Guadalupe River above Canyon Lake Watershed: Bacteria in Waters Used for Contact Recreation

- One TMDL Adopted July 25, 2007
  Approved by EPA September 25, 2007
- **Two TMDLs Added by Addendum January 2018**
  Approved by EPA May 8, 2018 (scroll to view or print this addendum)

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Addendum One to One Total Maximum Daily Load for Bacteria in the Guadalupe River Above Canyon Lake

Two Total Maximum Daily Loads for Indicator Bacteria in Quinlan Creek and Town Creek

For Segments 1806D and 1806E

Assessment Units 1806D_01 and 1806E_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted *One Total Maximum Daily Load for Bacteria in the Guadalupe River Above Canyon Lake: For Segment 1806* (TCEQ, 2007) on July 25, 2007. The total maximum daily loads (TMDLs) were approved by the United States Environmental Protection Agency (EPA) on September 25, 2007. This document represents an addendum to the original TMDL document.

This addendum includes information specific to two additional assessment units (AUs) located within the watershed of the approved TMDL project for bacteria in the Guadalupe River Above Canyon Lake. Concentrations of indicator bacteria in these AUs exceed the criteria used to evaluate attainment of the water quality standard for contact recreation. This addendum presents the new information associated with the two additional AUs. For background or other explanatory information, please refer to the *Technical Support Document for Total Maximum Daily Loads for Indicator Bacteria in Quinlan Creek and Town Creek: Segments 1806D and 1806E* (Brady and Hauck, 2017). Refer to the original, approved TMDL document for details related to the overall Guadalupe River Above Canyon Lake watershed as well as the methods and assumptions used in developing the original and addendum TMDLs.

The addendum watersheds, including the regulated facility within one of them, were addressed in the original TMDL or in subsequent updates to the state's Water Quality Management Plan (WQMP). This addendum provides the details related to developing the TMDL allocations for these additional AUs, which were not specifically addressed in the original TMDL document.

Problem Definition

The TCEQ first identified the bacteria impairments within the Quinlan Creek and Town Creek segments included within this addendum in the *2010 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (2010 Integrated Report; TCEQ, 2010a). These impairments have been included in subsequent iterations of this report, including the 2014 Integrated report, which is the most recently approved version (Table 1). The impaired AUs are Quinlan Creek (1806D_01) and Town Creek (1806E_01), as shown in Figure 1. Both creeks have a single AU. The project watershed is located in Kerr and Gillespie counties.

The Texas Surface Water Quality Standards (TSWQS; TCEQ, 2010b) provide numeric and narrative criteria to evaluate attainment of designated uses. The basis for water quality targets for all TMDLs developed in this report will be the numeric criteria for bacterial indicators from the 2010 TSWQS. *Escherichia coli* (*E. coli*) are the preferred indicator bacteria for assessing contact recreation use in freshwater.

Table 1. Synopsis of the 2014 Integrated Report for the addendum water bodies.
Source: (TCEQ, 2015a)

Water Body	Segment	AU	Parameter	Contact Recreation Use	Year First Impaired	Category
Quinlan Creek	1806D	1806D_01	*E. coli*	Nonsupport	2010	5a
Town Creek	1806E	1806E_01	*E. coli*	Nonsupport	2010	5a

Table 2 summarizes the ambient water quality data for the TCEQ surface water quality monitoring (SWQM) stations on each impaired water body, as reported in the 2014 Integrated Report. The 2014 assessment data indicate nonsupport of the primary contact recreation use for the two addendum AUs, because the geometric mean concentrations exceed the geometric mean criterion of 126 most probable number (MPN)/100 milliliters (mL) *E. coli*. Figure 2 shows the location of the SWQM and Upper Guadalupe River Authority (UGRA) monitoring stations as well as the only wastewater treatment facility (WWTF) in the project watershed, Hill Country Camp.

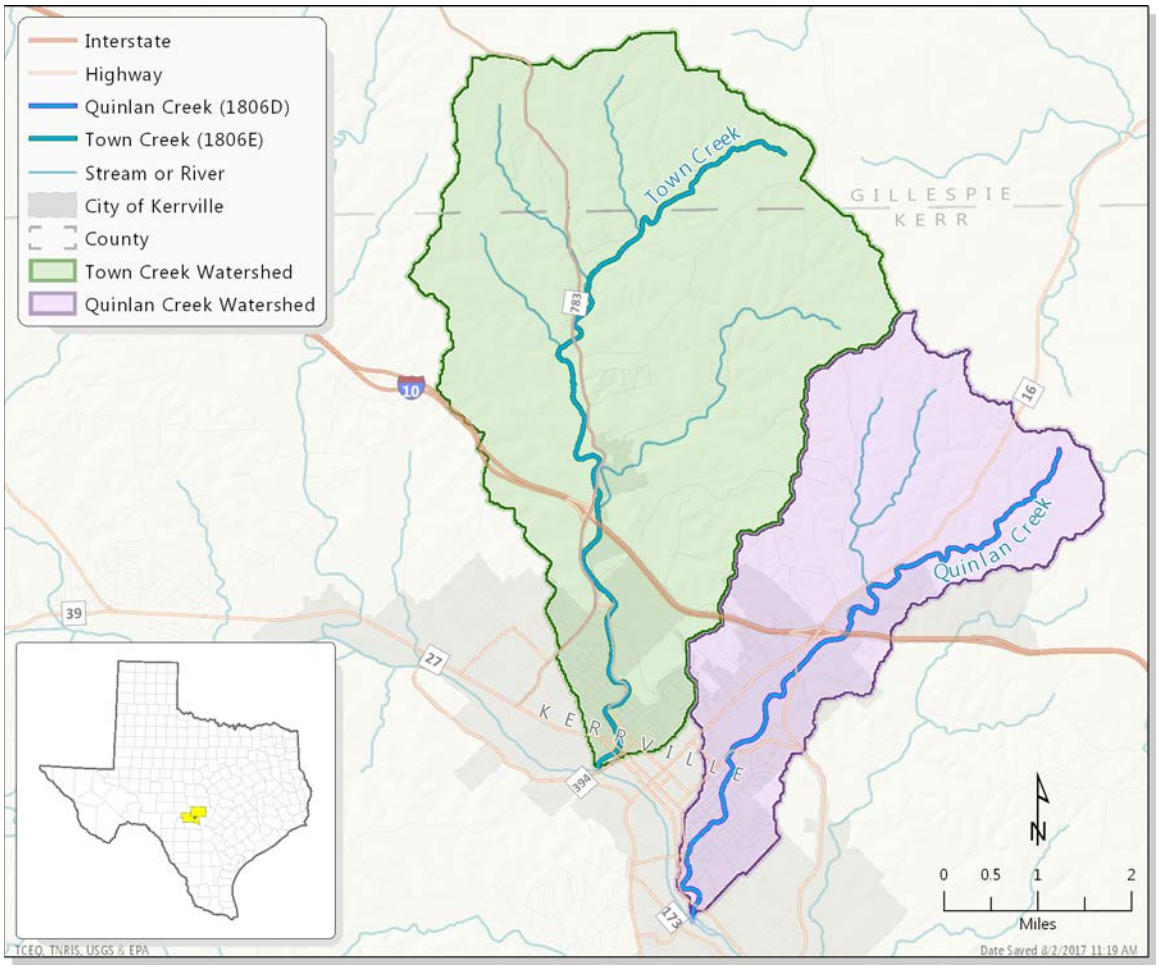

Figure 1. Overview map showing the watersheds for Quinlan Creek and Town Creek.

Source: (USGS and EPA, 2012)

Table 2. 2014 Integrated Report summary for the addendum TMDL AUs.

(The geometric mean criterion for primary contact recreation use is 126 MPN/100 mL of *E. coli*.)

Source: (TCEQ, 2015b)

Water Body	AU	Parameter	Number of Samples	Data Range	Station *E. coli* Geometric Mean (MPN/100 mL)
Quinlan Creek	1806D_01	*E. coli*	81	2005–2012	306.69
Town Creek	1806E_01	*E. coli*	66	2005–2012	251.20

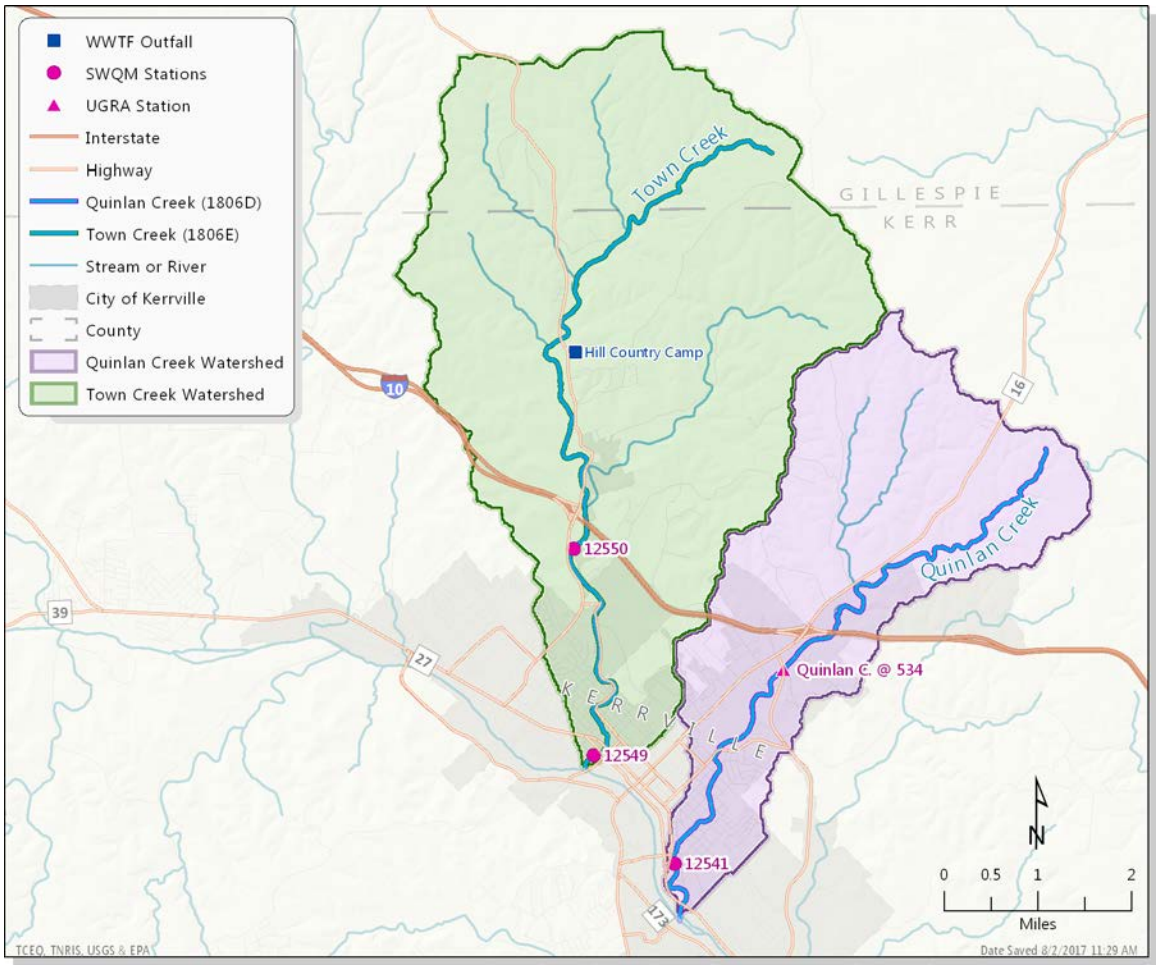

Figure 2. Map showing monitoring stations and the Hill County Camp WWTF outfall within the Quinlan Creek and Town Creek watersheds.

Source: (EPA, 2017)

Watershed Overview

Description of the Study Area

Quinlan Creek and Town Creek are adjacent water bodies and tributaries of the Guadalupe River Above Canyon Lake (Segment 1806). Both water bodies are located within the portion of the watershed of the Guadalupe River Above Canyon Lake addressed in the original TMDL document, as shown in Figure 3. This addendum incorporates a watershed approach where the drainage area of each creek is considered.

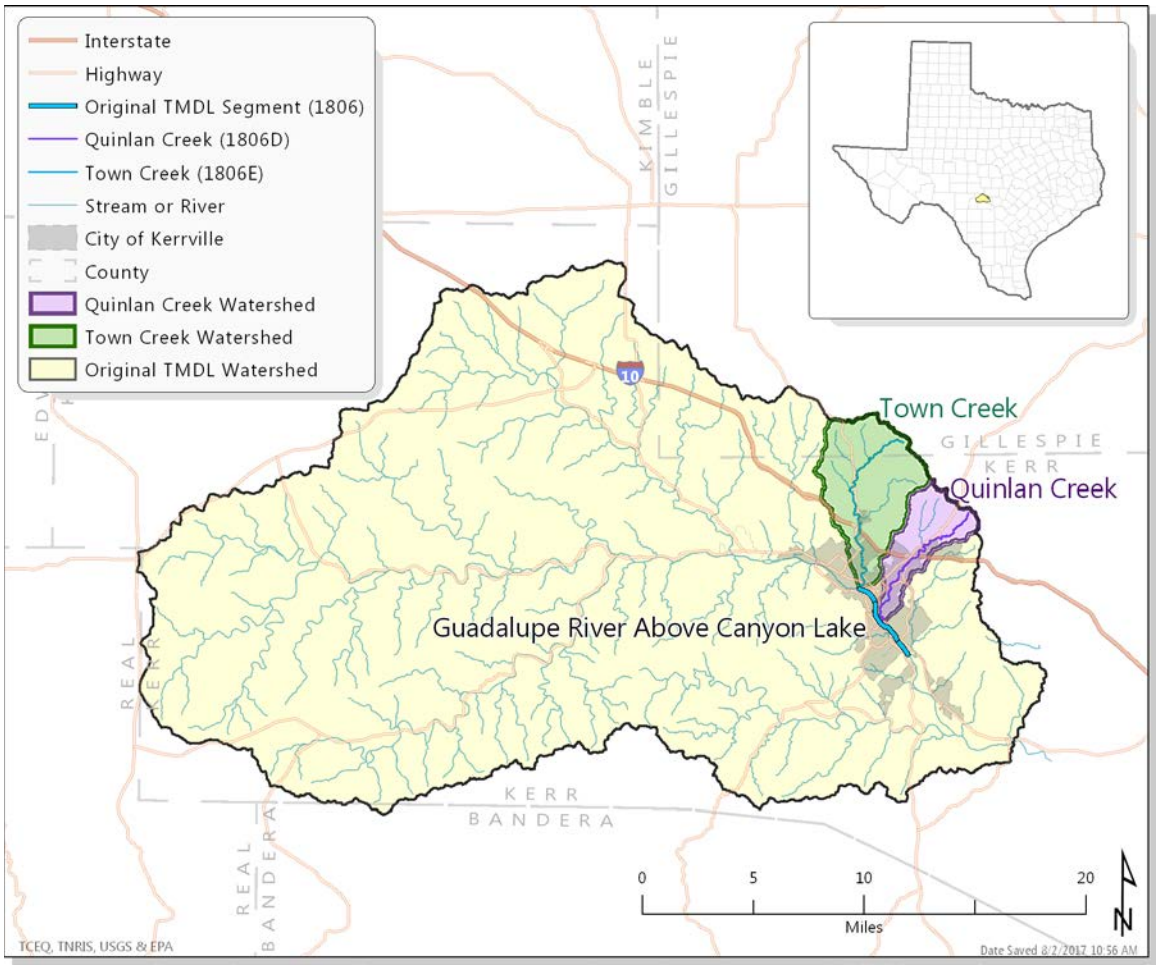

Figure 3. Map showing the Guadalupe River Above Canyon Lake TMDL watershed and the two watersheds considered in this addendum.

Quinlan Creek flows into the Guadalupe River in Kerrville, and is approximately 8.2 miles in length. At its mouth, Quinlan Creek drains an area of 11.7 square miles in Kerr County.

Town Creek flows into the Guadalupe River in Kerrville about two miles upstream of the Quinlan Creek confluence. Town Creek is approximately 9.6 miles long, and drains an area of 23.5 square miles in Kerr and Gillespie counties.

The segment and AU descriptions for the water bodies considered in this document are as follows:

- Quinlan Creek (AU 1806D_01): From the confluence of the Guadalupe River in Kerrville in Kerr County to the upstream perennial portion of the stream north of Kerrville in Kerr County (TCEQ, 2015a)
- Town Creek (AU 1806E_01): From the confluence of the Guadalupe River just upstream of FM 394 in Kerrville in Kerr County upstream to the headwaters in Gillespie County approximately 4.5 miles (7.4 km) north of Kerrville (P. Bohannon, personal communication, March 16, 2017)

Watershed Climate

The watersheds of Quinlan and Town creeks are in the central portion of Texas, classified as the Subtropical Subhumid climate region (Larkin and Bomar, 1983). As in much of the state, 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 and Bomar, 1983).

For the period from 1981–2010, average annual precipitation in the Quinlan Creek watershed was 31.5 inches, which is slightly higher than the average annual total precipitation for the Town Creek watershed of 31.0 inches (PRISM, 2012). This slight increase in precipitation, when moving from west to east, is concurrent with the statewide precipitation pattern, as shown in Figure 4.

In Kerrville, average high temperatures generally reach their peak of 94° Fahrenheit (F) in August (Figure 5), and highs above 100 °F have occurred from May through September (Arguez et al., 2010a). Fair skies generally accompany the highest temperatures of summer when nightly average lows drop to about 69 °F (Arguez et al., 2010a). During winter, the average low temperature reaches a minimum of 34 °F in January, although below-freezing temperatures have occurred from October through April (Arguez et al., 2010a). The frost-free period in Kerrville generally lasts for about 224 days, with the average last frost occurring March 29 and the average first frost occurring on November 8 (Arguez et al., 2010b).

Climate normals obtained from the National Oceanic and Atmospheric Administration (NOAA) for the Kerrville 3 NNE weather station (USC00414782, shown in Figure 4) indicate a bimodal precipitation pattern (Figure 5). The wettest months are typically May and June (4.0 inches each), followed by September and October (3.7 inches each), while January and August (at 1.6 and 1.7 inches, respectively) are normally the driest months.

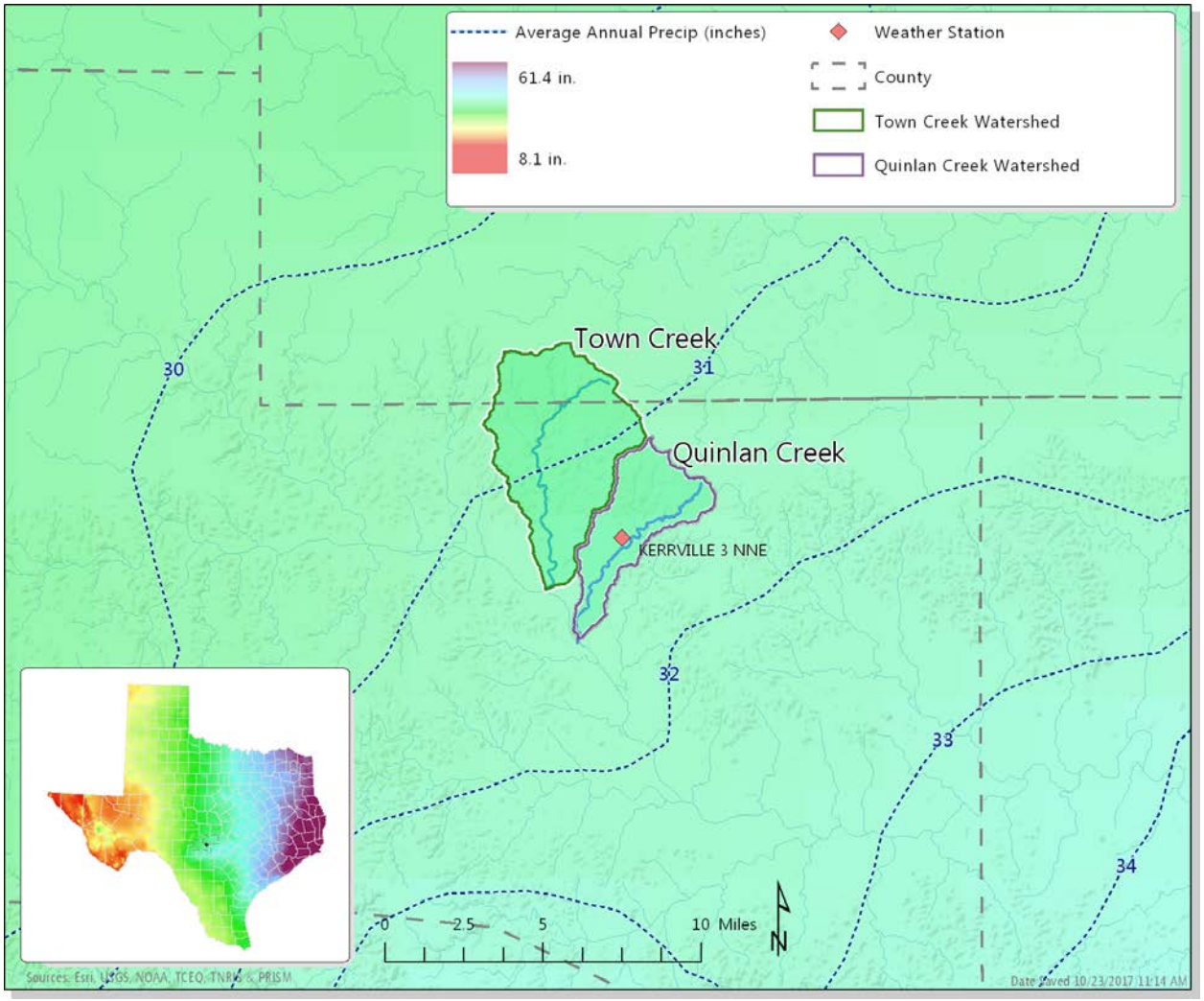

Figure 4. Annual average precipitation map showing isohyets (in inches) for areas in the vicinity of the Quinlan Creek and Town Creek watersheds (1981-2010).

Source: (PRISM, 2012)

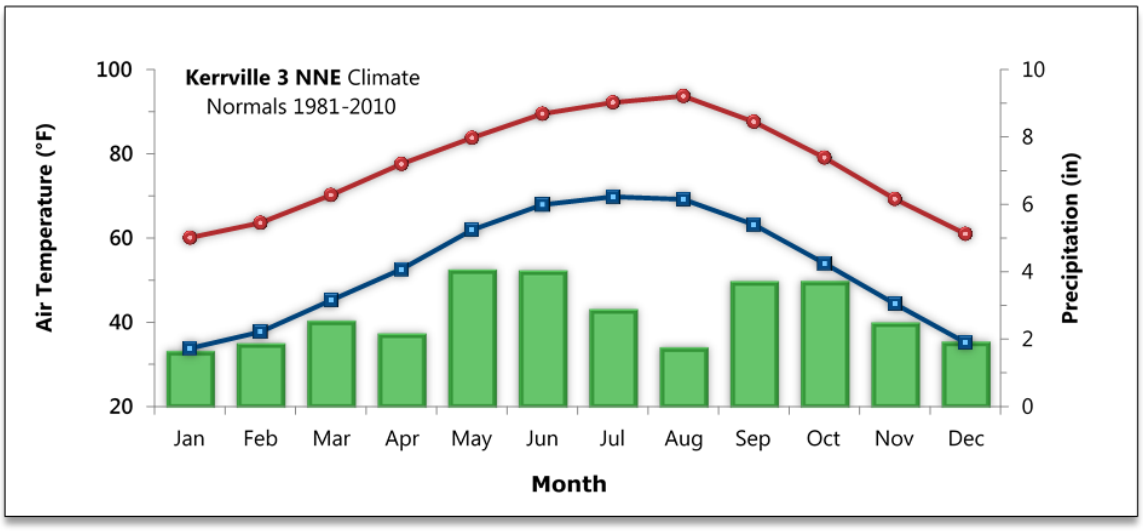

Figure 5. Chart showing the average minimum and maximum air temperature and total precipitation by month from 1981–2010 for the Kerrville 3 NNE weather station.

Source: (Arguez et al., 2010a)

Land Use

The land use/land cover data for the Quinlan Creek and Town Creek watersheds were obtained from the 2011 National Land Cover Database (NLCD; Homer et al., 2015) and are displayed in Figure 6.

As shown in Table 3, the watershed area encompassing Segment 1806D (Quinlan Creek watershed) is approximately 7,463 acres. Dominant land uses in the Quinlan Creek watershed include Evergreen Forest and Shrub/Scrub (both at 31 percent).

The watershed area encompassing Segment 1806E (Town Creek watershed) is about 15,028 acres and is also dominated by Evergreen Forest (41 percent) and Shrub/Scrub (32 percent).

Both watersheds are mostly rural, with only about 23 percent of the combined area classified as Developed. The Quinlan Creek watershed is more developed (33 percent) than the Town Creek watershed (18 percent).

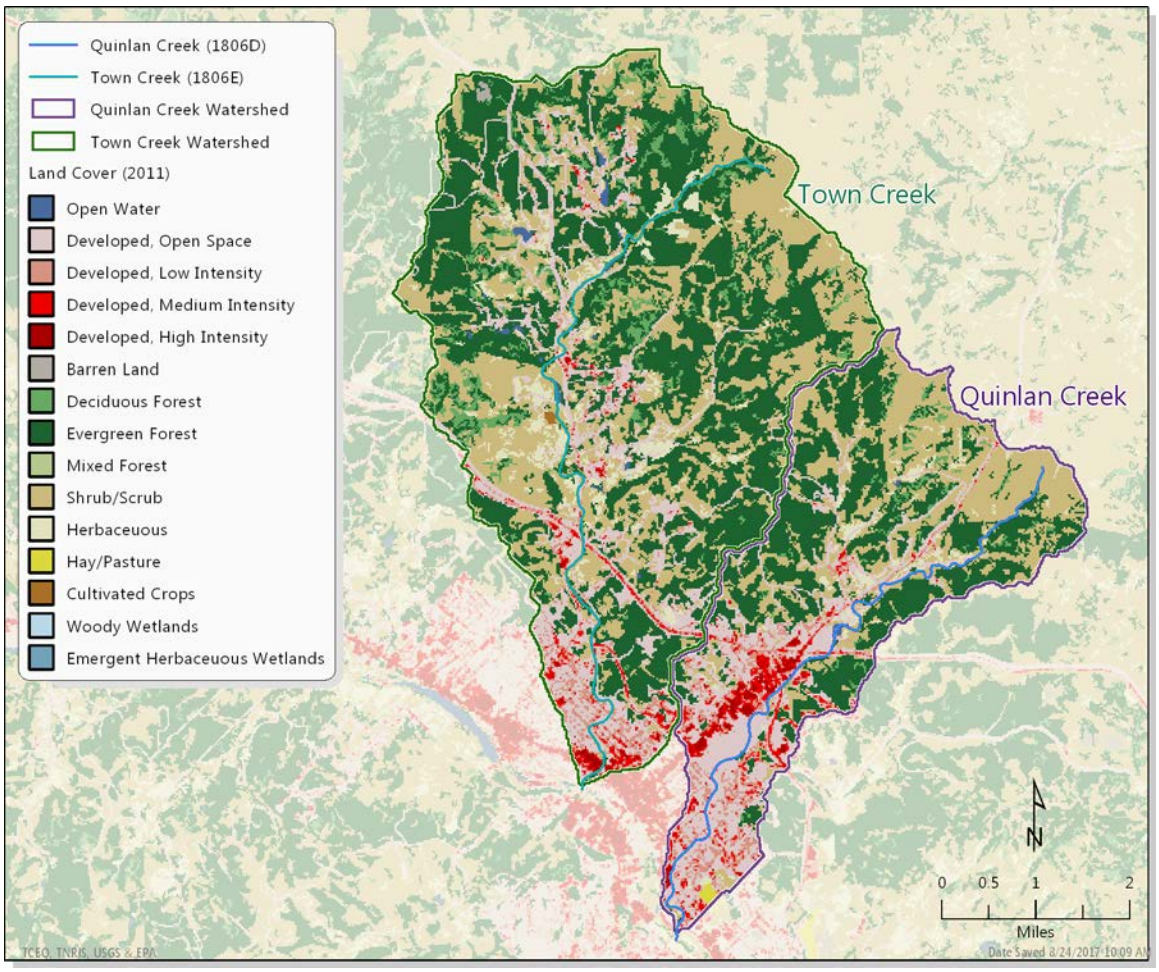

Figure 6. Land use/land cover map showing categories within the Quinlan Creek and Town Creek watersheds.

Source: (Homer et al., 2015)

Table 3. Land use/land cover within the Quinlan Creek and Town Creek watersheds.

Source: (Homer et al., 2015)

2011 NLCD Classification	Quinlan Creek Watershed		Town Creek Watershed	
	Acres	Percent of Total	Acres	Percent of Total
Open Water	8.5	0.1%	65.4	0.4%
Developed, Open Space	1,491.4	20.0%	1,930.4	12.8%
Developed, Low Intensity	539.1	7.2%	494.6	3.3%
Developed, Medium Intensity	289.8	3.9%	190.1	1.3%
Developed High Intensity	112.8	1.5%	50.3	0.3%
Barren Land (Rock/Sand/Clay)	-	-	15.8	0.1%
Deciduous Forest	154.6	2.1%	740.6	4.9%
Evergreen Forest	2,332.9	31.3%	6,169.0	41.1%
Shrub/Scrub	2,320.5	31.1%	4,770.8	31.7%
Herbaceous	193.5	2.6%	589.3	3.9%
Hay/Pasture	19.8	0.3%	-	-
Cultivated Crops	-	-	8.7	0.1%
Woody Wetlands	-	-	2.9	0.0%
Total	**7,462.9**	**100%**	**15,027.9**	**100%**

Watershed Population and Population Projections

According to the 2010 Census (USCB and TNRIS, 2017), there are an estimated 5,901 people in the Quinlan Creek watershed, indicating a population density of 506 people/square mile. The majority of the population (5,333 people, or 90 percent) lives within the Kerrville city limits (Figure 7). Approximately 34 percent of the area in the watershed is included within the Kerrville city boundary.

Also according to the 2010 Census, there are an estimated 5,314 people in the Town Creek watershed, indicating a population density of 226 people/square mile. The majority of the population (3,903 people, or 73 percent) lives within the Kerrville city limits (Figure 7). Approximately 11 percent of the area in the watershed is included within the Kerrville city boundary.

Geospatial analysis based on water user groups (WUGs), which allows a refinement of county and city-level projections developed by the Office of the State Demographer and the Texas Water Development Board (TWDB, 2016), reveals that populations are predicted to increase 14.0 percent in the Quinlan Creek watershed and 15.8 percent in the Town Creek watershed between 2010 and 2050 (Table 4).

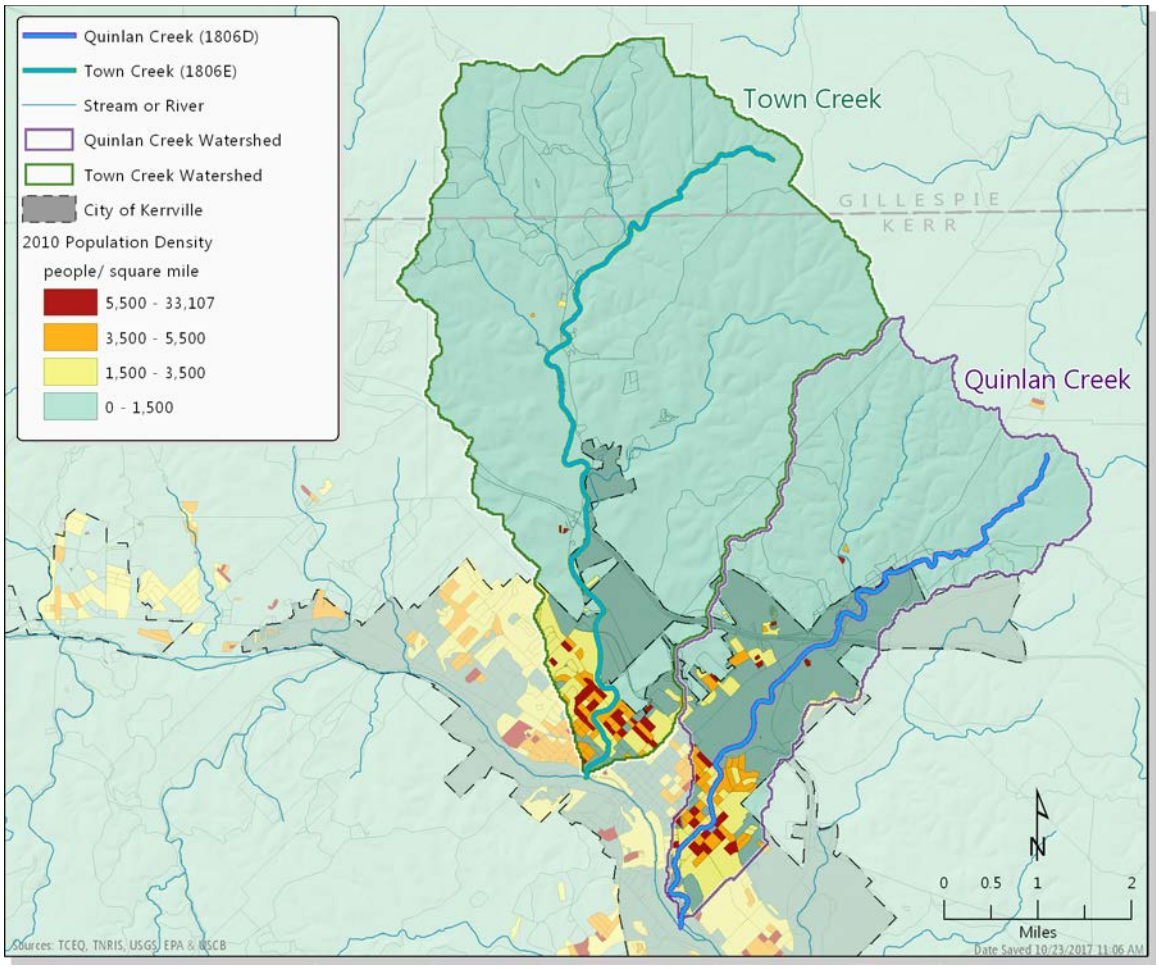

Figure 7. Population density map showing 2010 population by census block, along with the city of Kerrville boundary.

Source: (USCB and TNRIS, 2017)

Table 4. 2010 Population and 2020–2050 Population Projections for the Quinlan Creek and Town Creek watersheds.

Sources: (USCB and TNRIS, 2017; TWDB, 2016)

Watershed	Area (WUG)	2010 U.S. Census	Population Projections				Popu-lation Change (2010-2050)	Percent Increase (2010-2050)
			2020	2030	2040	2050		
Quinlan Creek	Kerrville	5,333	5,569	5,782	5,907	6,032	+699	13.11%
	Kerr County, outside Kerrville	568	609	649	673	696	+128	22.54%
	Total	**5,901**	**6,178**	**6,431**	**6,580**	**6,728**	**+827**	**14.01%**
Town Creek	Kerrville	3,903	4,076	4,231	4,323	4,415	+512	13.11%
	Kerr County, outside Kerrville	1,103	1,184	1,261	1,306	1,351	+248	22.48%
	Gillespie County, outside Fredericks-burg	308	317	343	363	388	+80	25.97%
	Total	**5,314**	**5,577**	**5,835**	**5,992**	**6,154**	**+840**	**15.81%**

Endpoint Identification

The endpoint for the TMDL is to maintain the concentration of *E. coli* below the geometric mean criterion of 126 MPN/100mL. This endpoint was applied to both AUs addressed by this TMDL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 TSWQS (TCEQ, 2010b).

Source Analysis

Regulated Sources

Permitted sources are regulated under the Texas Pollutant Discharge Elimination System (TPDES) and the National Pollutant Discharge Elimination

System (NPDES) programs. WWTF outfalls and stormwater discharges from industries and construction sites represent the regulated sources in the project watershed.

Domestic and Industrial WWTFs

Currently, no WWTFs exist within the Quinlan Creek watershed, and a single facility (Hill Country Camp; TPDES permit number 14832-002) within the Town Creek watershed treats domestic wastewater (Figure 2). The facility's current permit was issued in April 2016. The available discharge monitoring report (DMR) data indicate that there has been no discharge from May 2016 through February 2017. Table 5 summarizes the information for this permit.

Table 5. Permitted WWTF in the the Quinlan Creek and Town Creek watersheds.

Source: Individual TPDES Permit

TPDES Permit Number	NPDES Permit Number	Facility	AU	TMDL Receiving Waters	Final Permitted Discharge (MGD[1])	Average Discharge (MGD)
14832-002	TX0136298	Hill Country Camp	1806E_01	Unnamed Tributary; thence to Town Creek	0.025	No Discharge[2]

[1] MGD = million gallons per day

[2] From EPA Enforcement and Compliance History Online (ECHO), May 2016–February 2017. Additionally, indicated to be operating and using effluent for irrigation, with no discharge (T. Bushnoe, personal communications, April 5, 2017).

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party. The TCEQ Region 13 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 summary of the reports of SSO events that were determined to have occurred within the Quinlan Creek and Town Creek watersheds between January 2012 and December 2016 are shown in Table 6.

Table 6. Summary of SSO incidences reported in the Quinlan Creek and Town Creek watersheds from 2012–2016.

Source: TCEQ Region 13

AU	Number of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
1806D_01	9	4,555	506	15	2,940
1806E_01	13	3,990	307	10	1,200

TPDES-Regulated Stormwater

TPDES general permits cover stormwater discharges from Phase II urbanized areas, industrial facilities (General Permit number TXR050000), concrete production facilties (General Permit number TXG110000), and construction sites over one acre (General Permit number TXR150000). A review of active stormwater general permits coverage (TCEQ, 2017) in the Quinlan Creek watershed as of June 8, 2017, found one active industrial facility and one active concrete production facility. A concurrent review of active stormwater general permits coverage in the Town Creek watershed found one active industrial facility and two active construction sites. There are currently no Phase II municipal separate storm sewer systems (MS4s) in either watershed. Table 7 summarizes the area in each watershed covered by general stormwater permits.

Table 7. Summary of land area (acres / % of watershed) covered by general stormwater permits in the Quinlan Creek and Town Creek watersheds as of June 8, 2017.

Source: TCEQ Water Quality General Permits & Registration Search (TCEQ, 2017)

AU	MS4	Industrial	Construction	Concrete Production	Total Area of General Permits
1806D_01	0 / 0.000%	14 / 0.188%	45 / 0.603%	4 / 0.054%	63 / 0.844%
1806E_01	0 / 0.000%	27 / 0.180%	53 / 0.353%	0 / 0.000%	80 / 0.532%

Unregulated Sources

Unregulated sources of indicator bacteria are generally nonpoint and can originate from wildlife and feral hogs, various agricultural activities, agricultural animals, land application fields, urban runoff not covered by a permit, failing onsite sewage facilities (OSSFs), and domestic pets.

Wildlife and Unmanaged Animal Contributions

E. coli bacteria are common inhabitants of the intestines of all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify the potential for bacteria contributions from wildlife. Riparian corridors of streams and rivers naturally attract wildlife. With direct access to the stream channel, direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Wildlife also deposit fecal bacteria onto land surfaces, where rainfall runoff may wash bacteria into nearby streams.

For feral hogs, the Texas A&M Institute of Renewable Natural Resources (IRNR), recently renamed as the Texas A&M Natural Resources Institute, reported a range of feral hog densities within Texas of 1.33 to 2.45 hogs/square mile (IRNR, 2013). The average hog density (1.89 hogs/square mile) was multiplied by

the hog-habitat area in the Quinlan Creek and Town Creek watersheds (7.85 and 19.19 square miles, respectively). Habitat deemed suitable for hogs followed as closely as possible to the land use selections of the IRNR study and include from the 2011 NLCD: Pasture/Hay, Cultivated Crops, Shrub/Scrub, Grassland/Herbaceous, Deciduous Forest, Evergreen Forest, and Woody Wetlands. Table 8 identifies the estimated feral hog population for each AU watershed.

For deer, the Texas Parks and Wildlife Department (TPWD) publishes data showing deer population-density estimates by deer management unit (DMU) across the state (TPWD, 2017). Spatial analysis using DMU and white-tailed deer range layers provided by TPWD reveals that for the Quinlan Creek watershed, 3,009 acres are within DMU 5, and 1,373 acres are within DMU 7 North. For the Town Creek watershed, 13,023 acres are within DMU 5. The 2017 population densities for those DMUs are 9.58 acres/deer (DMU 5) and 6.45 acres/deer (DMU 7 North). Table 8 identifies the estimated deer population for each AU watershed.

Table 8. Estimated feral hog and deer populations in the Quinlan Creek and Town Creek watersheds.

Sources: (INRI, 2013; TPWD, 2017)

AU	Feral Hogs	Deer
1806D_01	15	527
1806E_01	36	1,359

Domesticated Animals

Livestock are a potential source of bacteria in the project watershed. The numbers of livestock that are found within the Quinlan Creek and Town Creek watersheds were estimated from county level data obtained from the 2012 Census of Agriculture (USDA NASS, 2014; Table 9). The county-level data were refined to better reflect actual numbers within the impaired AU watersheds. Using the 2011 NLCD, the refinement was performed by determining the total area of the suitable livestock land cover categories of Grassland/Herbaceous and Pasture/Hay within the Quinlan Creek watershed and Kerr County. A ratio was then computed by dividing the livestock total land use area of the watershed by the livestock total land use area of the county. The county-level agricultural census data were then multiplied by the ratio to determine the estimated Quinlan Creek watershed domestic animal populations. For Town Creek, the same approach was used, but Gillespie County informaion was also included in the calculations. These numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Table 9. Estimated total livestock inventory, by commodity, for Quinlan Creek and Town Creek watersheds in 2012.

Source: (USDA NASS, 2014)

AU	Cattle and Calves	Deer and Elk (Domestic)	Goats and Sheep	Horses, Ponies, Mules, Burros, and Donkeys	Poultry
1806D_01	66	44	125	11	17
1806E_01	201	99	356	27	45

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 10 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 (AVMA, 2012). The actual contribution and significance of bacteria loads from pets reaching the water bodies of the impaired AU watersheds is unknown.

Table 10. Estimated households and pet populations for the Quinlan Creek and Town Creek watersheds.

Source: (AVMA, 2012)

AU	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
1806D_01	2,583	1,508	1,648
1806E_01	2,472	1,444	1,577

OSSFs

Estimates of the number of OSSFs in the Quinlan Creek and Town Creek watersheds were based on 9-1-1 building locations received from the Kerr Emergency 9-1-1 Network (T. Bushnoe, personal communication, April 6, 2017). For the areas of the Quinlan Creek and Town Creek watersheds, OSSFs were estimated to be households that were outside of either a Certificate of Convenience and Necessity (CCN) sewer area (PUC, 2016) or a city boundary (TNRIS, 2016). The estimated number of OSSFs by watershed using the 9-1-1 addresses is provided in Table 11, and potential OSSF locations are presented in Figure 8.

Table 11. OSSF estimate for the Quinlan Creek and Town Creek watersheds.

Sources: (Kerr Emergency 9-1-1 Network; PUC, 2016; and TNRIS, 2016)

AU	Estimated OSSFs
1806D_01	298
1806E_01	933

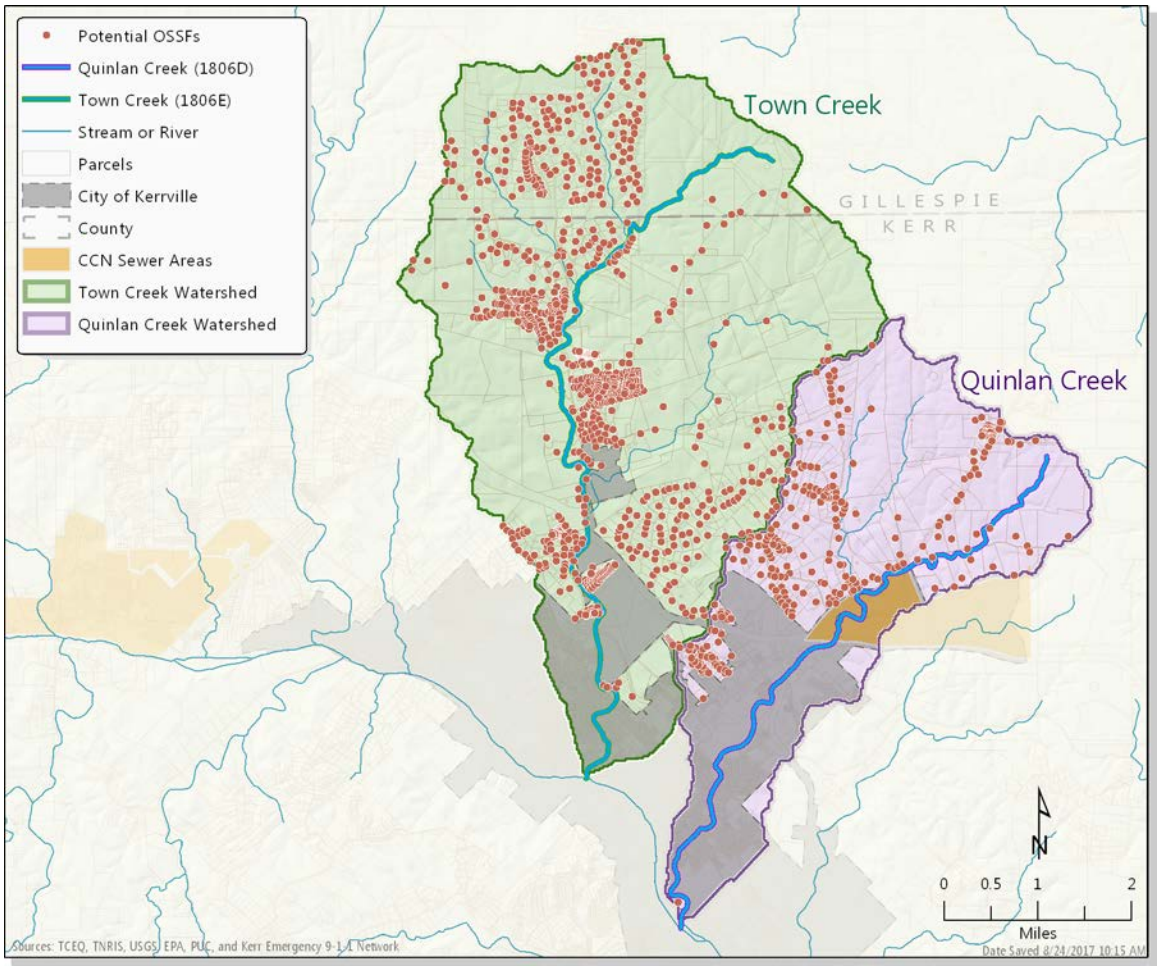

Figure 8. OSSF locations within the Quinlan Creek and Town Creek watersheds.

Sources: (Kerr Emergency 9-1-1 Network; PUC, 2016; and TNRIS, 2016)

Linkage Analysis

Load duration curves (LDCs) were used to examine the relationship between instream water quality and the source of indicator bacteria loads. 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 non-regulated sources. Further, this one-to-one relationship was also inherently assumed when using LDCs to define the TMDL pollutant load allocation. The LDC method allows for estimation of existing and TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating stream loads, this method allows for the

determination of the hydrologic conditions under which impairments are typically occurring, can give indications of the broad origins of the bacteria (i.e., point source and stormwater), and provides a means to allocate allowable loadings. The technical support document (Brady and Hauck, 2017) provides details about the analyses, tools, and their applications.

Margin of Safety

The margin of safety (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. The TMDLs covered by this report incorporate an explicit MOS by setting a target for indicator bacteria loads that is 5 percent lower than the geometric mean criterion.

Pollutant Load Allocation

The TMDL component for the two impaired AUs covered in this report are derived using the median flow within the High Flows regime (or 5 percent flow) of the LDC developed for the sampling station located near the outlet of each AU watershed.

Based on the LDCs to be used in the pollutant load allocation process with historical *E. coli* data added to the graphs (Figures 9 and 10), the following broad linkage statements can be made. For both the Quinlan Creek and Town Creek watersheds, the historical *E. coli* data indicate that elevated bacteria loadings occur under all flow conditions, but become most elevated under the highest flows and are often below the single sample criterion under the lowest flows. Regulated stormwater comprises a small portion of the watershed (0.84 percent for the Quinlan Creek watershed and 0.53 percent for the Town Creek 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 to WWTFs since the DMR records for the single WWTF in the Town Creek watershed indicate “no discharge” and the Quinlan Creek watershed contains no permitted WWTFs. 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 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.

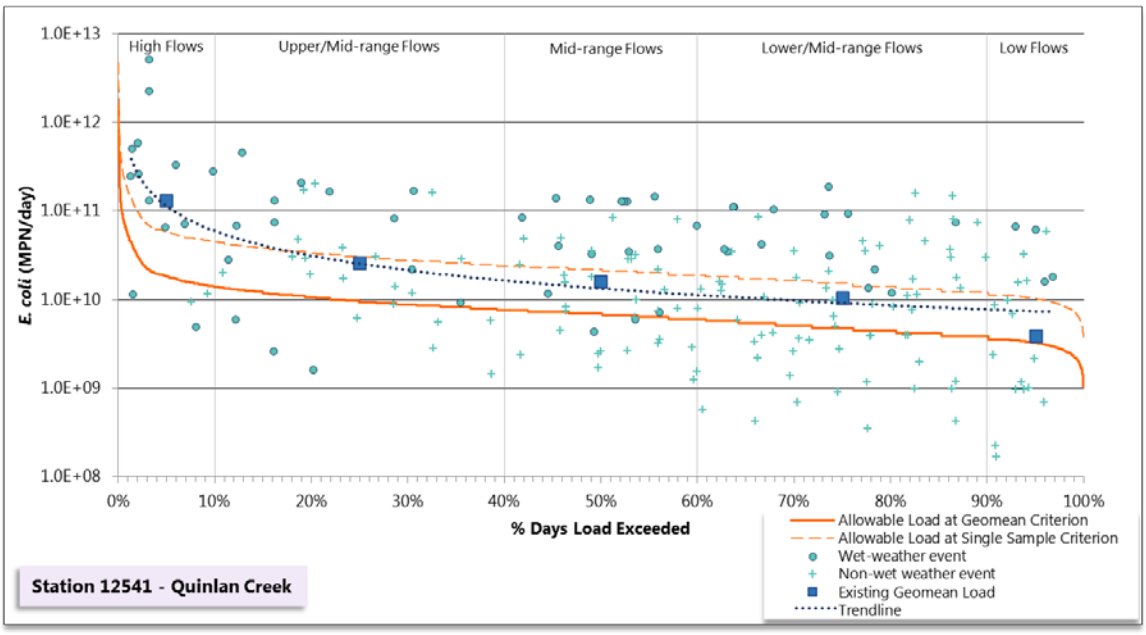

Figure 9. LDC for Quinlan Creek (Station 12541).

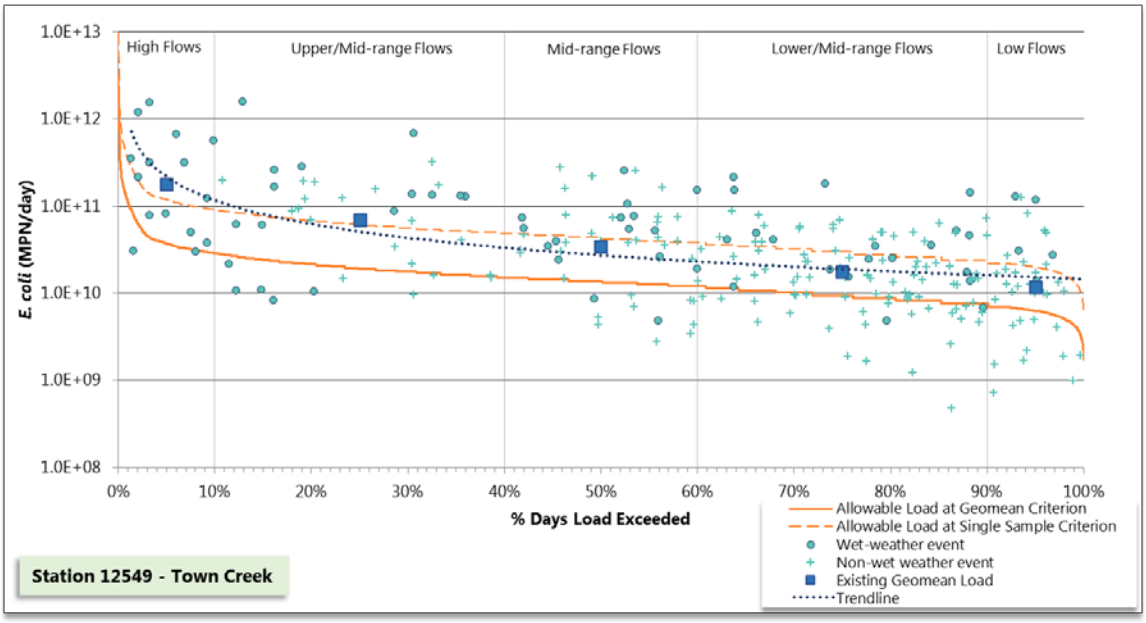

Figure 10. LDC for Town Creek (Station 12549).

Wasteload Allocation

The wasteload allocation (WLA) is the sum of loads from regulated sources, which are WWTFs and regulated stormwater.

WWTFs

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by the instream geometric mean criterion. The *E. coli* primary contact recreation geometric mean criterion of 126 MPN/100mL is used as the WWTF target. Table 12 presents the WLA for the WWTF located in the project watershed.

Table 12. Summary of WLAs for WWTFs in the the Quinlan Creek and Town Creek watersheds.

TPDES / NPDES Permit	Facility	Final Permitted Discharge (MGD)	*E. coli* Permit Limit (MPN/100 mL)	*E. coli* WLA_{WWTF} (Billion MPN/day)
not applicable	-	-	-	-
1806D_01 Total WLA_{WWTF}				0.000
14832-002 / TX0136298	Hill Country Camp	0.025	126	0.119
1806E_01 Total WLA_{WWTF}				0.119

Regulated Stormwater

Stormwater discharges from MS4, industrial, and construction sites are also 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 land area included in each watershed that is under the jurisdiction of stormwater permits is used to estimate the amount of overall runoff load that should be allocated as the permitted stormwater contribution in the WLA_{SW} component of the TMDL. For the construction activities general permits, the authorization contains an “Area Disturbed” field. Due to the variable and temporary nature of construction projects, it was preferable to average the acreages (on a monthly basis) associated with active permits over the most recent 10 years of the available period of record. The results of this temporal averaging were used as representative of the average area under construction activities stormwater permits. The percentage of land under the jurisdiction of stormwater permits in each watershed was less than 1 percent (0.84 percent for Quinlan Creek and 0.53 percent for Town Creek).

Load Allocation

The load allocation (LA) component of the TMDL corresponds to runoff from unregulated sources. It is calculated by subtracting the sum of the WLA_{WWTF}, WLA_{SW}, MOS, and future growth (FG) allocations from the total TMDL allocation.

Future Growth

The FG component of the TMDL equation addresses the requirement of TMDLs to account for future loadings that might occur as a result of population growth, changes in community infrastructure, and development. The assimilative capacity of streams increases as the amount of flow increases. Increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard.

For this TMDL, the conventional FG calculation is affected by the scarcity of WWTFs. In this case, the single WWTF (located within the Town Creek watershed) is associated with a camp (Table 12), rather than a community or municipality. By using TCEQ design guidance for domestic WWTFs, and assuming the potential for a residential development of a density sufficient to require centralized sewer collection, an alternative method was implemented.

According to Rule § 217.32 of the Texas Administrative Code (TAC), new WWTFs are to be designed for a daily wastewater flow of 75–100 gallons per capita per day (TAC, 2008). Conservatively taking the higher daily wastewater flow capacity (100 gallons) and multiplying it by a potential population change would result in a permitted flow for FG. Based on the information in Table 4, the projected population change for unincorporated areas of the subject watersheds for the 2010–2050 time period is 128 in the Quinlan Creek watershed and 328 in the Town Creek watershed. Conservatively assuming a larger population consistent with a potential residential development—1,000 people—and multiplying that by the higher daily wastewater flow capacity yields a value of 0.10 MGD. This value would be considered the full permitted discharge of a potential future WWTF.

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

TMDL Calculations

Table 13 summarizes the TMDL calculations for the Quinlan Creek and Town Creek watersheds. Each of the TMDLs was calculated based on median flow in the 0–10 percentile range (5 percent exceedance, High Flows regime) for flow exceedance from the LDC developed for the the downstream SWQM station in each watershed (12541 and 12549, respectively). Allocations are based on the current geometric mean criterion for *E. coli* of 126 MPN/100mL for each component of the TMDL.

The final TMDL allocations (Table 14) needed to comply with the requirements of 40 Code of Federal Regulations (CFR) § 103.7 include the FG component within the WLA_{WWTF}.

In the event that the criterion changes due to a change in the designated recreational use, Appendix A provides guidance for recalculating the allocations in Table 14.

Table 13. TMDL allocation summary for the Quinlan Creek and Town Creek watersheds.

All loads expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS	FG
1806D_01	18.291	0	0.143	16.756	0.915	0.477
1806E_01	37.428	0.119	0.186	34.775	1.871	0.477

Table 14. Final TMDL allocations for the Quinlan Creek and Town Creek watersheds.

All loads expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}[1]	WLA_{SW}	LA	MOS
1806D_01	18.291	0.477	0.143	16.756	0.915
1806E_01	37.428	0.596	0.186	34.775	1.871

[1] WLA_{WWTF} includes the future potential allocation to WWTFs

For the previous TMDL on the Guadalupe River Above Canyon Lake (TCEQ, 2007), pollutant load allocations were determined from the median flow of each of the five flow regimes comprising the LDCs: 5 percent exceedance for High Flows (0–10 percent), 25 percent exceedance for Moist Conditions (10–40 percent), 50 percent exceedance for Mid-range Flow (40–60 percent), 75 percent exceedance for Dry Conditions (60–90 percent), and 95 percent exceedance for Low Flows (90–100 percent). For more recent bacteria TMDLs across Texas, the TCEQ has considered only the median value of the highest designated flow regime in the pollutant load allocations. For consistency with the original Guadalupe River Above Canyon Lake TMDL, the pollutant load allocations for each of the five flow regimes are provided in Appendix B.

Seasonal Variation

Federal regulations in 40 CFR § 130.7(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 12 years (2005–2016) of routine monitoring collected in the warmer months (May–September) against those collected during the cooler months (October–April). Differences in *E. coli* concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log transformed dataset. This analysis of *E.coli* data indicated that there was a significant difference in indicator bacteria between cool and warm weather seasons for both Quinlan Creek (two-sample t (n = 188) = 3.58, p = 0.436E-04) and Town Creek (two-sample t (n = 230) = 4.24, p = 3.21E-05), with the warm season having the higher concentrations.

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the TMDL study, the TCEQ 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 technical support document for these TMDL additions (Brady and Hauck, 2017) was posted on the TMDL project page at: <www.tceq.texas.gov/assets/public/waterquality/tmdl/65guadalupe/65-quinlantown-tsd-final.pdf> on September 8, 2017. Stakeholders were consulted on the addendum to these TMDLs through a public meeting held in Kerrville on December 14, 2017, where the results of the study were presented by the TCEQ project manager. This is an ongoing process, so notice of the public comment period for this addendum will be sent to the stakeholders and posted on the TCEQ's TMDL Program online news page at <www.tceq.texas.gov/waterquality/tmdl/tmdlnews.html>, and the document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. The public will have an opportunity to comment on this addendum during a 30-day WQMP update public comment period (February 9–March 12, 2018).

TCEQ accepted public comments on the original TMDL during the period March 23–April 23, 2007. Three comments were submitted, and none of them referred directly to the AUs in this TMDL addendum. TCEQ accepted public comments on the corresponding Implementation Plan (I-Plan) during the period April 23–May

23, 2011. Three comments were submitted, and none of them referred directly to the AUs in this TMDL addendum.

Implementation and Reasonable Assurance

The two segments and AUs covered by this addendum are within the existing bacteria TMDL watershed of the Guadalupe River Above Canyon Lake. These watersheds are within the area covered by the I-Plan developed with the assistance of local stakeholders. The I-Plan (TCEQ, 2011) was approved by the TCEQ on August 31, 2011. It outlines an adaptive management approach in which measures are periodically assessed for efficiency and effectiveness. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals, and expresses stakeholder commitment to the process.

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Appendix A

Equations for Calculating TMDL Allocations for Contact Recreation Standard Changes

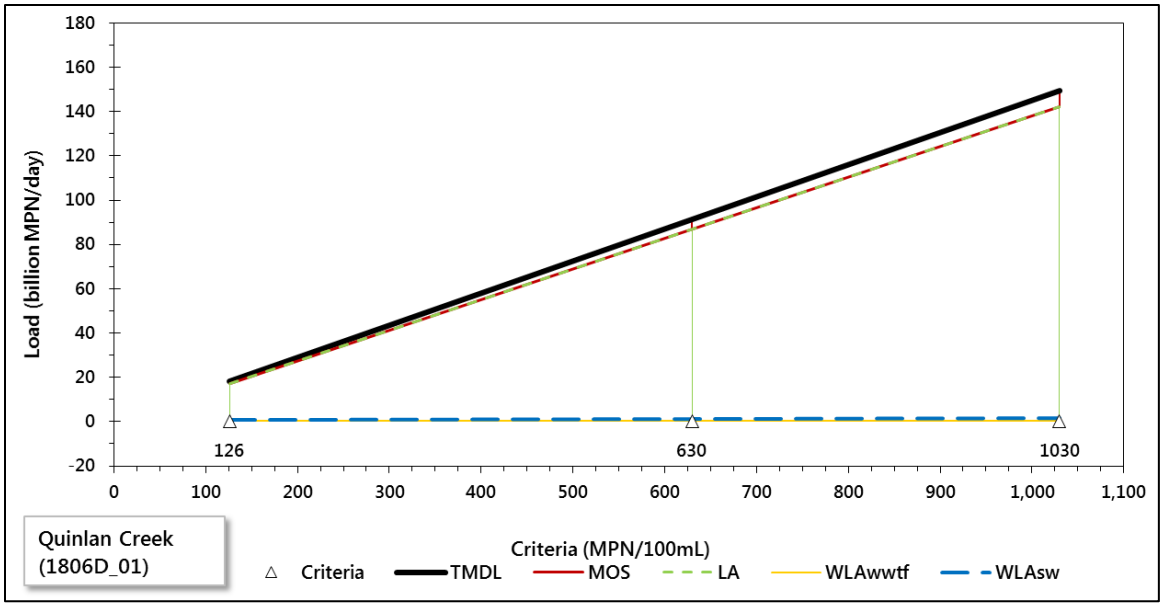

Figure A-1. *E. coli* allocation loads for Quinlan Creek (1806D_01) as a function of water quality criteria.

Equations for calculating new TMDL and allocations (in billion MPN/day *E. coli*) for Quinlan Creek (1806D_01):

TMDL = 0.14516487 * Std
MOS = 0.00725824 * Std
LA = 0.13674242 * Std - 0.47297317
WLA_{WWTF} = 0.47700000
WLA_{SW} = 0.00116421 * Std - 0.00402683

Where:

Std = Revised Water Quality Standard
MOS = Margin of Safety
LA = Total load allocation (non-permitted source contributions)
WLA_{WWTF} = Wasteload allocation (permitted WWTF + FG) [Note: WWTF load held at existing primary contact (126 MPN/100mL) criteria]
WLA_{SW} = Wasteload allocation (permitted stormwater)

Table A-1. Summary of allocation loads for Quinlan Creek (1806D_01) at selected revised water quality standards.

All loads expressed as billion MPN/day *E. coli*

Std (MPN/100mL)	TMDL	MOS	LA	WLA_{WWTF}[1]	WLA_{SW}
126	18.291	0.915	16.756	0.477	0.143
630	91.454	4.573	85.675	0.477	0.729
1030	149.520	7.476	140.372	0.477	1.195

[1] WLA_{WWTF} includes the future potential allocation to WWTFs and is held at the primary contact (126 MPN/100mL) criteria

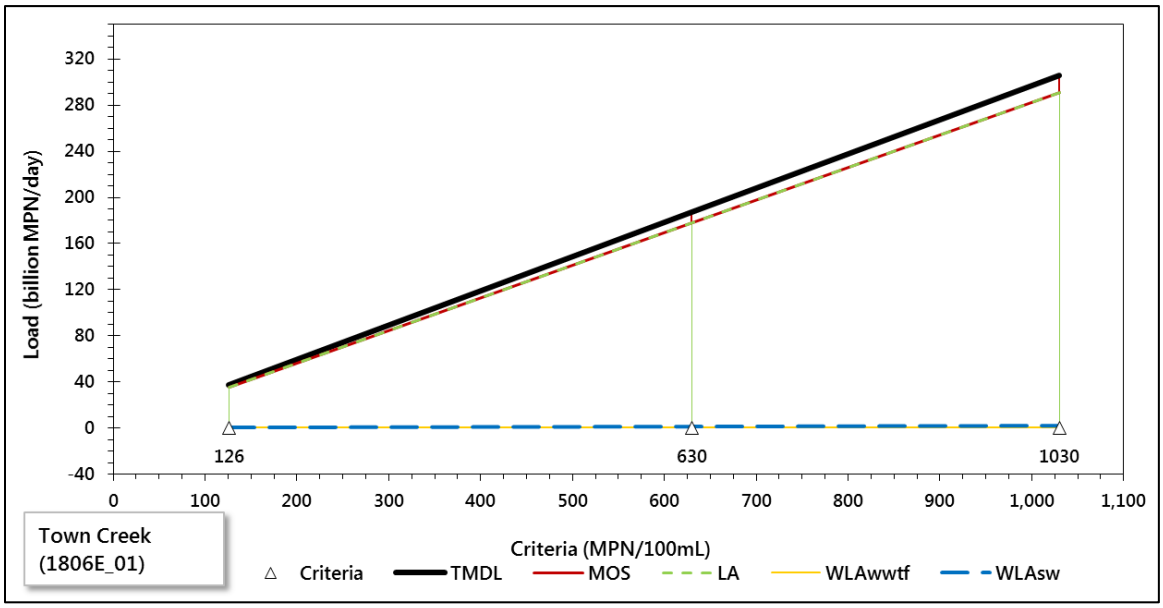

Figure A-2. *E. coli* allocation loads for Town Creek (1806E_01) as a function of water quality criteria.

Equations for calculating new TMDL and allocations (in billion MPN/day *E. coli*) for Town Creek (1806E_01):

TMDL = 0.29704802 * Std
MOS = 0.01485240 * Std
LA = 0.28069349 * Std - 0.5928749
WLA_{WWTF} = 0.59600000
WLA_{SW} = 0.00150213 * Std - 0.00317251

Where:

Std = Revised Water Quality Standard
MOS = Margin of Safety
LA = Total load allocation (non-permitted source contributions)

WLA_{WWTF} = Wasteload allocation (permitted WWTF + FG) [Note: WWTF load held at existing primary contact (126 MPN/100mL) criteria]
WLA_{SW} = Wasteload allocation (permitted stormwater)

Table A-2. Summary of allocation loads for Town Creek (1806E_01) at selected revised water quality standards.

All loads expressed as billion MPN/day *E. coli*

Std (MPN/100mL)	**TMDL**	**MOS**	**LA**	**WLA_{WWTF}[1]**	**WLA_{SW}**
126	37.428	1.871	34.775	0.596	0.186
630	187.140	9.357	176.244	0.596	0.943
1030	305.959	15.298	288.521	0.596	1.544

[1] WLA_{WWTF} includes the future potential allocation to WWTFs and held at the primary contact (126 MPN/100mL) criteria

Appendix B

Pollutant Load Allocations by Flow Regime for Quinlan Creek and Town Creek

For the previous TMDL on the Guadalupe River (TCEQ, 2007), pollutant load allocations were determined from the median flow of each of the five flow regimes comprising the LDCs:

1. 5 percent exceedance for High Flows (0–10 percent),
2. 25 percent exceedance for Upper/Mid-range Conditions (10–40 percent),
3. 50 percent exceedance for Mid-range Flow (40–60 percent),
4. 75 percent exceedance for Lower/Mid-range Conditions (60–90 percent), and
5. 95 percent exceedance for Low Flows (90–100 percent).

For more recent bacteria TMDLs across Texas, the TCEQ has considered only the median value of the highest designated flow regime in the pollutant load allocations. Within this appendix is provided the pollutant load allocation information for each of the five flow regimes of Quinlan and Town Creeks. Tables B-1 and B-2 contain the TMDL allocation summaries comparable to what is provided in Tables 13 and 14 of this addendum (which only presented the High Flows regime), expanded to include the values for each of the five flow regimes.

Table B-1. TMDL allocation summary by flow regime for the Quinlan Creek and Town Creek watersheds.

AU	Stream Name	Indicator	Flow Regime	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS	Future Growth
1806D_01	Quinlan Creek	*E. coli*	High Flows	18.291	0	0.143	16.756	0.915	0.477
			Upper/Mid-range Flows	9.384	0	0.071	8.367	0.469	0.477
			Mid-range Flows	6.927	0	0.052	6.052	0.346	0.477
			Lower/Mid-range Flows	4.777	0	0.034	4.027	0.239	0.477
			Low Flows	3.241	0	0.022	2.580	0.162	0.477
1806E_01	Town Creek	*E. coli*	High Flows	37.428	0.119	0.186	34.775	1.871	0.477
			High/Mid-range Flows	19.012	0.119	0.093	17.372	0.951	0.477
			Mid-range Flows	13.932	0.119	0.067	12.572	0.697	0.477
			Low/Mid-range Flows	9.487	0.119	0.045	8.372	0.474	0.477
			Low Flows	6.311	0.119	0.029	5.370	0.316	0.477

Table B-2. Final TMDL allocation summary by flow regime for the Quinlan Creek and Town Creek watersheds.

AU	Stream Name	Indicator	Flow Regime	TMDL	WLA_{WWTF} [a]	WLA_{SW}	LA	MOS
1806D_01	Quinlan Creek	*E. coli*	High Flows	18.291	0.477	0.143	16.756	0.915
			Upper/Mid-range Flows	9.384	0.477	0.071	8.367	0.469
			Mid-range Flows	6.927	0.477	0.052	6.052	0.346
			Lower/Mid-range Flows	4.777	0.477	0.034	4.027	0.239
			Low Flows	3.241	0.477	0.022	2.580	0.162
1806E_01	Town Creek	*E. coli*	High Flows	37.428	0.596	0.186	34.775	1.871
			Upper/Mid-range Flows	19.012	0.596	0.093	17.372	0.951
			Mid-range Flows	13.932	0.596	0.067	12.572	0.697
			Lower/Mid-range Flows	9.487	0.596	0.045	8.372	0.474
			Low Flows	6.311	0.596	0.029	5.370	0.316

[a] WLA_{WWTF} includes the FG component.