky Creek (Segment 1602B) in the *2014 Texas Integrated Report of Surface Water Quality for the federal Clean Water Act Sections 305(b) and 303(d)*.

Two assessment units (AUs) within the two segments are impaired:

- Lavaca River Above Tidal (AU 1602_03)
- Rocky Creek (AU 1602B_01)

The Lavaca River watershed is located along the Texas Gulf Coast primarily in the counties of Lavaca, Jackson, and DeWitt (although portions of the watershed are in Gonzales, Fayette, Calhoun, and Victoria Counties). Rocky Creek, which begins in Gonzales County and runs into Lavaca County, flows into the Lavaca River Above Tidal below the city of Hallettsville, and then continues into Lavaca Bay. Both the Lavaca River Above Tidal and Rocky Creek are perennial freshwater streams (Figure 1).

Four wastewater treatment facilities (WWTFs) are located within the watershed of the Above Tidal portion of the Lavaca River (Segment 1602). These facilities exclusively treat domestic wastewater. Two (Moulton and Hallettsville) discharge into the above-tidal section of the Lavaca River, one (Shiner) discharges into Rocky Creek, and the other (Yoakum) discharges into Big Brushy Creek, which enters the above-tidal section of the Lavaca River.

No municipal separate storm sewer (MS4) permits are held in the Lavaca River Above Tidal watershed. A review of active stormwater general permits in the Lavaca River Above Tidal and Rocky Creek watersheds, as of September 22, 2017, found seven active construction notices of intent and twelve stormwater multi-sector general permit (MSGP) facilities. There are currently no Phase II

MS4s or petroleum bulk stations and terminal facilities in the watershed. Based on the low number of construction activities (minimal acreage disturbed) and stormwater MSGPs, regulated stormwater is considered to contribute minimally to the Lavaca River Above Tidal watershed.

Escherichia coli (*E. coli*) is widely used as an indicator bacteria to assess attainment of the contact recreation use in freshwater bodies, while *Enterococci* are used as the indicator bacteria in salt waters. *E. coli* is the relevant indicator for the Lavaca River Above Tidal segment and the Rocky Creek segment. The primary contact recreation use is not supported when the geometric mean of all *E. coli* samples exceeds 126 most probable number (MPN) per 100 milliliters (mL).

Recent environmental bacteria monitoring within the Lavaca River Above Tidal segment and Rocky Creek segment has occurred at four TCEQ monitoring stations within the watershed. *E. coli* data collected at these stations over the seven-year period of December 1, 2005 through November 30, 2012 were used in assessing attainment of the primary contact recreation use as reported in the Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d) (TCEQ, 2015a). The 2014 assessment data indicate nonsupport of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criteria of 126 colony forming units (cfu)/100 mL for *E. coli* in one AU within the Lavaca River Above Tidal segment and one AU within the Rocky Creek segment.

A load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria. The wasteload allocation (WLA) for WWTFs was established as the full permitted discharge flow rate multiplied by the instream geometric criterion (126 MPN/100mL). Future growth of existing or new domestic point sources was determined using population projections. The overall margin of safety (MOS) was incorporated by setting the bacteria load target five percent lower than the geometric mean criterion for primary contact recreation.

The TMDL calculations in this report will guide determination of the assimilative capacity of each water body under changing conditions, including future growth. Wastewater discharge facilities will be evaluated on a case by case basis.

The endpoint for the TMDL in this report is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 cfu/100 mL.

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a TMDL for each pollutant that contributes to the impairment of a listed water body. The TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

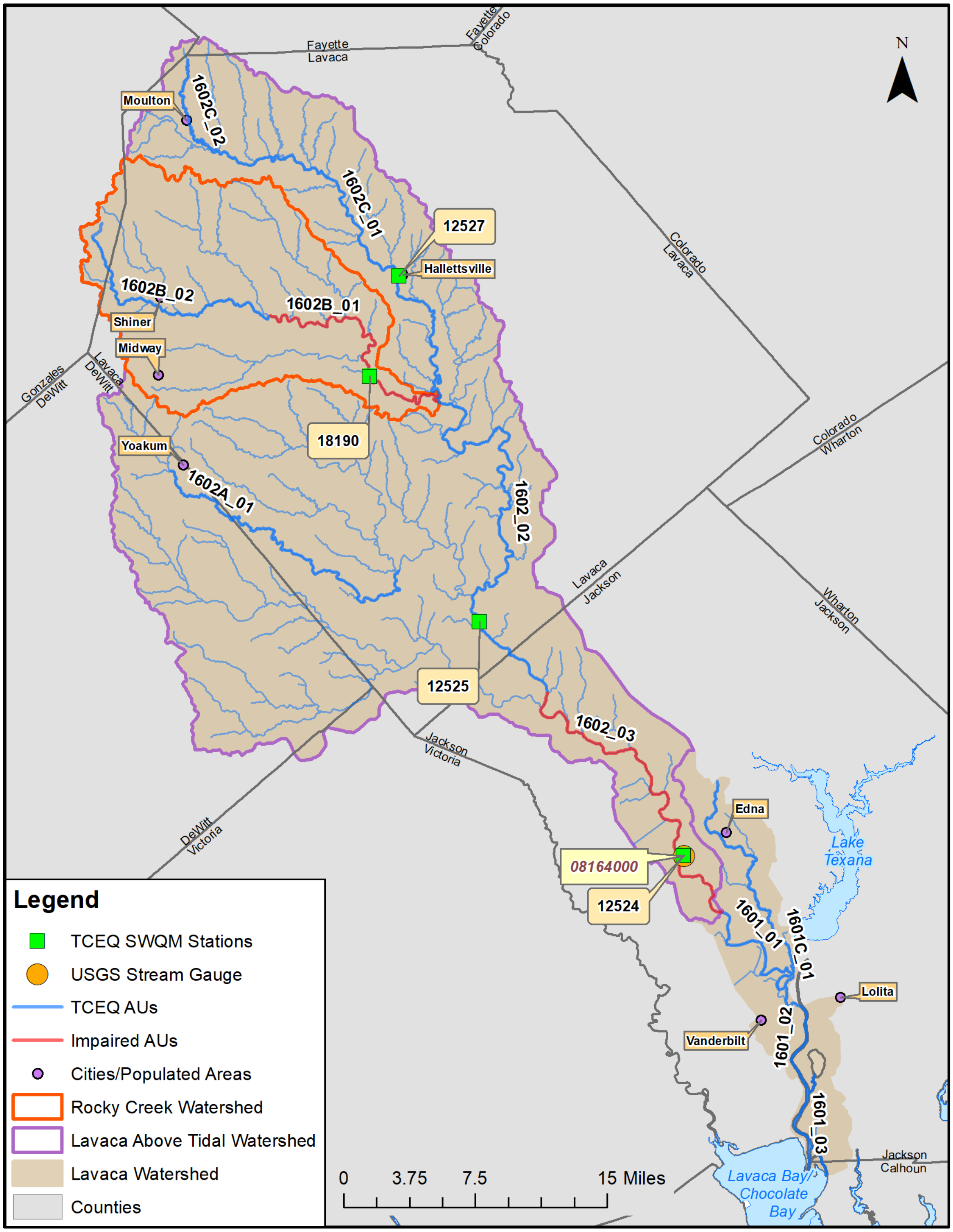

Figure 1. Overview map showing the total TMDL watershed area, including Segments 1602 and 1602B, and TCEQ surface water quality monitoring (SWQM) stations and United States Geological Survey (USGS) stream gauge

A TMDL is like a budget—it determines the amount of a particular pollutant that a water body can receive and still meet its applicable water quality standards. TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time, but may be expressed in other ways.

The TMDL Program is a major component of Texas' overall process for managing the quality of its surface waters. The program addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries (water bodies) in, or bordering on, the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses—such as drinking water supply, recreation, support of aquatic life, or fishing—of impaired or threatened water bodies.

These TMDLs address impairments to the primary contact recreation use due to indicator bacteria in two AUs of the Lavaca River Above Tidal (Segment 1602) and Rocky Creek (Segment 1602B). These TMDLs take a watershed approach to addressing the indicator bacteria impairment. While TMDL allocations were developed only for the impaired AUs identified in this report, the entire project watershed (Figure 1) and all WWTFs that discharge within it are included within the scope of these TMDLs.

Section 303(d) of the Clean Water Act and the implementing regulations of the United States Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations (40 CFR), Part 130 describe the statutory and regulatory requirements for acceptable TMDLs. The EPA provides further direction in its *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA, 1991). This TMDL document has been prepared in accordance with those regulations and guidelines.

The TCEQ must consider certain elements in developing a TMDL. They are described in the following sections of this report:

- Problem Definition
- Endpoint Identification
- Source Analysis
- Linkage Analysis
- Margin of Safety
- Pollutant Load Allocation
- Seasonal Variation
- Public Participation
- Implementation and Reasonable Assurance

Upon adoption of the TMDL report by the TCEQ and subsequent EPA approval, these TMDLs will become an update to the state's Water Quality Management Plan (WQMP).

Problem Definition

The TCEQ first identified the impairments to the Lavaca River Above Tidal (Segment 1602) in the *2008 Water Quality Inventory and 303(d) List*, and then in each subsequent edition of the *Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)* (Integrated Report). The impaired AU in the Lavaca River Above Tidal (Segment 1602) is 1602_03. The TCEQ first identified the impairments to Rocky Creek (Segment 1602B) in the 2014 Texas Integrated Report. The impaired AU in Rocky Creek (Segment 1602B) is 1602B_01.

Watershed Overview

The Lavaca River, located along the Texas Gulf Coast, is comprised of three segments — the most upstream segment is designated as the “Lavaca River Above Campbell Branch (Segment 1602C)”, the next segment is designated as “Lavaca River Above Tidal (Segment 1602)”, and the most downstream segment is designated as “Lavaca River Tidal (Segment 1601)”. The Lavaca River Above Tidal (Segment 1602) is a perennial freshwater stream, while the below tidal portion is influenced by saline water from Lavaca Bay. Rocky Creek (Segment 1602B) is a freshwater perennial stream that is a tributary of the Lavaca River and flows into the above tidal portion of the river downstream of the city of Hallettsville. This TMDL incorporates a watershed approach where the entire drainage area of these water bodies is considered (Figure 1). Throughout this document, the Lavaca River watershed (TMDL watershed), refers to the entire catchment area of the Lavaca River (Segment 1601), excluding the catchment area of the Navidad River (Segment 1603). The Lavaca River Above Tidal watershed is specified for the catchment area of the Lavaca River Above Tidal (Segment 1602) inclusive of Rocky Creek (Segment 1602B). The Rocky Creek watershed is specified for the catchment area of Rocky Creek (Segment 1602B). The Lavaca River TMDL watershed drains an area of approximately 909 square miles in Calhoun, DeWitt, Fayette, Gonzales, Jackson, Lavaca, and Victoria counties.

The Texas Integrated Report (TCEQ, 2105a) provides the following segment and AU descriptions for the water bodies considered in this document:

- Segment 1602: Lavaca River Above Tidal

  From a point 8.6 km (5.3 miles) downstream of US 59 in Jackson County to the confluence of Campbell Branch west of Hallettsville in Lavaca County.
  - Segment Type: Freshwater Stream
    - AU 1602_03 – Lower portion of segment from confluence with National Hydrography Dataset Reach Code 12100101002463 south of Edna in Jackson County upstream to confluence with Beard Branch.

- Segment 1602B: Rocky Creek

  Perennial stream from the confluence with the Lavaca River up to 1.0 km above FM 533 west of Shiner.
  - Segment Type: Freshwater Stream
    - AU 1602B_01 – From the confluence of Lavaca River upstream to confluence of Ponton Creek.

Ambient Indicator Bacteria Concentrations

Recent environmental bacteria monitoring for the Lavaca River in AU 1602_03 has occurred at one TCEQ monitoring station within the watershed — 12524 (Table 1 and Figure 1). Monitoring for Rocky Creek in AU 1602B_01 occurs at one TCEQ monitoring station — 18190 (Table 1 and Figure 1). *E. coli* data have been collected at these stations over the seven-year period of December 1, 2005 through November 30, 2012 and were used in assessing attainment of the primary contact recreation use as reported in the 2014 Texas Integrated Report (TCEQ, 2015a). The 2014 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criteria of 126 cfu/100 mL for *E. coli*.

Table 1. 2014 Integrated Report summary for the impaired AUs

The geometric mean criterion for primary contact recreation use is 126 cfu/100 mL for *E. coli*.

Water Body	Parameter	Data Date Range	Segment	AU	Stations	Number of Samples	Station Geometric Mean (cfu/100 mL)
Lavaca River Above Tidal	*E. coli*	12/2005-11/2012	1602	1602_03	12524	21	294.94
Rocky Creek	*E. coli*	12/2005-11/2012	1602B	1602B_01	18190	21	222.16

Watershed Climate and Hydrology

The Lavaca River watershed is located in the southern portion of the state of Texas, where the climate is classified as "Subtropical Humid" (Larkin & Bomar, 1983). The region's subtropical climate is caused by the "predominant onshore flow of tropical maritime air from the Gulf of Mexico," while the increasing moisture content (from west to east) reflects variations in "intermittent seasonal intrusions of continental air" (Larkin & Bomar, 1983). For the period from 1981 to 2010, average annual precipitation over the Lavaca River watershed was 41 inches (PRISM Climate Group at Oregon State University, 2012) (Figure 2).

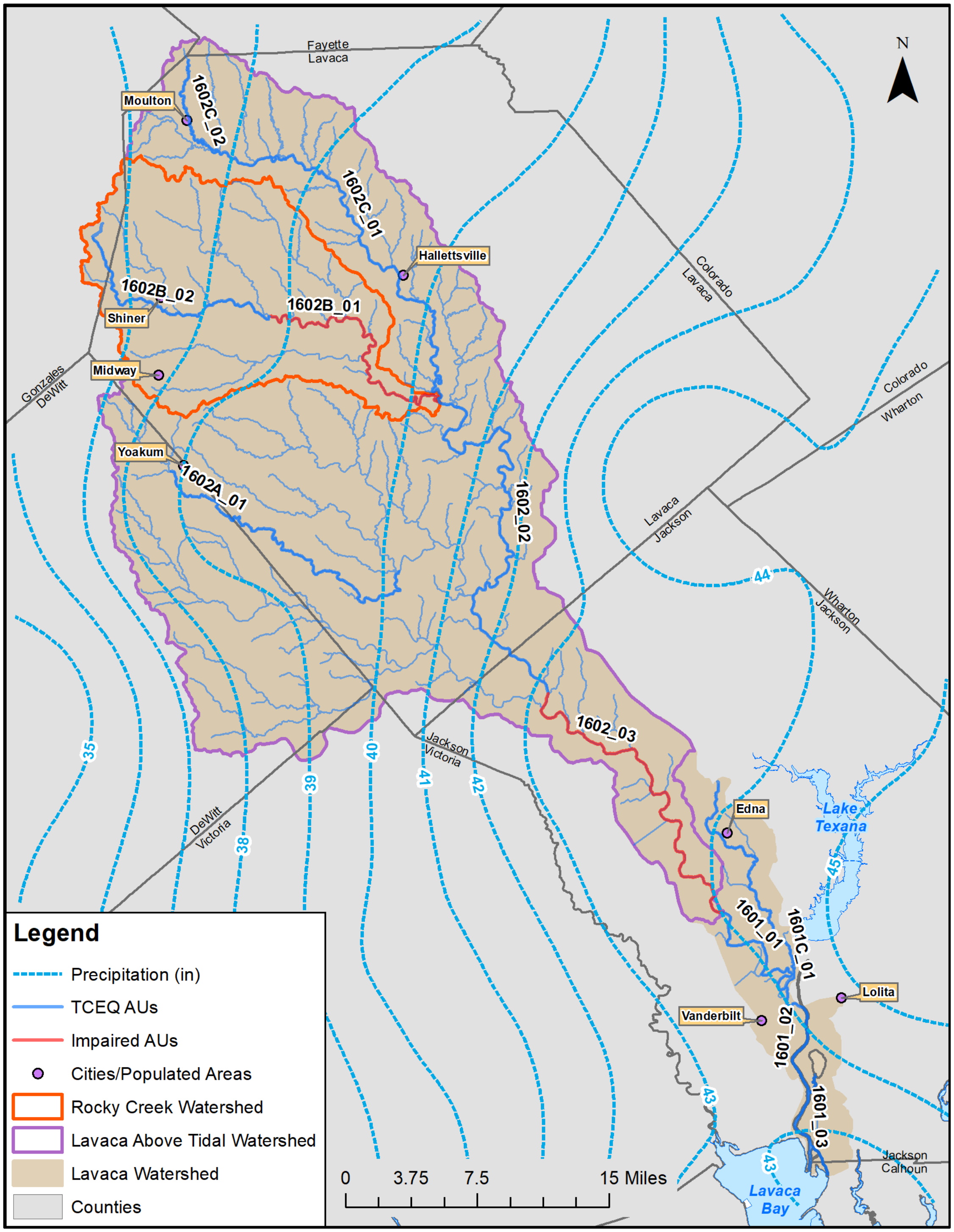

Figure 2. Annual average precipitation isohyets (in inches) in the Lavaca River watershed (1981-2010)

Source: PRISM Climate Group at Oregon State University (2012)

At the Victoria Regional Airport, average high temperatures generally peaked in August with an average temperature of 85˚F and a typical high of 94.5˚F; highs above 100˚F are not uncommon and have occurred from April through September. Fair skies generally accompany the highest temperatures of summer when nightly average lows drop to about 74˚F. During winter, the average low temperatures typically reach 45˚F in January; although below freezing temperatures have occurred from September through April. The wettest month is normally May (5.19 inches), and the driest month is normally February (2.08 inches), although some rainfall typically occurs year-round [National Oceanic and Atmospheric Administration (NOAA), 2015] (Figure 3).

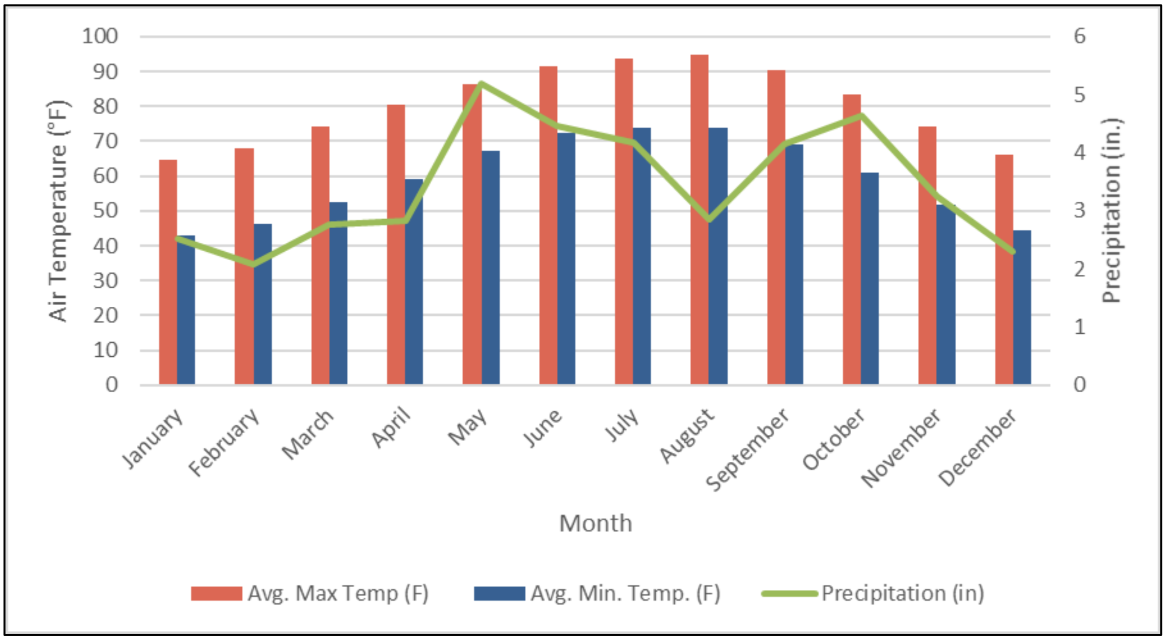

Figure 3. Average annual precipitation (in inches) and minimum and maximum temperatures for the Lavaca River watershed area (1981-2010)

Source: NOAA, 2015

Watershed Population and Population Projections

According to the 2010 Census, the Lavaca River watershed (including the Rocky Creek watershed) has a total population of 30,156 and a population density of about 33 people/square mile (Table 2 and Figure 4). The municipalities include Shiner, Hallettsville, Yoakum, and Edna. Population projections developed by the Office of the State Demographer and the Texas Water Development Board [(TWDB), 2014] indicate that the populations of the seven counties within the Lavaca River watershed are projected to increase, with the exception of Lavaca County (Table 3). Data in Table 2 were based on the US Census block population data for the portion of the county within the Lavaca River and Rocky Creek watersheds. Percent increase was determined by looking at projected population percent increases for the whole county and applying them to the specific population estimates within the watershed.

Table 2. 2010 population for the Lavaca River and Rocky Creek watershed

Source: Calculated from Census Blocks, United States Census Bureau [(USCB), 2010]

Watershed	Segment	2010 Census Population
Lavaca River (incl. Rocky Creek)	Above Tidal (1602) & Tidal (1601)	30,156
Lavaca River Above Tidal (incl. Rocky Creek)	Above Tidal (1602)	23,107
Rocky Creek	1602B	5,884

Calculations based on population projections developed by the Office of the State Demographer and the TWDB (2014) indicate that between 2010 and 2070, the populations of six counties in the Lavaca River watershed are expected to increase. Lavaca County, encompassing the majority of the watershed, is not expected to increase in population. Population percent increases range from zero percent to 68.93 percent (Table 3).

Table 3. Projected population growth for counties in the Lavaca River and Rocky Creek watersheds

Source: TWDB, 2014

County	2010	2020	2030	2040	2050	2060	2070	Percent Increase (2010-2070)
DeWitt	20,052	20,855	21,555	21,900	22,216	22,425	22,572	12.57%
Lavaca	19,263	19,263	19,263	19,263	19,263	19,263	19,263	0.00%
Jackson	14,002	14,606	15,119	15,336	15,515	15,627	15,699	12.12%
Fayette	24,397	28,373	32,384	35,108	37,351	29,119	40,476	65.91%
Calhoun	21,240	24,037	26,866	29,622	32,276	34,906	37,454	76.34%
Gonzales	19,686	21,751	23,921	25,963	28,330	30,738	33,256	68.93%
Victoria	86,410	93,857	100,260	105,298	109,785	113,470	116,522	34.85%

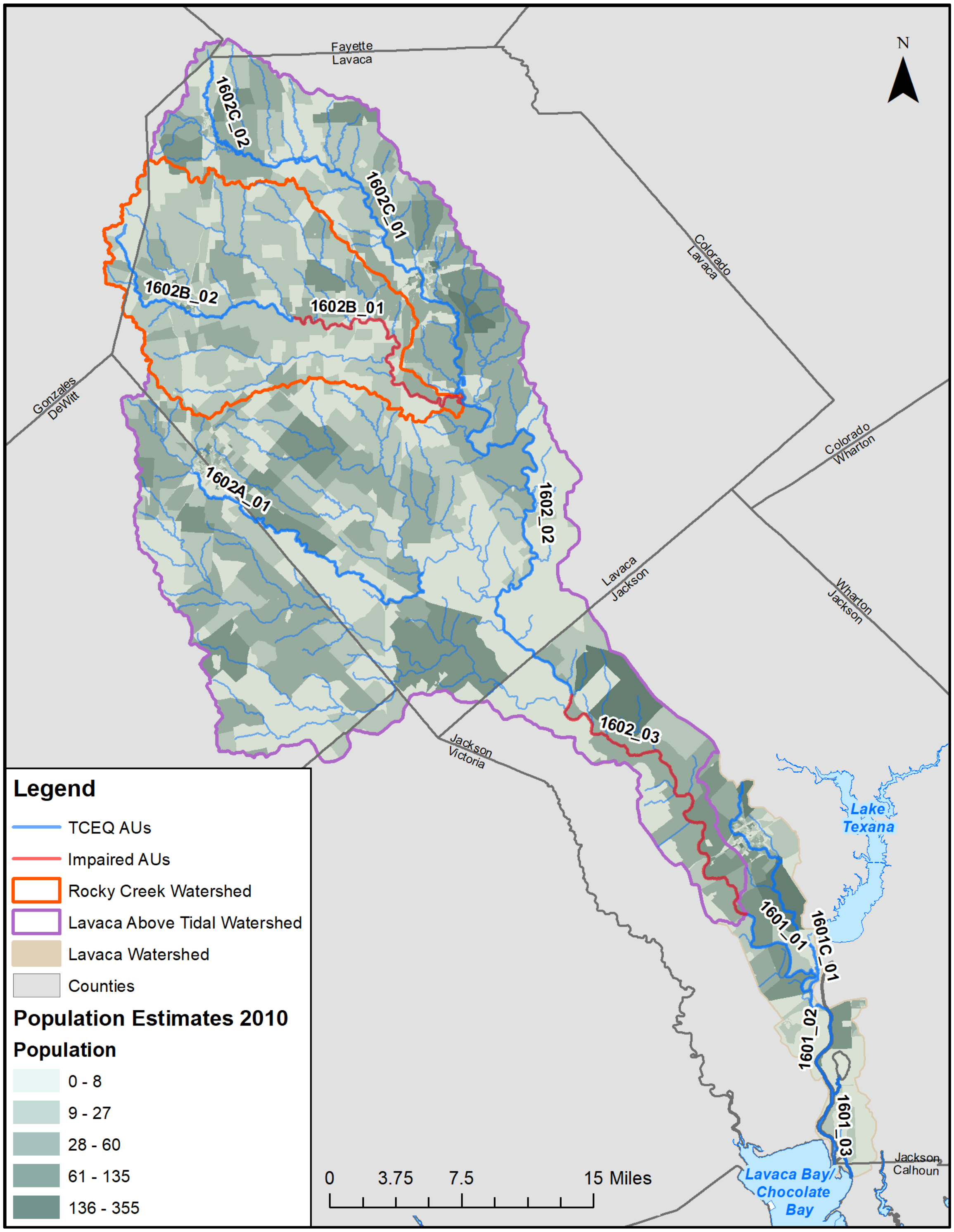

Figure 4. 2010 total population by census block

Source: StratMap city boundaries (Texas Natural Resources Information System, 2012), Census Blocks (USCB, 2010)

Land Use

The land use/land cover data for the Lavaca River watershed was obtained from the USGS 2011 National Land Cover Database (NLCD) and are displayed in Figure 5.

The land use/land cover is represented by the following categories and definitions (USGS, 2014):

- **Open Water** - areas of open water, generally with less than 25 percent cover of vegetation or soil.
- **Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- **Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.
- **Developed, Medium Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.
- **Developed High Intensity** - highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.
- **Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
- **Deciduous Forest** - areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
- **Evergreen Forest** - areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
- **Mixed Forest** - areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
- **Shrub/Scrub** - areas dominated by shrubs; less than five meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

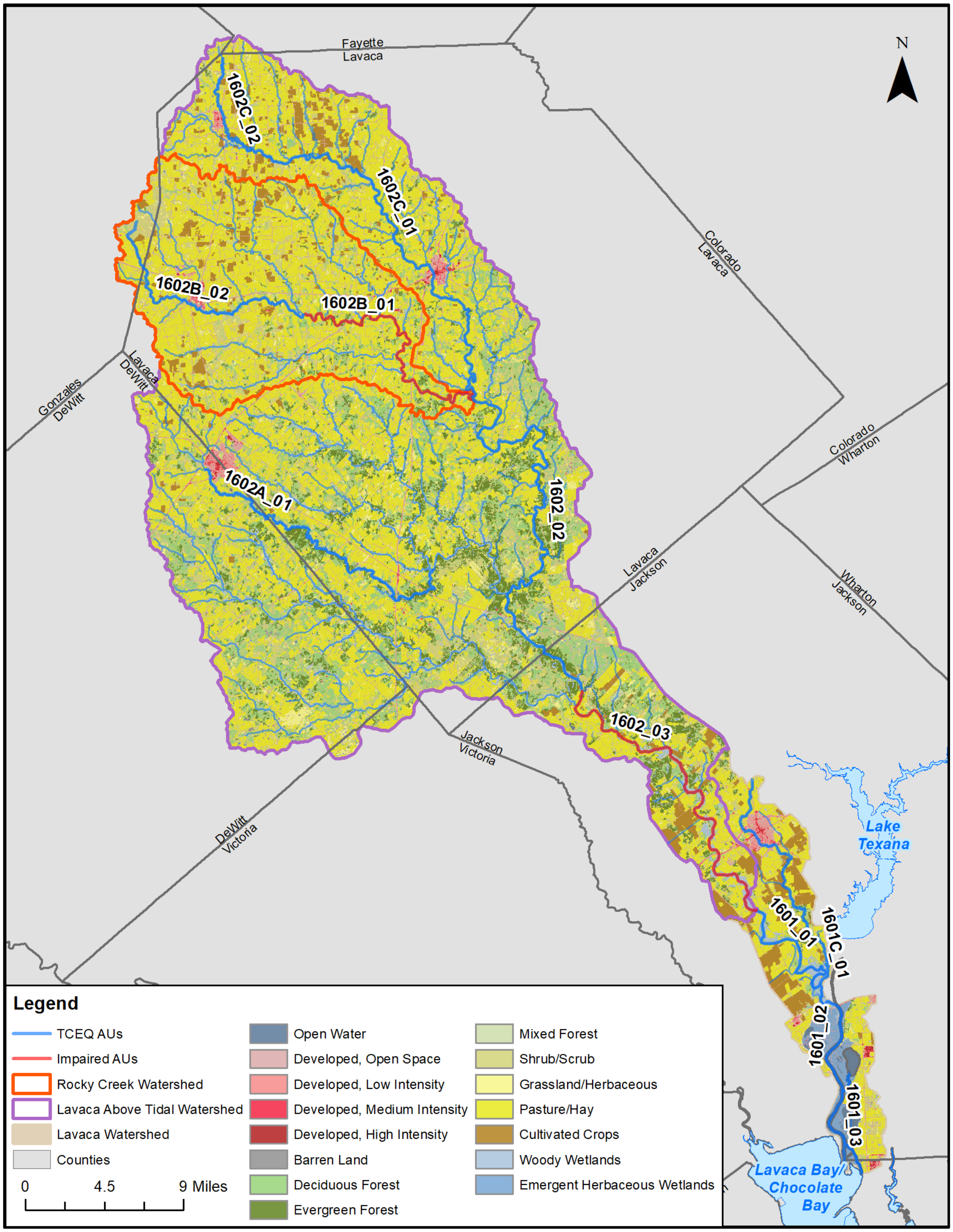

Figure 5. 2011 NLCD land use/land cover within the Lavaca River and Rocky Creek watersheds

Source: USGS, 2014

- **Grassland/Herbaceous** - areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
- **Pasture/Hay** - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
- **Cultivated Crops** - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
- **Woody Wetlands** - areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- **Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

As displayed in Table 4, the dominant land use in the watershed area of the Lavaca River watershed, which includes Rocky Creek, is Hay/Pasture (44.48 percent) followed by Shrub/Scrub (14.12 percent). The watershed is predominantly rural in land-use, as only approximately six percent of the area is classified as Developed (open space, low intensity, medium intensity, and high intensity).

In solely the Rocky Creek watershed, the predominant land use is also Hay/Pasture (56.32 percent) followed by shrub/scrub (16.10 percent) as displayed in Table 4. The watershed is only seven percent developed (open space, low intensity, medium intensity, and high intensity) and therefore this watershed is predominately rural as well.

Soils

Soils within the Lavaca River and Rocky Creek watersheds, categorized by their Hydrologic Soil Group, are shown in Figure 6. The data were obtained through the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS, 2013a). Soil Group A accounted for 14.5 percent of soils in the Lavaca River watershed, mostly represented along the east and west sides of the watershed. Soils classified in Group A have a high infiltration rate when thoroughly wet and therefore have a low runoff potential. Soils classified within Hydrologic Soil Group C (12.16 percent of the watershed) occur along portions of the Lavaca River Tidal segment and in the upper part of the watershed; these soils have moderately high runoff potential when thoroughly wet (NRCS, 2007). The majority of the Lavaca River watershed, 65.5 percent, has soils that fall under the classification of Soil Group D. Soils within this classification have the highest runoff potential since water movement through the soil is restricted or very restricted (NRCS, 2007). Within the Rocky Creek watershed, the most common soil is Group D (56.4 percent), followed by Group C (35.4 percent). Groups A and B soils compose approximately eight percent of Rocky Creek soils.

Table 4. Land use/land cover within the Lavaca River and Rocky Creek watersheds

Source: USGS, 2014

2011 NLCD	Lavaca Watershed (including Rocky Creek)		Lavaca River Above Tidal Watershed (including Rocky Creek)		Rocky Creek Watershed	
Classification	**Acres**	**% of Total**	**Acres**	**% of Total**	**Acres**	**% of Total**
Open Water	4,287.32	0.74%	947.85	0.18%	147.67	0.13%
Developed, Open Space	29,417.23	5.05%	26,289.59	4.92%	6,421.86	5.65%
Developed, Low Intensity	4,329.35	0.74%	3,120.68	0.58%	704.77	0.62%
Developed, Medium Intensity	1,381.29	0.24%	918.13	0.17%	231.74	0.20%
Developed, High Intensity	527.07	0.09%	314.12	0.06%	68.72	0.06%
Barren Land	662.51	0.11%	554.65	0.10%	33.58	0.03%
Deciduous Forest	80,410.07	13.81%	78,971.45	14.78%	7,782.92	6.84%
Evergreen Forest	36,604.80	6.29%	35,846.38	6.71%	1,930.16	1.70%
Mixed Forest	7,431.09	1.28%	7,272.66	1.36%	742.13	0.65%
Shrub/Scrub	82,232.15	14.12%	77,751.17	14.55%	18,310.18	16.10%
Herbaceous	19,505.33	3.35%	18,589.65	3.48%	3,011.00	2.65%
Hay/Pasture	258,964.83	44.48%	241,108.19	45.13%	64,035.16	56.32%
Cultivated Crops	26,085.99	4.48%	19,392.24	3.63%	7,214.70	6.35%
Woody Wetlands	24,186.07	4.15%	22,004.09	4.12%	2,929.60	2.58%
Emergent Herbaceous Wetlands	6,229.94	1.07%	1,204.70	0.23%	140.33	0.12%
Total	**582,255.04**	***100%***	**534,285.55**	***100%***	**113,704.52**	***100%***

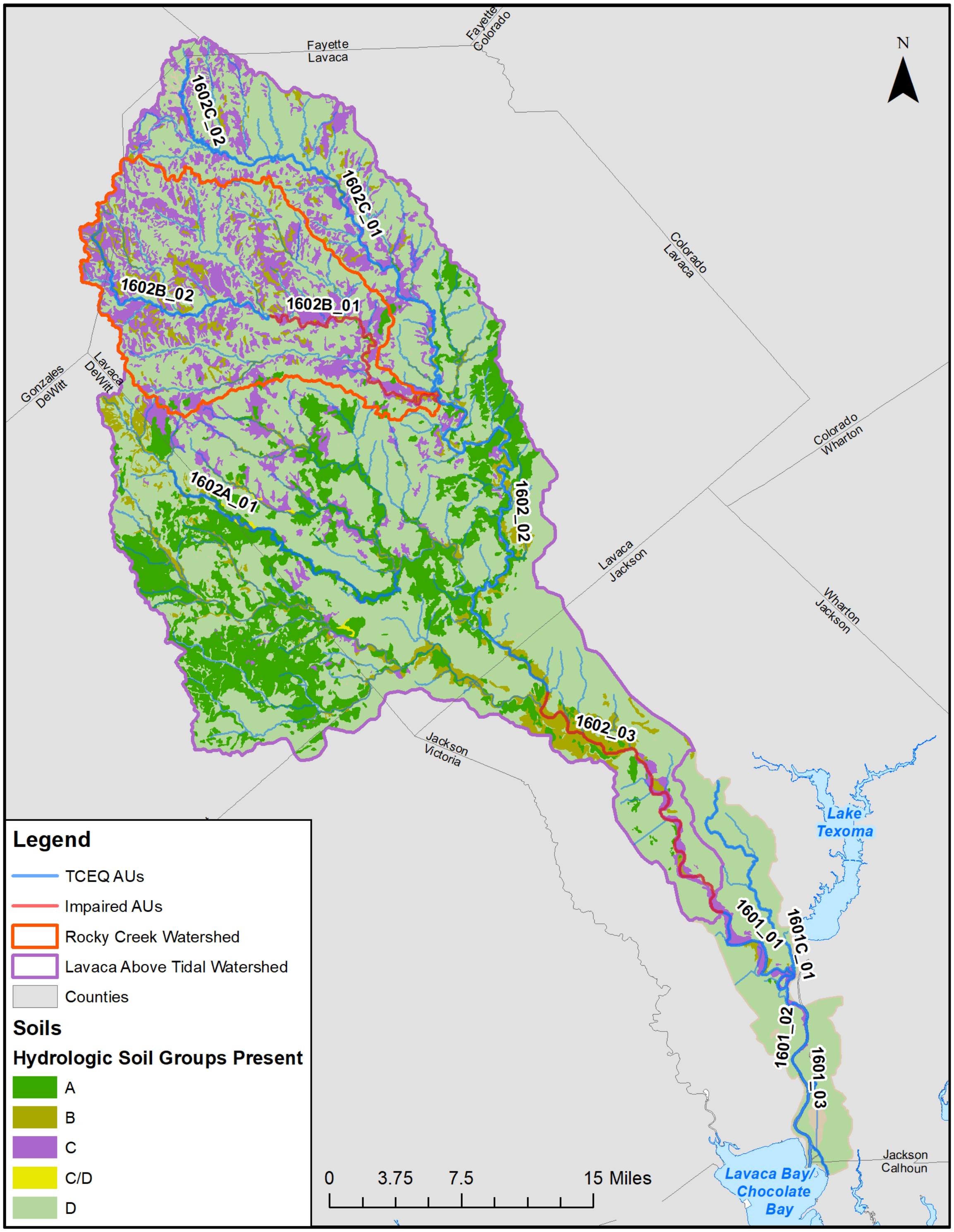

Figure 6. Lavaca River and Rocky Creek watersheds soil map: soils categorized by Hydrologic Soil Group

Source: NRCS, 2013a; NRCS 2013b; NRCS 2014

Endpoint Identification

All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions.

The endpoint for the TMDLs in this report is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 MPN/100 mL. This endpoint is identical to the geometric mean criterion in the 2010 Texas Surface Water Quality Standards (TCEQ, 2010) for primary contact recreation in freshwater bodies.

Source Analysis

Pollutants may come from several sources, both regulated and unregulated. Regulated pollutants, referred to as "point sources," come from a single definable point, such as a pipe, and are regulated by permit under the Texas Pollutant Discharge Elimination System (TPDES) or the National Pollutant Discharge Elimination System (NPDES). WWTFs and stormwater discharges from industries, construction, and the separate storm sewer systems of cities are considered point sources of pollution.

Unregulated sources are typically nonpoint source in origin, meaning the pollutants originate from multiple locations and rainfall runoff washes them into surface waters. Nonpoint sources are not regulated by permit.

With the exception of WWTFs, which receive individual WLAs (see the "Wasteload Allocation" section), the regulated and unregulated sources in this section are presented to give a general account of the different sources of bacteria expected in the watershed. These are not meant to be used for allocating bacteria loads or interpreted as precise inventories and loadings.

Regulated Sources

Regulated sources are controlled by permit under the TPDES and the NPDES programs. The regulated sources in the TMDL watershed include WWTF outfalls and stormwater discharges from industries and construction.

Domestic and Industrial Wastewater Treatment Facilities

As of March 2016, there were seven facilities with TPDES/NPDES permits that operated within the watershed (Table 5 and Figure 7). Four of the WWTFs are located in the watershed of the Lavaca River Above Tidal (Segment 1602) with one located within the boundaries of the Rocky Creek (Segment 1602B) watershed (TCEQ, 2012). These four facilities treat solely domestic wastewater. Two discharge directly into the above tidal section of the Lavaca River, one discharges into Rocky Creek, and the last one discharges into Big Brushy Creek (Segment 1602A), which enters the above-tidal section of the Lavaca River.

Three other facilities, Jackson County Water Control and Improvement District (WCID) Number 2 WWTF, Inteplast Group LTD, and Edna WWTF, are located within the project watershed, but all discharge below the impaired AUs 1602_03 and 1602B_01. They are listed in Table 5 but will not be included in TMDL analysis.

A review of the EPA Enforcement and Compliance History Online database (EPA, 2014) conducted on June 9, 2016 for records between January 1, 2013 and March 31, 2016 revealed several non-compliance issues regarding bacteria for two of the four WWTFs in the Lavaca River Above Tidal and Rocky Creek (see Table 6). As of March 2016, the City of Moulton reported bacteria exceedances in one of 28 months from January 2014 through April 2016. The City of Hallettsville reported daily maximum bacteria violations in four of 21 months from September 2014 through April 2016. The City of Edna reported daily maximum bacteria exceedances in 25 of the 37 months from March 2013 through March 2016. None of the bacteria effluent violations were reported as “Significant Non-compliance” effluent violations.

The City of Shiner (the only facility to discharge to Rocky Creek), City of Yoakum, Jackson County WCID No. 2, and Inteplast Group LTD had no compliance issues within the past three years due to elevated bacteria loads within the reporting time period (January 1, 2013 to March 31, 2016).

In addition to the individual wastewater discharge permits listed in Table 5, dischargers of processed wastewater from certain types of facilities are required to be covered by one of several TPDES general permits:

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production facilities
- TXG340000 – petroleum bulk stations and terminals
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances
- TXG920000 – concentrated animal feeding operations
- WQG20000 – livestock manure compost operations (irrigation only)

A review of active general permit coverage (TCEQ, 2015c) in the Lavaca River Above Tidal and Rocky Creek watersheds as of June 9, 2016 found two concrete production facilities covered by the general permit. These facilities are located in Jackson and Lavaca counties, in Segment 1602 – Lavaca River Above Tidal, and 1602B – Rocky Creek. The concrete production facilities do not have bacteria reporting or limits in their permits. The facilities were assumed to contain inconsequential amounts of indicator bacteria in their effluent; therefore, it was unnecessary to allocate bacteria load to these concrete production facilities.

No other active general wastewater permit facilities or operations were found. There were no facilities covered under the general permits for aquaculture, petroleum bulk stations and terminals, petroleum fuel or petroleum substances, hydrostatic test water discharges, concentrated animal feeding operations, or livestock manure compost operations.

Table 5. Regulated WWTFs in the Lavaca River and Rocky Creek watersheds

Source: Individual TPDES Permits

TPDES Permit Number	Facility	Held By	AU	Receiving Waters	Discharge Type	Permitted Discharge (MGD[a])	Recent Discharge (MGD)[b]
WQ0010013001	City of Hallettsville WWTF	City of Hallettsville	1602_02[c]	Lavaca River Above Tidal	Treated domestic wastewater	0.800	0.595
WQ0010227001	City of Moulton WWTF	City of Moulton	1602C_02[c]	Lavaca River Above Tidal	Treated domestic wastewater	0.242	0.079
WQ0010463001	City of Yoakum WWTF	City of Yoakum	1602A_01[c]	Big Brushy Creek	Treated domestic wastewater	0.950	0.592
WQ0010280001	City of Shiner WWTF	City of Shiner	1602B_02[d]	Rocky Creek to Lavaca River	Treated domestic wastewater	0.850	0.736
WQ0010196001	Jackson County WCID NO 2 WWTF	Jackson County WCID NO 2	ditch to 1601_03[e]	Drainage Ditch, unnamed tributary	Treated domestic wastewater	0.045	0.008
WQ0003477000	Inteplast Group Facility	Inteplast Group Corporation	1601_02[e]	Lavaca River Tidal	Wastewater (> or = 1 MGD domestic sewage or process water including WTP discharge)	0.045	0.040
WQ0010164001	City of Edna WWTF	City of Edna	tributary to 1601C_01[e]	Dry Creek to Lavaca River Tidal	Wastewater (> or = 1 MGD domestic sewage or process water including WTP discharge)	1.800	0.484

[a] MGD = million gallons per day
[b] Based on average discharge from January 1, 2013 to March 31, 2016
[c] Discharges upstream of 1602_03 but included in the 1602_03 TMDL calculations
[d] Included in 1602B_01 and 1602_03 TMDL calculations

[e] Discharge below the impaired assessment units and are not included in TMDL calculations

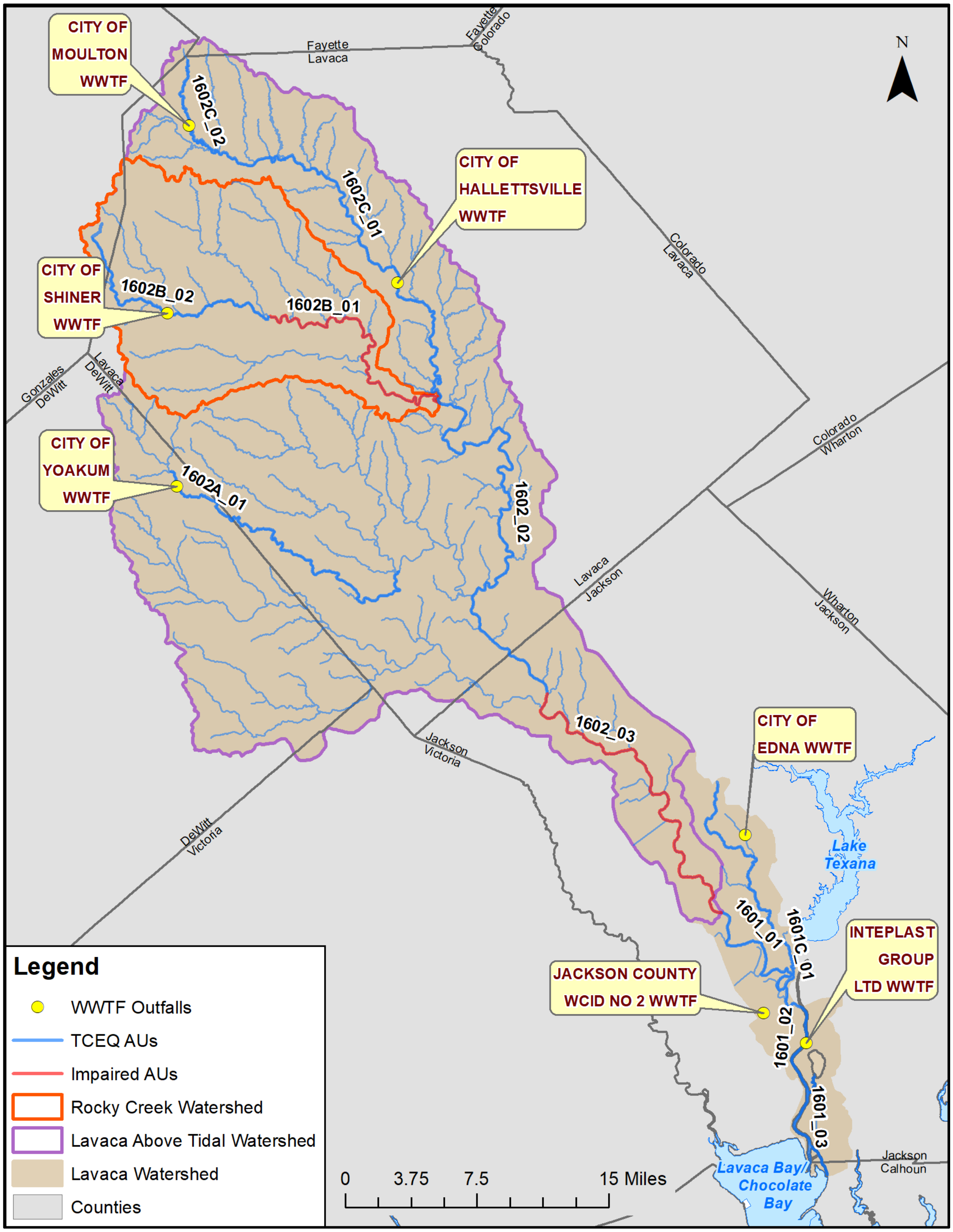

Figure 7. Lavaca River and Rocky Creek watershed showing WWTF outfalls

Source: Regulated outfalls (TCEQ, 2012)

Table 6. Bacteria monitoring requirements and compliance status of WWTFs in the Lavaca River Above Tidal and Rocky Creek watersheds

Source: TCEQ, 2014c

NPDES Permit No.	Facility	Held By	Bacteria Monitoring Requirements	Min. Self-Monitoring Requirement Frequency	Daily Average (Geo Mean) Limitation	Single Grab (Daily Max) Limitation	% Monthly Exceedances Daily Avg	% Monthly Exceedances Single Grab
TX0053287	City of Moulton WWTF	City of Moulton	*E. coli*	One/month	126	399	3.57%[a]	3.57%[a]
TX0026042	City of Shiner WWTF	City of Shiner	*E. coli*	Two/month	126	399	0.00%[b]	0.00%[b]
TX0025232	City of Hallettsville	City of Hallettsville	*E. coli*	Two/month	126	399	14.29%[c]	19.05%[c]
TX0026034	City of Yoakum WWTF	City of Yoakum	*E. coli*	Two/month	126	399	0.00%[d]	0.00%[d]

[a] 28 monthly *E. coli* records (1/2014 – 4/2016)

[b] 19 monthly *E. coli* records (11/2014 – 5/2016)

[c] 21 monthly *E. coli* records (9/2014 – 5/2016)

[d] 20 monthly *E. coli* records (10/2014 - 6/2016)

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party, either the TPDES permittee or the owner of the collection system that is connected to a regulated system. SSOs in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease, and other debris. Inflow and infiltration (I&I) are typical causes of SSOs under conditions of high flow in the WWTF system. Blockages in the line may exacerbate the I&I problem. Other causes, such as a collapsed sewer line, may occur under any condition.

The TCEQ Region 12 Office maintains a database of SSO data reported by municipalities. These SSO data typically contain estimates of the total gallons spilled, responsible entity, and a general location of the spill. A search of the database, based on the four domestic facilities in Segments 1602, 1602A, 1602B, and 1602C revealed that six SSOs have been reported from January 2009 through December 2015 (Table 7) (TCEQ, 2015b).

TPDES-Regulated Stormwater

When evaluating stormwater for a TMDL allocation, a distinction must be made between stormwater originating from an area under a TPDES or NPDES-regulated discharge permit and stormwater originating from areas not under a TPDES or NPDES-regulated discharge permit. Stormwater discharges fall into two categories:

1) Stormwater subject to regulation, which is any stormwater originating from TPDES/NPDES regulated MS4 entities, industrial facilities, and regulated construction activities.
2) Stormwater runoff not subject to regulation.

Three of these permits (MS4, MSGP, and construction) pertain solely to stormwater discharges. The other two — concrete production facilities and petroleum bulk stations and terminals — also authorize the discharge of processed wastewater as discussed above under Domestic and Industrial WWTFs.

A review of active stormwater general permits coverage (TCEQ, 2015c) in the Lavaca River Above Tidal and Rocky Creek watersheds, as of September 22, 2017, found seven active construction notices of intent and twelve stormwater MSGPs for industrial facilities. There are currently no Phase II MS4s or petroleum bulk stations and terminals facilities in the watershed. Based on the low amount of acreage disturbed from the construction notices (28.19 acres total) and small number of stormwater MSGPs, regulated stormwater is considered to contribute minimally to the Lavaca River Above Tidal and Rocky Creek watersheds.

Table 7. SSOs in the Lavaca River Above Tidal and Rocky Creek watersheds along Segments 1602, 1602A, 1602B, and 1602C from January 2009 through December 2015

Source: TCEQ, 2016

Permit Number	Facility Name	Discharge Date	Duration	Gallons	Cause	Corrective/Preventive Actions Taken	Location of Discharge
WQ0010463001	City of Yoakum WWTF	10/4/2009	Unknown	Unknown	I&I	None	Various manholes in collection system overflowed due to I&I
WQ0010463001	City of Yoakum WWTF	4/25/2010	2 hours 18 minutes	3000	Grease Blockage	Contained, vacuumed, and disinfected	Ellen May Rd
WQ0010227001	City of Moulton WWTF	10/14/2013	3 hours	1000	Line blockage (grease)	Line was cleared and degreaser injected	204 E. Rose
WQ0010463001	City of Yoakum WWTF	12/5/2014	35 minutes	3000	Backup in collection system (trapped piece of wood)	Wastewater was pumped back into the collection system and area was treated with granular chlorine.	1510 West Grand
WQ0010227001	City of Moulton WWTF	3/12/2015	Unknown	Unknown	40% bacteriological permit exceedance	Increase sewage wasting schedule	Outfall
WQ0010227001	City of Moulton WWTF	12/3/2015	24 minutes	250	Breakers in lift station pump tripped, causing the discharge	Disinfected affected area/checked all electric connections for malfunctioning parts	Lift station located at the intersection of Longhorn and Lancaster streets

Illicit Discharges

Pollutant loads can enter streams from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry-and wet-weather conditions. The term "illicit discharge" is defined in TPDES General Permit No. TXR040000 for Phase II MS4s as "Any discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities." Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (New England Interstate Water Pollution Control Commission, 2003) include:

Direct Illicit Discharges:

- sanitary wastewater piping that is directly connected from a home to the storm sewer,
- materials that have been dumped illegally into a storm drain catch basin,
- a shop floor drain that is connected to the storm sewer, and
- a cross-connection between the sanitary sewer and storm sewer systems.

Indirect Illicit Discharges:

- an old and damaged sanitary sewer line that is leaking fluids into a cracked storm sewer line, and
- a failing septic system that is leaking into a cracked storm sewer line or causing surface discharge into the storm sewer.

Unregulated Sources

Unregulated sources of bacteria are generally nonpoint. Nonpoint source loading enters the impaired segment through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities, agricultural animals, land application fields, failing on-site sewage facilities (OSSFs), unmanaged and feral animals, and domestic pets.

Unregulated Agricultural Activities and Domesticated Animals

A number of agricultural activities that do not require permits can be potential sources of fecal bacteria loading. Livestock are present throughout the rural portions of the project watershed. Table 8 provides estimated numbers of selected livestock in the watershed based on the 2012 Census of Agriculture conducted by USDA - National Agricultural Statistics Service (USDA NASS, 2014). The county-level estimated livestock populations were reviewed by Texas State

Soil and Water Conservation Board (TSSWCB) staff and were distributed based on Geographic Information System (GIS) calculations of pastureland in the watershed, based on the Texas 2011 Land Cover Data (USGS, 2014). These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table 8. Estimated distributed domesticated animal populations within the Lavaca River and Rocky Creek watersheds, based on proportional area

Source: USDA NASS, 2014; TPWD, 2012

Watershed	Segment	Cattle and Calves	Goats	Horses and Ponies	Poultry	Sheep and Lambs
Lavaca River (incl. Rocky Creek)	Above Tidal (1602) & Tidal (1601)	72,182	937	803	494,844	632
Lavaca River Above Tidal (incl. Rocky Creek)	1602	68,689	879	790	494,768	629
Rocky Creek	1602 B	16,727	195	209	279,673	146

Fecal matter from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 9 summarizes the estimated number of dogs and cats for the TMDL watershed. Pet population estimates were calculated as the estimated number of dogs (0.584) and cats (0.638) per household (American Veterinary Medical Association), 2012). The actual contribution and significance of fecal coliform loads from pets reaching the water bodies of the watershed is unknown.

Table 9. Estimated households and pet populations for the Lavaca River and Rocky Creek watersheds

Source: AVMA, 2012

Watershed	Segment	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
Lavaca River (incl. Rocky Creek)	Above Tidal (1602) & Tidal (1601)	14,713	8,592	9,387
Lavaca River Above Tidal (incl. Rocky Creek)	1602	11,523	6,729	7,532
Rocky Creek	1602B	3,149	1,839	2,009

Wildlife and Unmanaged Animals

E. coli bacteria inhabit the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify by watershed the potential for bacteria contributions from wildlife. Wildlife are naturally attracted to riparian corridors of streams and rivers. With direct access to the stream channel, the direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Fecal bacteria from wildlife are also deposited onto land surfaces, where they may be washed into nearby streams by rainfall runoff.

Unfortunately, quantitative estimates of wildlife are rare, inexact, and often limited to discrete taxa groups or geographical areas of interest so that even county-wide approximations of wildlife numbers are difficult or impossible to acquire. However, population estimates for feral hogs and deer are readily available for the Lavaca River watershed.

For feral hogs, estimates were generated by looking at feral hog estimated populations used in nearby watersheds and consulting with local Texas Parks and Wildlife biologists. The average hog density generated was one hog per 33 acres. This density was multiplied by the hog-habitat area in the Lavaca River watershed (including Rocky Creek) of 541,650 acres. Habitat deemed suitable for hogs followed as closely as possible to the land use selections of the Institute of Renewable and Natural Resources (IRNR) study (2013) and include from the 2011 NLCD classifications: hay/pasture, cultivated crops, shrub/scrub, herbaceous, deciduous forest, evergreen forest, mixed forest, woody wetlands, and emergent herbaceous wetlands. Using this methodology, there are an estimated 16,414 feral hogs within the Lavaca River and Rocky Creek watersheds (Table 10).

For deer, the Texas Parks and Wildlife Department (TPWD) published data showing deer population-density estimates by Resource Management Unit (RMU) and Ecoregion in the state (TPWD, 2012). The Lavaca River and Rocky Creek watersheds incorporate areas of RMU 12, for which the average deer density over the period 2005-2011 was calculated to be one deer/19 acres. Applying this value to the area of the entire watershed returns an estimated 30,645 deer within the entire watershed (Lavaca River including Rocky Creek) (Table 10).

Table 10. Estimated distributed wildlife populations within the Lavaca River and Rocky Creek watersheds, based on land use

Source: IRNR, 2013; TPWD, 2012

Watershed	Segment	Feral Hogs	Whitetail Deer
Lavaca River (incl. Rocky Creek)	Above Tidal (1602) & Tidal (1601)	16,414	30,645
Lavaca River Above Tidal (incl. Rocky Creek)	1602	15,216	26,428
Rocky Creek	1602 B	3,215	5,984

On-site Sewage Facilities

Private residential OSSFs, commonly referred to as septic systems, consist of various designs based on physical conditions of the local soils. Typical designs consist of 1) one or more septic tanks and a drainage or distribution field (anaerobic system) and 2) aerobic systems that have an aerated holding tank and often an above ground sprinkler system for distributing the liquid. In simplest terms, household waste flows into the septic tank or aerated tank, where solids settle out and treatment occurs. The liquid portion of the water flows to the distribution system which may consist of buried perforated pipes or an above ground sprinkler system.

Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter the ground and surface waters, if the systems are not properly operating. Properly designed and operated, however, OSSFs would be expected to contribute virtually no fecal bacteria to surface waters. For example, it has been reported that less than 0.01 percent of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drainfield of a septic system (Weikel et al., 1996). Reed, Stowe, and Yanke LLC (2001) provide information on estimated failure rates of OSSFs for different regions of Texas. The Lavaca River Above Tidal and Rocky Creek watersheds are located within the east-central Texas area, which has a reported failure rate of about 12 percent, providing insights into expected failure rates for the area.

Estimates of the number of OSSFs in the Lavaca River watershed were based on 911 phone line data. OSSFs were estimated to be households that were outside of either a Certificate of Convenience and Necessity sewer area or a city boundary. The total estimate of the whole watershed, as well as specifically for Rocky Creek, is shown in Table 11. The OSSF density is shown in Figure 8.

Table 11. OSSF estimate for the Lavaca River and Rocky Creek watersheds

Watershed	Segment(s)	Estimated OSSFs
Lavaca River (incl. Rocky Creek)	1601 & 1602	5,246
Lavaca River Above Tidal (incl. Rocky Creek)	1602	4,836
Rocky Creek	1602B	1,507

Bacteria Survival and Die-off

Bacteria are living organisms that survive and die. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature). Fecal organisms can survive and replicate from improperly treated effluent during their transport in pipe networks and in organic rich materials such as compost and sludge. While the die-off of indicator bacteria has been demonstrated in natural water systems due to the presence of sunlight and predators, the potential for their replication is less well understood. Both processes (replication and die-off) are instream processes and are not considered in the bacteria source loading estimates for the TMDL watershed.

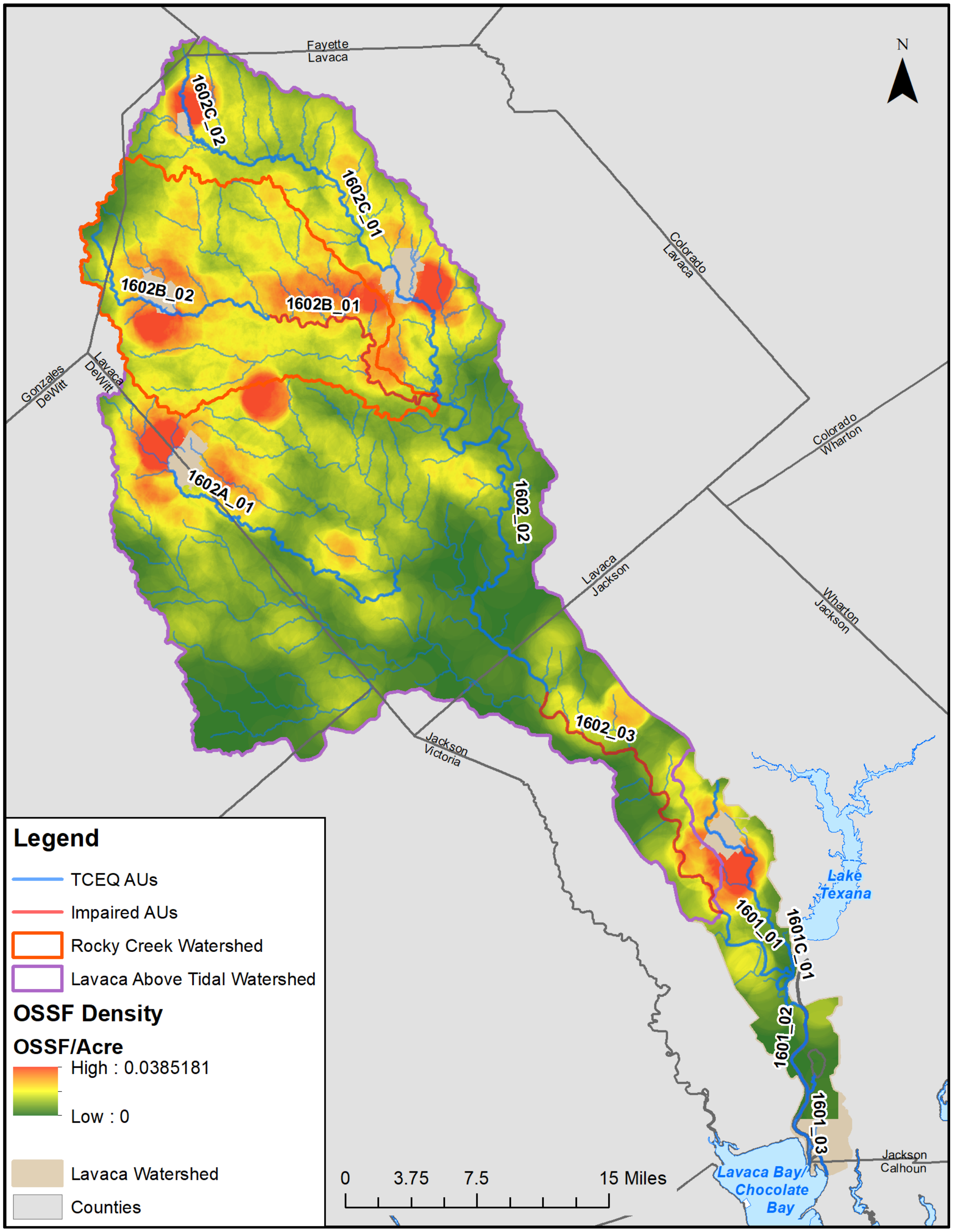

Figure 8. OSSF densities within the Lavaca River and Rocky Creek watersheds

Linkage Analysis

Establishing the relationship between instream water quality and the source of loadings is an important component in developing a TMDL. It allows for the evaluation of management options that will achieve the desired endpoint. This relationship may be established through a variety of techniques.

Generally, if high bacteria concentrations are measured in a water body at low to median flow in the absence of runoff events, the main contributing sources are likely to be point sources and direct fecal material deposition into the water body. During ambient flows, these inputs to the system will increase pollutant concentrations depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources and direct deposition is typically diluted, and would therefore be a smaller part of the overall concentrations.

Bacteria load contributions from regulated and unregulated stormwater sources are greatest during runoff events. Rainfall runoff, depending upon the severity of the storm, has the capacity to carry indicator bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of lower concentrations in the water body just before the rain event, followed by a rapid increase in bacteria concentrations in the water body as the first flush of storm runoff enters the receiving stream. Over time, the concentrations decline because the sources of indicator bacteria are attenuated as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Load Duration Curve Analysis

LDC and flow duration curve (FDC) methods were used to examine the relationship between instream water quality and the source of indicator bacteria loads. LDCs are graphs of the frequency distribution of loads of pollutants in a stream. In the case of these TMDLs, the loads shown are of *E. coli* bacteria in cfu/day. LDCs are derived from FDCs, which are graphs of the frequency distribution of flow in a stream. The LDCs represent the maximum acceptable load in the stream that will result in achievement of the TMDL water quality target.

LDCs are a simple statistical method that provide a basic description of the water quality problem. The strength of this tool is that it is easily developed and explained to stakeholders, and uses available water quality and flow data. The LDC method does not require any assumptions regarding loading rates, stream hydrology, land use conditions, and other conditions in the watershed. The EPA supports the use of this method to characterize pollutant sources.

Inherent to the use of LDCs as the mechanism of linkage analysis is the assumption of a one-to-one relationship between instream loadings and loadings originating from point sources, and the landscape as regulated and unregulated sources. This one-to-one relationship was also inherently assumed when using LDCs to define the TMDL pollutant load allocation. The allocation of pollutant loads was based on apportioning the loadings based on flows assigned to WWTFs, a fractional proportioning of the remaining flow based on the area of the watershed under stormwater regulation, and assigning the remaining portion to unregulated stormwater.

The weaknesses of the LDC method include the limited information it provides regarding the magnitude or specific origin of the various sources. Only limited information is gathered regarding point and nonpoint sources in the watershed.

The LDC method allows for estimation of existing TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating instream loads, this method 1) allows for the determination of the hydrologic conditions under which impairments are typically occurring, 2) can give indications of the broad origins of the bacteria (i.e., point source and stormwater), and 3) provides a means to allocate allowable loadings.

A 14-year period of record from October 2001 through April 2015 was selected for the Lavaca River Above Tidal, and an 11-year period from March 2004 through March 2015 was selected for Rocky Creek. These 14 and 11-year period of records were selected in an effort to capture a reasonable range of extremes in high and low streamflows, and represent a period in which most of the *E. coli* data were collected at both sites.

For this report, an LDC was constructed for two monitoring stations: one within the Lavaca River Above Tidal segment (Station 12524) and one within the Rocky Creek segment (Station 18190). These SWQM stations were selected because of their locations within the impaired TMDL assessment units.

Daily streamflow records were available for one USGS gauge location in the TMDL watersheds. On numerous creeks and rivers in Texas, USGS streamflow gauging stations have been in operation for a sufficient period to provide long-term streamflow records. USGS streamflow gauge 08164000 (Lavaca River near Edna, TX) was used for LDC development. Daily streamflow records are available at this gauge from August 1938 to present. There is no USGS streamflow gauge in Rocky Creek. The daily streamflow records were developed from extant USGS records modified by the imposition of certain rules necessitated by hydrologic complicating factors. The required daily streamflows for the Rocky Creek FDC and LDC were developed using the Drainage Area Ratio method. This method involves multiplying daily streamflow values by a ratio of the streamflow gauge and sampling site catchment areas. Further information on this approach is provided in the *Technical Support Document for Total Maximum Daily Loads for Indicator Bacteria in the Lavaca River Above Tidal and Rocky Creek* (TWRI, 2017).

The FDC was generated by:

1) Ordering the daily streamflow data from highest to lowest values and assigning a rank to each data point (one for the highest flow, two for the second highest flow, and so on);

2) Computing the percent of days each flow was exceeded by dividing each rank by the total number of data points plus one; and

3) Plotting the corresponding flow data (y-axis) against exceedance percentages (x-axis).

Exceedance values along the x-axis represent the percent of days that flow was at or above the associated flow value on the y-axis. Exceedance values near 100 percent occur during low flow or drought conditions while values approaching zero percent occur during periods of high flow or flood conditions.

Bacteria LDCs were developed by multiplying each streamflow value along the FDCs by the *E. coli* geometric mean criterion (126 MPN/100 mL) and by the conversion factor to convert to loading in colonies per day. This effectively displays the LDC as the TMDL curve of maximum allowable loading:

> TMDL (MPN/day) = Criterion * flow [cubic feet per second (cfs)] * conversion factor

Where:

> Criterion = 126 MPN/100 mL (*E. coli*)
>
> Conversion factor (to MPN/day) = 283.168 100 mL/ft^3 * 86,400 seconds/day (s/d)

The resulting curve plots each bacteria load value (y-axis) against its exceedance value (x-axis). Exceedance values along the x-axis represent the percent of days that the bacteria load was at or above the allowable load on the y-axis.

For the LDCs developed for Stations 12524 and 18190, historical bacteria data obtained from the TCEQ Surface Water Quality Monitoring Information System database was superimposed on the allowable bacteria LDC. Each historical *E. coli* measurement was associated with the flow on the day of measurement and converted to a bacteria load. The associated flow for each bacteria loading was compared to the FDC data to determine its value for "percent days flow exceeded," which becomes the "percent of days load exceeded" value for purposes of plotting the *E. coli* loading. Each load was then plotted on the LDC at its percent exceedance. This process was repeated for each *E. coli* measurement. Points above the LDC represent exceedances of the bacteria criterion and their associated allowable loadings.

The hydrologic classification scheme utilized for the TMDL watershed is as follows: 0-10 percent (high flows); 10-40 percent (moist conditions); 40-60 percent (mid-range flows); 60-90 percent (dry conditions); and 90-100 percent (low flows). Additional information explaining the LDC method may be found in Cleland (2003) and Nevada Division of Environmental Protection (NDEP, 2003).

The median loading of the high flow regime (0-10 percent exceedance) is used for the TMDL calculations. The median loading of the high flow regime is represented by the five percent exceedance and is used for the TMDL calculations, because it represents a reasonable yet high value for the allowable pollutant load allocation.

Load Duration Curve Results

To develop the TMDL allocation, an LDC was constructed for two monitoring stations: one within the Lavaca River Above Tidal segment (Figure 9) and one within the Rocky Creek segment (Figure 10). The LDC provides a means of identifying the streamflow conditions under which exceedances in *E. coli* concentrations have occurred. The LDC depicts the allowable loadings at the station under the geometric mean criterion (126 MPN/100 mL) and shows that existing loadings often exceed the criterion. The LOADEST line illustrates the estimated constituent load at the two different SWQM stations, based on the load regression curve generated by the USGS Load Estimator (LOADEST) program.

Based on these LDCs (Figures 9-10) with the addition of historical *E. coli* data, the following broad linkage statements can be made. For the Lavaca River Above Tidal and Rocky Creek watersheds, the historical *E. coli* data indicate that elevated bacteria loadings occur under all flow conditions for station 18190 at Rocky Creek, with the highest bacteria elevations occur during the highest flows. Historical *E. coli* data indicate that elevated bacteria levels occur during mostly high to mid-range flows for station 12524 on the Lavaca River Above Tidal segment. Regulated stormwater comprises a small portion of the watershed and must be considered only a minor contributor. Most likely, unregulated stormwater comprises the majority of high-flow related loadings. The elevated *E. coli* loadings under the lower flow conditions cannot be reasonably attributed exclusively to WWTFs due to outfalls being located at a distance from Station 12524 for the Lavaca River Above Tidal and Station 18190 for Rocky Creek. As well, the upstream WWTFs have a low percentage of monthly exceedances of bacteria. Therefore, other sources of bacteria loadings under lower flows and in the absence of overland flow contributions (i.e., without stormwater contribution) are most likely contributing bacteria directly to the water as could occur

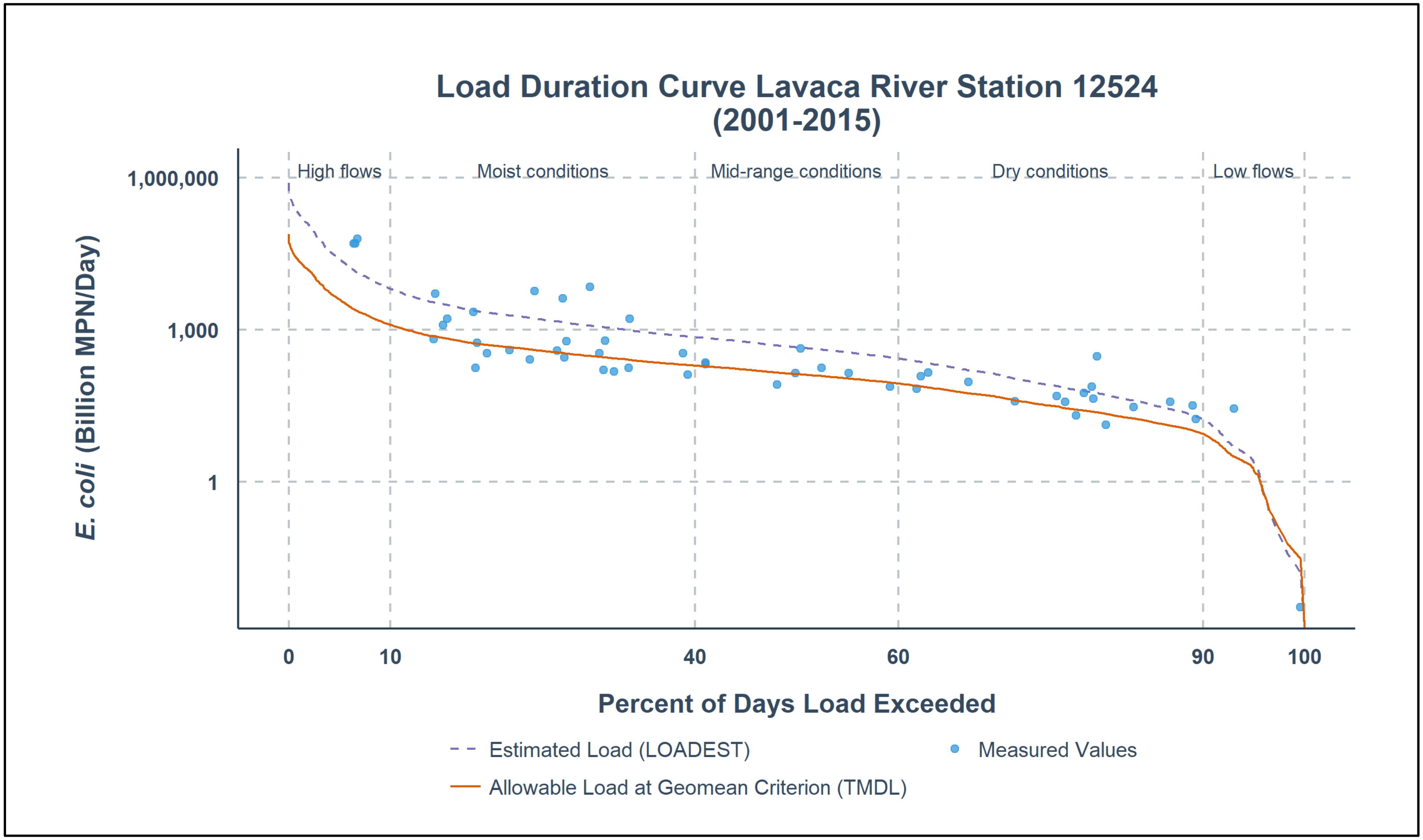

Figure 9. Load duration curve at Station 12524 on Lavaca River Above Tidal (Segment 1602) for the period of 2001 through 2015

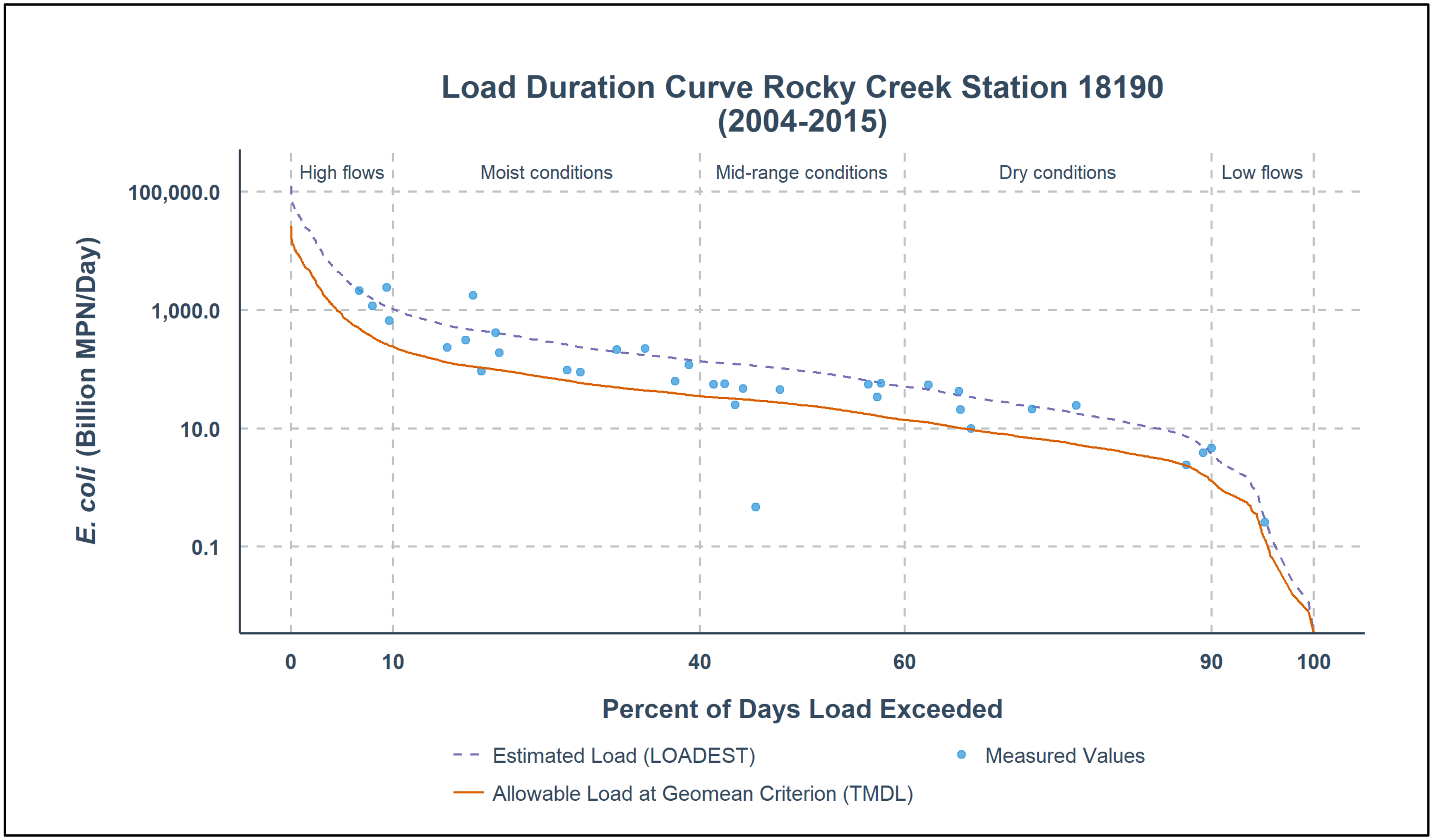

Figure 10. Load duration curve at Station 18190 on Rocky Creek (Segment 1602B) for the period of 2004-2015

through direct deposition of fecal material from wildlife, feral hogs, and livestock. The actual contribution of bacteria loadings attributable to these direct sources of fecal material deposition cannot be determined using LDCs.

Margin of Safety

The MOS is used to account for uncertainty in the analysis used to develop the TMDL and thus provide a higher level of assurance that the goal of the TMDL will be met. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

1) Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
2) Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning an MOS.

These TMDLs incorporate an explicit MOS by setting a target for indicator bacteria loads that is five percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for *E. coli* of 119.7 MPN/100 mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

Pollutant Load Allocation

The TMDL represents the maximum amount of a pollutant that the stream can receive in a single day without exceeding water quality standards. The pollutant load allocations for the selected scenarios were calculated using the following equation:

TMDL = WLA + LA + FG + MOS

Where:

WLA = wasteload allocation, the amount of pollutant allowed by regulated dischargers

LA = load allocation, the amount of pollutant allowed by unregulated sources

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety

As stated in 40 CFR §130.2(1), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For *E. coli*, TMDLs are expressed as MPN/day, and represent the maximum one-day load the stream can assimilate while still attaining the standards for surface water quality.

The TMDL component for the impaired AUs covered in this report is derived using the median flow within the high flow regime (or five percent flow) of the LDC developed for the two SWQM stations (12524 for Lavaca River Above Tidal and 18190 for Rocky Creek) in the Above tidal segments. The immediately following sections will present an explanation of the TMDL component first, followed by the results of the calculation for that component.

AU-Level TMDL Computations

The bacteria TMDLs for the Lavaca River Above Tidal segment and Rocky Creek segment were developed as a pollutant load allocation based on information from the LDC for SWQM stations located in each impaired AU (Figure 1). The bacteria LDCs were developed by multiplying each flow value along the flow duration curves by the *E. coli* criterion (126 MPN/100 mL) and by the conversion factor used to represent maximum loading in MPN/day. Effectively, the “Allowable Load” displayed in the LDC at five percent exceedance (the median value of the high-flow regime) is the TMDL:

TMDL (MPN/day) = Criterion * Flow (cfs) * Conversion factor

Where:

Criterion = 126 MPN/100 mL (*E. coli*)

Conversion factor (to MPN/day) = 283.168 100 mL/ft^3 * 86,400 s/d

At five percent load duration exceedance, the TMDL values are provided in Table 12.

Table 12. Summary of allowable loading calculations for the impaired AU 1602_03 within Lavaca River Above Tidal (Station 12524) and impaired AU 1602B_01 within Rocky Creek (Station 18190)

Station/ Impaired AU	5% Exceedance Flow (cfs)	5% Exceedance Load (MPN/day)	Indicator Bacteria	TMDL (Billion MPN/day)
Station 12524/ Lavaca River Above Tidal AU 1602_03	1,290.00	3.97666E+12	*E. coli*	3,976.657
Station 18190/ Rocky Creek AU 1602B_01	268.67	8.28224E+11	*E. coli*	828.224

Margin of Safety

The margin of safety is only applied to the allowable loading for a watershed. Therefore, the margin of safety is expressed mathematically as the following:

MOS = 0.05 * TMDL

Where:

MOS = margin of safety

TMDL = total maximum daily load

Since the MOS is based solely on the TMDL term, the calculation is straightforward and shown in Table 13.

Table 13. MOS calculations for Lavaca River Above Tidal (AU 1602_03) and Rocky Creek (1602B_01)

Station/ Impaired AU	Indicator Bacteria	TMDL (Billion MPN/day)	MOS (Billion MPN/day)
Station 12524/ Lavaca River Above Tidal AU 1602_03	*E. coli*	3,976.657	198.833
Station 18190/ Rocky Creek AU 1602B_01	*E. coli*	828.224	41.411

Wasteload Allocation

The WLA is the sum of loads from regulated sources.

WWTFs

TPDES-regulated WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by the instream geometric criterion and also reduced to account for the required MOS. The WLA_{WWTF} term is calculated for the freshwater *E. coli* primary contact recreation geometric mean criterion of 126 MPN/100 mL, since WWTF bacteria permit limits are often expressed in terms of *E. coli*. This is expressed in the following equation:

WLA_{WWTF} = Criterion * Flow * Conversion Factor

Where:

Flow (MGD) = full permitted flow

Criterion= 126 MPN/100 mL for *E. coli* primary contact recreation

Conversion Factor (to MPN/day) = 1.54723 cfs/MGD *283.168 100 mL/ft^3 * 86,400 s/d

Thus, the daily allowable loading of *E. coli* assigned to WLA_{WWTF} was determined based on the full permitted flow of each WWTF and summed for the watershed. Table 14 presents the WLAs for each individual WWTF located within the TMDL watershed. The WLA_{WWTF} for the Lavaca River Above Tidal AU (1602_03) includes the sum of the WWTF allocations for all upstream AUs, including Rocky Creek. The WLA_{WWTF} for the Rocky Creek AU (1602B_01) only includes the WWTF allocations for the City of Shiner WWTF, since that is the only facility within the Rocky Creek watershed boundaries. Since the pollutant load allocation is developed in terms of *E. coli* as the indicator bacteria, it is the *E. coli* loadings from Table 14 that will be used in subsequent computations.

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered 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 watershed that is under the jurisdiction of stormwater permits 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 runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}.

Table 14. Wasteload allocations for TPDES-regulated facilities in Lavaca River Above Tidal (incl. Rocky Creek) watershed

Segment	Receiving Waters	TPDES Permit No.	Outfall Number	NPDES Permit No.	Facility	Full Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/ day)
1602	Lavaca River Above Tidal	WQ0010 013001	001	TX002 5232	City of Hallettsville WWTF	0.80	3.816
1602	Lavaca River Above Tidal	WQ0010 227001	001	TX005 3287	City of Moulton WWTF	0.242	1.154
1602A	Big Brushy Creek	WQ0010 463001	001	TX002 6034	City of Yoakum WWTF	0.95	4.531
1602B	Rocky Creek to Lavaca River	WQ0010 280001	001	TX002 6042	City of Shiner WWTF	0.85	4.054
Lavaca River Above Tidal (including Rocky Creek) Watershed Total							**13.555**
Rocky Creek Watershed Total							**4.054**

Thus, WLA_{SW} is the sum of loads from regulated stormwater sources and is calculated as follows:

$$WLA_{SW} = (TMDL - WLA_{WWTF} - FG - MOS) * FDA_{SWP}$$

Where:

WLA_{SW} = sum of all regulated stormwater loads

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety

FDA_{SWP} = fractional proportion of drainage area under jurisdiction of stormwater permits

To calculate the WLA_{SW} component of the TMDL, the fractional proportion of the drainage area under the jurisdiction of stormwater permits (FDA_{SWP}) must be determined in order to estimate the amount of overall runoff load that should be allocated to WLA_{SW}. The term FDA_{SWP} was calculated based on the combined area under regulated stormwater permits. As described in the Source Analysis section, a search for all five categories of stormwater general permits was performed. The search results are summarized in Table 15.

No MS4 permits are held in the Lavaca River Above Tidal and Rocky Creek watersheds. For the MSGPs, only the acreages associated with active permits were tallied. As well, there are three concrete production facilities located within the Lavaca River Above Tidal watershed. Acreages associated with MSGP and concrete production facility permits were calculated by importing the location information associated with the authorizations into Google Earth, and measuring the estimated disturbed area based on the most recently available aerial imagery. For the Construction Activities general permits, the authorization contains an "Area Disturbed" field. There are no Petroleum Bulk Stations located within the Lavaca River Above Tidal watershed.

Table 15. Stormwater General Permit areas and calculation of the FDA_{SWP} term for the Lavaca River Above Tidal (including Rocky Creek) watershed

Watershed	MS4 General Permit (acres)	MSGP (acres)	Construction Activities (acres)	Concrete Production Facilities (acres)	Petroleum Bulk Stations (acres)	Total Area of Permits (acres)	Watershed Area (acres)	FDA_{SWP}
Lavaca River Above Tidal (incl. Rocky Creek)	0	249.98	28.19	13.25	0	291.42	582,255.04	0.05 %
Rocky Creek	0	15.62	12.84	2.69	0	31.15	113,704.5	0.03%

In order to calculate WLA_{SW}, the Future Growth (FG) term must be known. The calculation for the FG term is presented in the next section, but the results will be included here for continuity. Table 16 provides the information needed to compute WLA_{SW}.

Table 16. Regulated stormwater calculations for the Lavaca River Above Tidal and Rocky Creek watersheds

Load units expressed as billion MPN/day *E. coli*

Watershed	TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
Lavaca River Above Tidal (incl. Rocky Creek)	3,976.657	13.555	1.459	198.833	0.05%	1.881
Rocky Creek	828.224	4.054	0.892	41.411	0.03%	0.235

Once the WLA_{SW} and WLA_{WWTF} terms are known, the WLA term can be calculated as the sum of the two parts, as shown in Table 17.

Table 17. WLA calculations for the Lavaca River Above Tidal and Rocky Creek watersheds

Load units expressed as billion MPN/day *E. coli*

Watershed	WLA_{WWTF}	WLA_{SW}	WLA
Lavaca River Above Tidal (incl. Rocky Creek)	13.555	1.881	15.436
Rocky Creek	4.054	0.235	4.289

An iterative, adaptive management approach will be used to address stormwater discharges. This approach encourages the implementation of structural or non-structural controls, implementation of mechanisms to evaluate the performance of the controls, and finally, allowance to make adjustments [e.g., more stringent controls or specific best management practices (BMPs)] as necessary to protect water quality.

Implementation of WLAs

The TMDLs in this document will result in protection of existing beneficial uses and conform to Texas' antidegradation policy. The three-tiered antidegradation policy in the Texas Water Quality Standards prohibits an increase in loading that would cause or contribute to degradation of an existing use. The antidegradation policy applies to point 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 TCEQ intends to implement the individual WLAs through the permitting process as monitoring requirements and/or effluent limitations as required by the amendment of 30 Texas Administrative Code (30 TAC) Chapter 319, which became effective November 26, 2009. WWTFs discharging to the TMDL segments will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in 30 TAC §319.9.

The permit requirements will be implemented during the routine permit renewal process. However, there may be a more economical or technically feasible means of achieving the goal of improved water quality and circumstances may warrant changes in individual WLAs after these TMDLs are adopted. Therefore, the individual WLAs, as well as the WLAs for stormwater, are non-binding until implemented via a separate TPDES permitting action, which may involve preparation of an update to the state's WQMP. Regardless, all permitting actions will demonstrate compliance with the TMDL.

The executive director or commission may establish interim effluent limits and/or monitoring-only requirements during a permit amendment or permit renewal. These interim limits will allow a permittee time to modify effluent quality in order to attain the final effluent limits necessary to meet the TCEQ and EPA approved TMDL allocations. The duration of any interim effluent limits may not be any longer than three years from the date of permit re-issuance. New permits will not contain interim effluent limits because compliance schedules are not allowed for a new permit.

Where a TMDL has been approved, domestic WWTF TPDES permits will require conditions consistent with the requirements and assumptions of the WLAs. For NPDES/ TPDES-regulated municipal discharges, construction stormwater discharges, and industrial stormwater discharges, water quality-based effluent limits (WQBELs) that implement the WLA for stormwater may be expressed as BMPs or other similar requirements, rather than as numeric effluent limits.

The November 26, 2014 memorandum from EPA relating to establishing WLAs for stormwater sources states:

> "Incorporating greater specificity and clarity echoes the approach first advanced by EPA in the 1996 Interim Permitting Policy, which anticipated that where necessary to address water quality concerns, permits would be modified in subsequent terms to include "more specific conditions or limitations [which] may include an integrated suite of BMPs, performance objectives, narrative standards, monitoring triggers, numeric WQBELs, action levels, etc."

Using this iterative, adaptive BMP approach to the maximum extent practicable is appropriate to address the stormwater component of these TMDLs.

Updates to WLAs

These TMDLs are, by definition, the total of the sum of the WLA, the sum of the LA, and the MOS. Changes to individual WLAs may be necessary in the future in order to accommodate growth or other changing conditions. These changes to individual WLAs do not ordinarily require a revision of the TMDL document; instead, changes will be made through updates to the state's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Load Allocation

The LA is the sum of loads from unregulated sources, and is calculated as:

$$LA = TMDL - WLA_{WWTF} - WLA_{SW} - FG - MOS$$

Where:

LA = allowable load from unregulated sources

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

WLA_{SW} = sum of all regulated stormwater loads

FG = sum of future growth loads from potential regulated facilities

MOS = margin of safety

The calculation results are shown in Table 18.

Table 18. Load allocation calculations for the Lavaca River Above Tidal and Rocky Creek watersheds

Load units expressed as billion MPN/day *E. coli*

Watershed	TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
Lavaca River Above Tidal (incl. Rocky Creek)	3,976.657	13.555	1.881	1.459	198.833	3,760.929
Rocky Creek	828.224	4.054	0.235	0.892	41.411	781.632

Allowance for Future Growth

The future growth component of the TMDL equation addresses the requirement to account for future loadings that may occur due to population growth, changes in community infrastructure, and development. Specifically, these TMDL components take into account the probability that new flows from WWTF discharges may occur in the future. The assimilative capacity of streams increases as the amount of flow increases.

The allowance for future growth will result in protection of existing beneficial uses and conform to Texas' antidegradation policy.

Currently, four facilities that treat domestic water are located within the impaired AU watersheds, and each has been assigned an individual WLA (Table 13). To account for the FG component of impaired AU 1602_03, the loading from all WWTFs is included in the FG computation, which is based on the WLA_{WWTF} formula. The FG equation (below) contains an additional term to account for projected population growth between 2010 and 2070 in the watershed counties (provided previously in Table 3). To calculate the FG component of the impaired AU 1602B_01, the loading from only the Shiner WWTF was included, as well as the projected population growth for Lavaca County.

$$FG = Criterion * [\%POP_{2010\text{-}2070} * WWTF_{FP}] * Conversion\ Factor$$

Where:

Criterion = 126 MPN/100 mL for *E. coli*

$\%POP_{2010\text{-}2070}$ = estimated % increase in population between 2010 and 2070

$WWTF_{FP}$ = full permitted discharge (MGD)

Conversion Factor = 1.547 cfs/MGD *283.168 100 mL/ft^3 * 86,400 s/d

For this TMDL, conventional future growth calculations are hampered in the Rocky Creek watershed by a projected population growth of zero by TWDB. While there are no plans for any additional WWTFs to be built in the watershed, the TMDL must still account for the possibility of future growth for all impaired segments. In order to address this shortcoming, a FG term was calculated for the Rocky Creek watershed to accommodate the potential of a WWTF to serve residents that are not connected to the existing Shiner WWTF.

Discharge flow for the potential WWTF was determined by first estimating the population served. The population of Shiner (2,137) was subtracted from the estimated watershed population (5,884) (Table 2). Because of the low population density, it was assumed that only half the population could be connected to a WWTF. Section 217.32 of the TAC states that a new WWTF must be designed for a wastewater flow of 75-100 gallons per capita per day (TAC, 2008). The discharge flow was then estimated by multiplying the estimated population served by 100 gallons per capita per day and converted to MGD. Discharge flow was then converted to FG using the conversion factor above (Table 19).

Table 19. Future Growth calculation for potential WWTF in the Rocky Creek watershed

Rocky Creek Watershed Population	City of Shiner Population	Potential WWTF Service Population	Potential WWTF Discharge (MGD)	FG (*E. coli* Billion MPN/day)
5,884	2,137	1,874	0.187	0.892

The calculation results for the total FG in the impaired AU watersheds are shown in Table 20.

Table 20. Future Growth Calculations for the Lavaca River Above Tidal and Rocky Creek watersheds

AU	Receiving Waters	Facility	Full Permitted Flow (MGD)	County	% Increase Population (2010-2070)	Future Growth (MGD)	FG (*E. coli* Billion MPN/ day)
1602_01	Lavaca River Above Tidal	City of Hallettsville WWTF	0.80	Lavaca	0.0%	0.0	0.0
1602C_02	Lavaca River Above Tidal	City of Moulton WWTF	0.242	Lavaca	0.0%	0.0	0.0
1602A_01	Big Brushy Creek	City of Yoakum WWTF	0.95	DeWitt	12.57%	0.119	0.567
1602B_02	Rocky Creek to Lavaca River Above Tidal	City of Shiner WWTF	0.85	Lavaca	0.0%	0.0	0.0
1602B_02	Rocky Creek to Lavaca River Above Tidal	Future Facility	NA	Lavaca	NA	0.187	0.892[a]
Lavaca River Above Tidal (including Rocky Creek) Total						**0.306**	**1.459**
Rocky Creek Total						**0.187**	**0.892**

[a] Calculated in Table 19

Compliance with these TMDLs is based on keeping the bacteria concentrations in the selected waters below the limits that were set as criteria for the individual sites. Future growth of existing or new point sources is not limited by these TMDLs as long as the sources do not cause bacteria to exceed the limits. The assimilative capacity of streams increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The LDC and tables in these TMDLs will guide determination of the assimilative capacity of the stream under changing conditions, including future growth.

Summary of TMDL Calculations

Table 21 summarizes the TMDL calculations for Lavaca River Above Tidal (1602_03) and Rocky Creek (1602B_01). The TMDLs were calculated based on the median flow in the zero - 10 percentile range (five percent exceedance, high flow regime) for flow exceedance from the LDCs developed for two SWQM stations in the watershed (12524 on Lavaca River and 18190 on Rocky Creek). Allocations are based on the current geometric mean criterion for *E. coli* of 126 MPN/100 mL for each component of the TMDLs.

Table 21. TMDL allocation summary for the Lavaca River Above Tidal and Rocky Creek watersheds

Load units expressed as billion MPN/day *E. coli*

AU	Stream Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA[e]	Future Growth[f]
1602_03	Lavaca River Above Tidal	3,976.657	198.833	13.555	1.881	3,760.929	1.459
1602B_01	Rocky Creek	828.224	41.411	4.054	0.235	781.632	0.892

[a] TMDL = Median flow (highest flow regime) * 126 MPN/100 mL * Conversion Factor; where the Conversion Factor = 283.168 100 mL/ft^3 * 86,400 sec/day; Median (5 percent exceedance) Flow from Table 11

[b] MOS = 0.05 * TMDL; (Table 13)

[c] WLA_{WWTF} = 126 MPN/day * Flows (MGD) * Conversion Factor; where Flow is the full permitted flow from regulated discharging facilities; Conversion Factor = 1.54723 cfs/MGD * 283.168 100 mL/ft^3; (Table 14)

[d] WLA_{SW} = (TMDL - ΣWLA_{WWTF} - ΣFG) * FDA_{SWP}; (Table 16)

[e] LA = TMDL - ΣWLA_{WWTF} - ΣWLA_{SW} - ΣFG - MOS; (Table 18)

[f] Future Growth = 126 MPN/100 mL * [%POP2010-2070 * $WWTF_{FP}$] * Conversion Factor; Conversion Factor = 1.54723 cfs/MGD * 283.168 100 mL/ft^3; $WWTF_{FP}$ is full permitted flows and %POP2010-2070 is from Table 20

The final TMDL allocations (Table 22), needed to comply with the requirements of 40 CFR §130.7, include the future growth component within the WLA_{WWTF}.

In the event that the criterion changes due to future revisions in the state's surface water quality standards, Appendix A provides guidance for recalculating the allocations in Table 22. Figures A-1 and A-2 were developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant load allocations change in relation to a number of proposed water quality criteria for *E. coli*. The equations provided, along with Figures A-1 and A-2, allow calculation of a new TMDL and pollutant load allocation based on any potential new water quality criterion for *E. coli*. Tables A-1 and A-2 summarize the changes in pollutant load allocations under selected revised standards.

Table 22. Final TMDL allocations for the impaired Lavaca River Above Tidal AU 1602_03 and Rocky Creek AU 1602B_01 watersheds

Load units expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}[a]	WLA_{SW}	LA	MOS
1602_03	3,976.657	15.014	1.881	3,760.929	198.833
1602B_01	828.224	4.946	0.235	781.632	41.411

[a] WLA_{WWTF} includes the future growth component

Seasonal Variation

Federal regulations [40 CFR §30.7(c)(1)] require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from routine monitoring collected in the warmer months (May - September) against those collected during the cooler months (November - March). The months of April and October were considered transitional between the warm and cool seasons and were excluded from the seasonal analysis. Differences in *E. coli* concentrations obtained in warmer versus cooler months were then evaluated by performing a Wilcoxon Rank Sum test on the original dataset. The nonparametric Wilcoxon Rank Sum test was selected since the bacteria data were non-normally distributed. The analysis of *E. coli* data for both the Lavaca River (Station 12524, Segment 1602) and Rocky Creek (Station 18190, Segment 1602B) indicates that there was no significant difference (α=0.05, p=0.422 for Rocky Creek and α=0.05, p=0.251 for Lavaca River Above Tidal) in indicator bacteria between cool and warm weather seasons at both stations.

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the investigation, the project team sought to ensure that stakeholders were informed and involved. Communication and comments from the stakeholders in the watershed strengthen TMDL projects and their implementation.

The TCEQ and Texas Water Resources Institute (TWRI) are jointly providing coordination for public participation in this project for development of the TMDL and Implementation Plan (I-Plan). A series of public meetings were held to keep the public aware of the TMDL and to engage public participation in development of the I-Plan.

Public meetings were held in Edna on October 24, 2016, December 15, 2016, March 23, 2017, March 30, 2017, May 4, 2017, and June 6, 2017. At many of the meetings, the main focus was development of the I-Plan and Watershed Protection Plan, but at certain strategic meetings, the participants were introduced to the TMDL process and progress on its development. Notices of meetings were posted on the project Web pages at both TWRI and TCEQ and on the TCEQ TMDL program’s online calendar. At least two weeks prior to scheduled meetings, the TWRI issued direct mailings and media releases and formally invited stakeholders to attend. To ensure that absent or new stakeholders could get information about past meetings and pertinent material, the TWRI project Web page provides meeting summaries, presentations, ground rules, and documents produced for review.

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that the WLA in this TMDL report will be achieved. Per federal requirements, each TMDL is included in an update to the Texas WQMP as a plan element.

The WQMP coordinates and directs the state's efforts to manage water quality and maintain or restore designated uses throughout Texas. The WQMP is continually updated with new, more specifically focused plan elements, as identified in federal regulations [40 CFR §130.6(c)]. Commission adoption of a TMDL is the state's certification of the associated WQMP update.

Because the TMDLs do not reflect or direct specific implementation by any single pollutant discharger, the TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the Commission. Based on the TMDLs and I-Plan, the TCEQ will propose and certify WQMP updates to establish required water-quality-based effluent limitations necessary for specific TPDES wastewater discharge permits.

Currently, there are no Phase II MS4 permit authorizations or Phase I MS4 individual permits held in the TMDL watersheds. However, future population growth within the urbanized areas located in the watershed may require some entities to obtain authorizations under the Phase II MS4 general permit. Where numeric effluent limitations are infeasible for MS4 entities, the TCEQ normally establishes BMPs, which are a substitute for effluent limitations, as allowed by federal rules. When such practices are established in Phase II MS4 permit authorizations or Phase 1 MS4 individual permits, the TCEQ will not identify specific implementation requirements applicable to a specific TPDES stormwater permit or permit authorization through an effluent limitation update. Rather, the TCEQ will revise its Phase II MS4 general permit during the renewal process or amend or revise a permittee's Phase I MS4 individual permit as needed, to require a revised Stormwater Management Program or to require the implementation of other specific revisions in accordance with an approved I-Plan.

Strategies for achieving pollutant loads in TMDLs from both point and nonpoint sources are reasonably assured by the state's use of an I-Plan. The TCEQ is committed to supporting implementation of all TMDLs adopted by the Commission.

I-Plans for Texas TMDLs use an adaptive management approach that allows for refinement or addition of methods to achieve environmental goals. This adaptive approach reasonably assures that the necessary regulatory and voluntary activities to achieve pollutant reductions will be implemented. Periodic, repeated evaluations of the effectiveness of implementation methods ascertain whether progress is occurring, and may show that the original distribution of loading among sources should be modified to increase efficiency. I-Plans will be adapted as necessary to reflect needs identified in evaluations of progress.

Key Elements of an Implementation Plan

An I-Plan includes a detailed description and schedule of the regulatory and voluntary management measures to implement the WLAs and LAs of particular TMDLs within a reasonable time. I-Plans also identify the organizations responsible for carrying out management measures, and a plan for periodic evaluation of progress.

Strategies to optimize compliance and oversight are identified in an I-Plan when necessary. Such strategies may include additional monitoring and reporting of effluent discharge quality to evaluate and verify loading trends, adjustment of an inspection frequency or a response protocol to public complaints, and escalation of an enforcement remedy to require corrective action of a regulated entity contributing to an impairment.

The TCEQ works with stakeholders and interested governmental agencies to develop and support I-Plans and track their progress. Work on the I-Plan begins during development of TMDLs. Because these TMDLs address agricultural sources of pollution, the TCEQ will also work in close partnership with the TSSWCB when developing the I-Plan. The TSSWCB is the lead agency in Texas responsible for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural nonpoint sources of water pollution. The cooperation required to develop an I-Plan will become a cornerstone for the shared responsibility necessary to carry it out.

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the I-Plan that is approved may not approximate the predicted loadings identified category-by-category in the TMDL and its underlying assessment. The I-Plan is adaptive for this very reason; it allows for continuous update and improvement.

In most cases, it is not practical or feasible to approach all TMDL implementation as a one-time, short-term restoration effort. This is particularly true when a challenging wasteload reduction or load reduction is required by the TMDL, there is high uncertainty with the TMDL analysis, there is a need to reconsider or revise the established water quality standard, or the pollutant load reduction would require costly infrastructure and capital improvements.

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Appendix A. Equations for Calculating TMDL Allocations for Changed Contact Recreation Standards

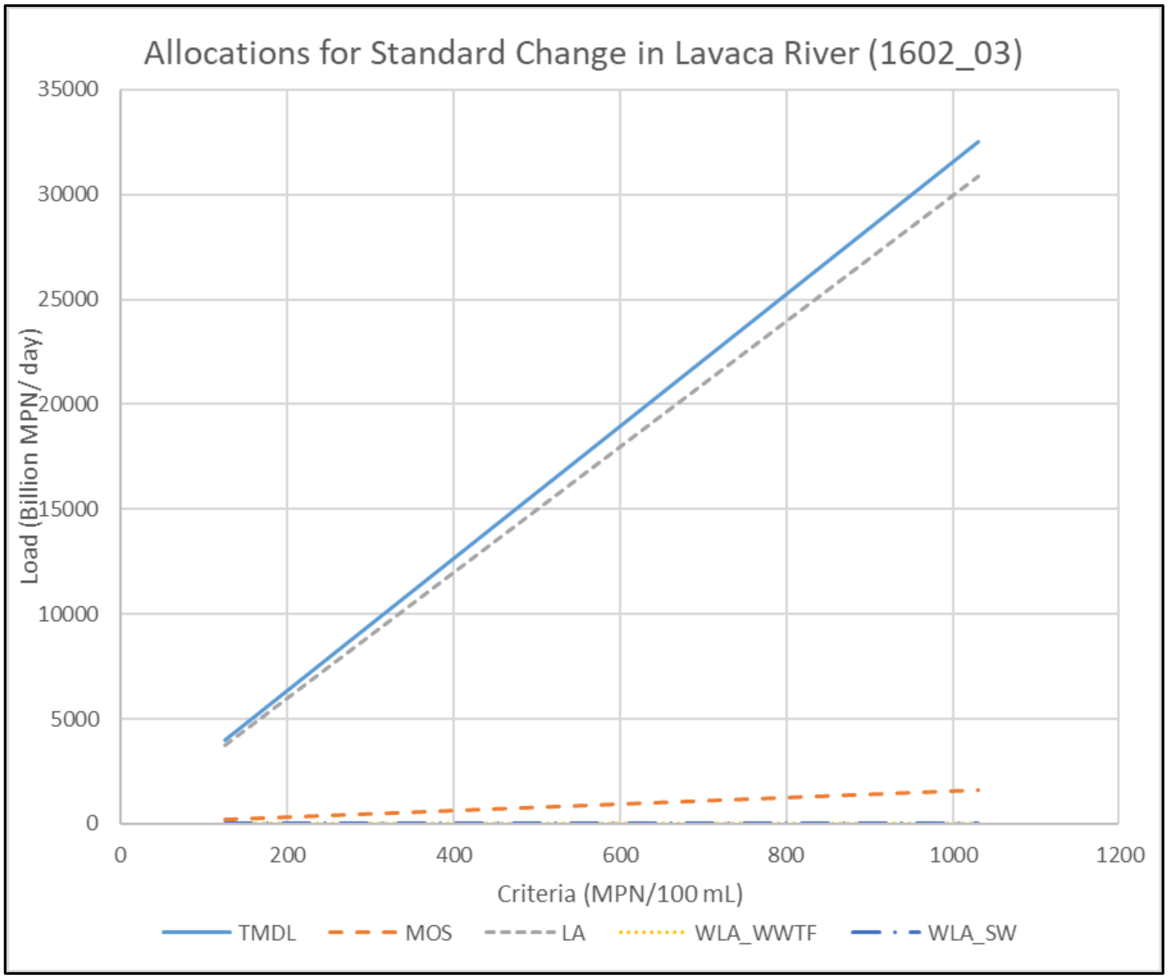

Figure A-1. Allocation loads for Lavaca River Above Tidal (AU 1602_03) as a function of water quality criteria

Equations for calculating new TMDL and allocations for Lavaca River Above Tidal (billion MPN/day):

$$TMDL = 31.5607727 * Std - 0.0000656$$

$$MOS = 1.5780386 * Std + 0.0000193$$

$$LA = 29.9677427 * Std - 15.0065858$$

$$WLA_{WWTF} = 15.014$$

$$WLA_{SW} = 0.0149914 * Std - 0.0074991$$

Where:

Std = Revised Contact Recreation Standard

MOS = Margin of Safety

LA = Total load allocation (unregulated source contributions)

WLA_{WWTF} = Wasteload allocation (permitted WWTF load + future growth)
[Note: WWTF load held at Primary Contact (126 MPN/100mL) criterion]

WLA_{SW} = Wasteload allocation (regulated stormwater)

Table A-1. Summary of allocation loads for Lavaca River Above Tidal (AU 1602_03) at selected revised water quality standards

Std (MPN/100mL)	TMDL†	MOS†	LA†	WLA_{WWTF}†*	WLA_{SW}†
126	3,976.657	198.833	3,760.929	15.014	1.881
630	19,883.287	994.164	18,864.671	15.014	9.437
1030	32,507.596	1,625.380	30,851.768	15.014	15.434

† in units of billion MPN/day *E. coli*

* WLA_{WWTF} includes the future potential allocation to wastewater treatment facilities and held at the primary contact criteria (126 MPN/100mL)

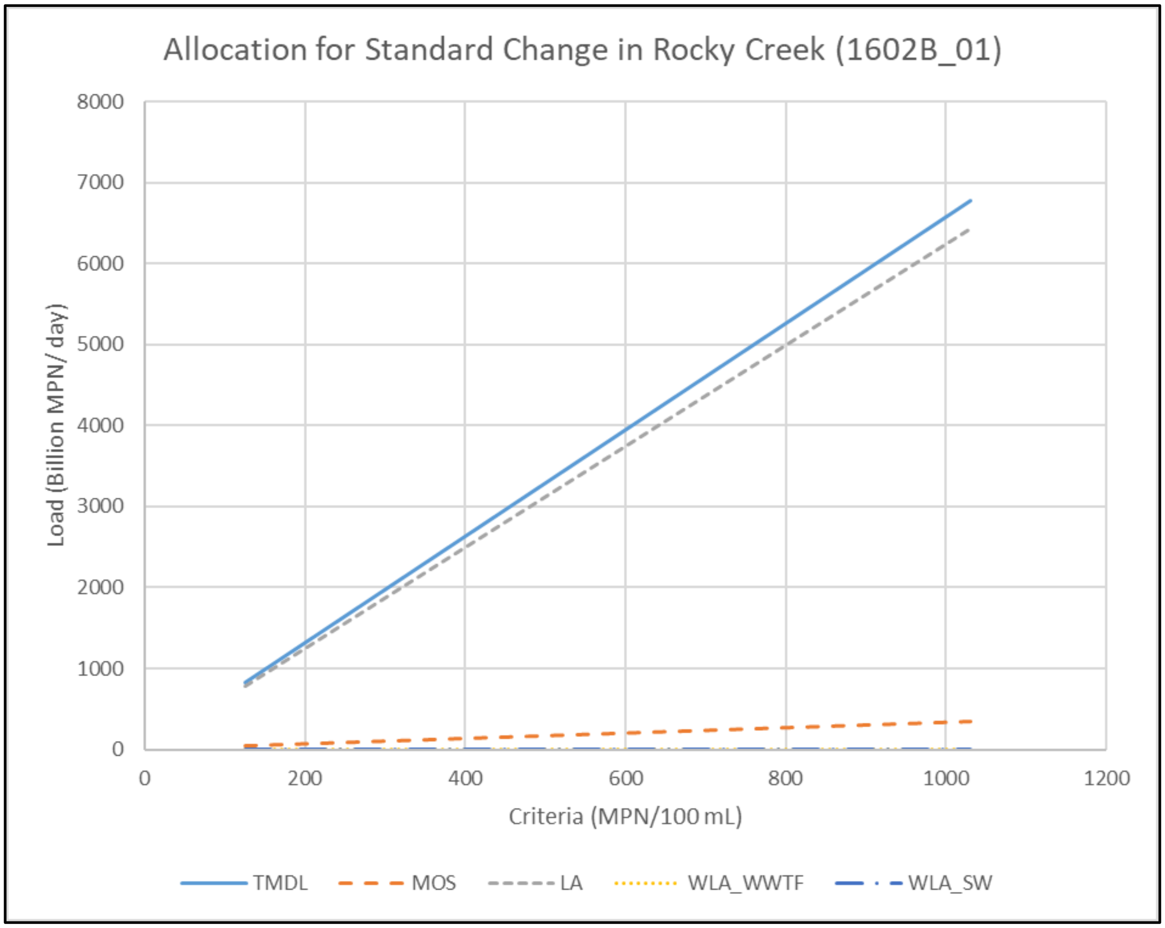

Figure A-2. Allocation loads for Rocky Creek (AU 1602B_01) as a function of water quality criteria

Equations for calculating new TMDL and allocations for Rocky Creek (billion MPN/day):

$$TMDL = 6.5732037 * Std$$

$$MOS = 0.3286602 * Std$$

$$LA = 6.24267015 * Std - 4.9445162$$

$$WLA_{WWTF} = 4.946$$

$$WLA_{SW} = 0.00187336 * Std - 0.0014838$$

Where:

Std = Revised Contact Recreation Standard

MOS = Margin of Safety

LA = Total load allocation (unregulated source contributions)

WLA_{WWTF} = Wasteload allocation (permitted WWTF load + future growth) [Note: WWTF load held at Primary Contact (126 MPN/ 100 mL) criterion]

WLA_{SW} = Wasteload allocation (regulated stormwater)

Table A-2. Summary of allocation loads for Rocky Creek (AU 1602B_01) at selected revised water quality standards

Std (MPN/100mL)	TMDL†	MOS†	LA†	WLA_{WWTF}†*	WLA_{SW}†
126	828.224	41.411	781.632	4.946	0.235
630	4,141.118	207.056	3,927.938	4.946	1.179
1030	6,770.400	338.520	6,425.006	4.946	1.928

† in units of billion MPN/day *E. coli*

* WLA_{WWTF} includes the future potential allocation to wastewater treatment facilities and held at the primary contact criteria (126 MPN/100mL)