Draft for Public Comment: January 2024
Adopted: Month Day, Year
AS-482

Two Draft Total Maximum Daily Loads for Indicator Bacteria in Big Creek

Assessment Units 1202J_01 and 1202J_02

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Total Maximum Daily Load Team
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Total maximum daily load project reports are available on the Texas Commission on Environmental Quality website at: www.tceq.texas.gov/waterquality/tmdl.

The preparation of this report was financed in part through grants from the United States Environmental Protection Agency.

This total maximum daily load report is based in large part on the report titled: "Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in Big Creek," TCEQ AS-479 by Steven Johnston of the Houston-Galveston Area Council

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Abbreviations

AU	Assessment Unit
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfu	Colony Forming Units
cfs	Cubic Feet Per Second
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency (United States)
FDC	Flow Duration Curve
FG	Future Growth
GIS	Geographic Information System
H3M	hexagonal grid of three-square miles
HGAC	Houston-Galveston Area Council
I-Plan	Implementation Plan
LA	Load Allocation
LDC	Load Duration Curve
MCM	Minimum Control Measure
ml	Milliliter
MGD	Million Gallons Per Day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Permit
MUD	Municipal Utility District
NEIWPCC	New England Interstate Water Pollution Control Commission
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OSSF	On-Site Sewage Facility
SSO	Sanitary Sewer Overflow
SSURGO	Soil Survey Geographic Database
sq mi	Square Mile
SWMP	Stormwater Management Program
SWQM	Surface Water Quality Monitoring
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality

TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
U.S.	United States
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WLA	Wasteload Allocations
WQBELs	Water Quality-Based Effluent Limits
WQMP	Water Quality Management Plan
WWTF	Wastewater Treatment Facility

Two Total Maximum Daily Loads for Indicator Bacteria in Big Creek

Executive Summary

This document describes two total maximum daily loads (TMDLs) for Big Creek where concentrations of indicator bacteria exceed the criteria used to evaluate attainment of the primary contact recreation 1 use. The Texas Commission on Environmental Quality (TCEQ) first identified the impairments to Big Creek in the *2002 Texas Water Quality Inventory and 303(d) List* (TCEQ, 2002).

The Big Creek watershed (Figure 1) occupies 222 square miles (sq mi) of Fort Bend County in the Houston-Galveston region of southeastern Texas. It falls within the greater Brazos River basin as a tributary system to Segment 1202, Brazos River Below Navasota River, and is within the Houston-The Woodlands-Sugar Land Metropolitan Statistical Area. Its main stem is approximately 34 miles long and includes a varied tributary network of both natural waterways and drainage conveyances.

The watershed includes two assessment units (AUs):

- AU 1202J_02- the upstream reach of Big Creek and its tributaries, the watershed is composed of rural headwater streams and drainage from urban developed areas around the City of Rosenberg; and
- AU 1202J_01- the downstream reach, composed primarily of small rural communities, rural residential areas, agricultural, industrial, and state park land uses upstream of the confluence with the Brazos River in Brazos Bend State Park.

Much of the watershed is historically agricultural, with most of the urban development focused in the areas surrounding the City of Rosenberg. Moderate areas of undeveloped land still exist in the watershed, including the many acres of forest, wetlands, and prairies inside Brazos Bend State Park. However, development is increasingly pushing south and west from the City of Rosenberg, and along the I-59/I-69, State Highway 99, and State Highway 36 transportation corridors that traverse the watershed. In addition to historical and natural sources, these pressures have impacted the water quality in the Big Creek watershed.

Escherichia coli (*E. coli*) are widely used as indicator bacteria to determine attainment of the contact recreation use in freshwater. The criterion for determining attainment of the contact recreation use is expressed as the number of bacteria, typically given as colony forming units (cfu) in

100 milliliters (mL) of water. The primary contact recreation 1 use is not supported in freshwater when the geometric mean of all samples for the assessment period exceeds 126 cfu per 100 mL.

E. coli data were collected at TCEQ surface water quality monitoring (SWQM) stations in each of the impaired AUs over a seven-year period from December 1, 2013 through November 30, 2020. These data were used in assessing attainment of the primary contact recreation 1 use and reported in the *2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d) List* (Texas Integrated Report; TCEQ, 2022a). The assessed data indicate non-attainment of the contact recreation standard in AU 1202J_01. For AU 1202J_02, three samples were collected in this assessment period with a geomean of 38.96, however, this was not enough data to assess the AU in the 2022 Texas Integrated Report. Due to the lack of data, the impairment on AU 1202J_02 is carried forward from the 2018 Texas Integrated Report, in which there were 20 assessed values with a geomean of 178.05.

Within the Big Creek watershed, probable sources of bacteria include unregulated waste from wildlife and invasive non-domestic animals like feral hogs, livestock and agricultural activities, domestic animals, unregulated urban runoff and failing on-site sewage facilities (OSSFs), and regulated wastewater and stormwater discharges.

A load duration curve (LDC) analysis was done for the TMDL watershed to quantify allowable pollutant loads, as well as allocations for point and nonpoint sources of bacteria. Wasteload allocations (WLAs) were established for WWTFs discharging to the AUs. The WLA was calculated as the full permitted daily-average flow rate multiplied by the geometric mean criterion. Future growth (FG) of existing or new domestic point sources was determined for the watershed using population growth projections.

The TMDL calculations in this report will guide determination of the assimilative capacity of each water body under changing conditions, including FG. WWTFs will be evaluated on a case-by-case basis.

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 water body included on a state's 303(d) list of impaired waters. TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

A TMDL is like a budget which determines the amount of a particular pollutant that a water body can receive and still meet 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 program's primary objective is to restore and maintain water quality uses; such as drinking water supply, recreation, support of aquatic life, or fishing, of impaired or threatened water bodies.

This TMDL report addresses impairments to the primary contact recreation 1 use due to elevated levels of indicator bacteria in AUs 1202J_01 and 1202J_02. This TMDL takes a watershed approach to addressing indicator bacteria impairments. While TMDL allocations were developed only for the impaired AUs identified in this report, the entire project watershed and all WWTFs that discharge within it are included within the scope of this TMDL. Information in this TMDL document was derived from the *Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in Big Creek* (H-GAC, 2023). [a]

Section 303(d) of the Clean Water Act and the implementing regulations of the United States (U.S.) Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations (CFR), Chapter 1, Part 130 (40 CFR Part 130) describe the statutory and regulatory requirements for acceptable TMDLs. 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.

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

[a] https://www.tceq.texas.gov/downloads/water-quality/tmdl/big-creek-recreational-122/tsd-122-big-creek-bacteria-as-479.pdf

- Implementation and Reasonable Assurance

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

Problem Definition

TCEQ first identified the impairment of the primary contact recreation 1 use in Big Creek (1202J) in the *2002 Texas Water Quality Inventory and 303(d) List* (TCEQ, 2002). At the time of the 2002 edition, the report identified waterbodies by their segment identification, but starting with the 2006 edition, the bacteria impairment within 1202J was identified as AU 1202J_01 (TCEQ, 2008). AU 1202J_02 was later identified as impaired for primary contact recreation 1 in the 2014 Texas Integrated Report (TCEQ, 2015). The impairments were again identified in the EPA-approved 2022 Texas Integrated Report (TCEQ 2022a).

Recent surface water *E. coli* monitoring within the Big Creek watershed has occurred at two TCEQ SWQM stations during the assessment period (Table 1). *E. coli* data, collected at TCEQ SWQM Station 16353 from December 1, 2013, through November 30, 2020, and TCEQ SWQM Station 17551 from November 1, 2007, through November 30, 2016 were used to determine attainment of primary contact recreation use 1. There was not enough data collected to assess 1202J_02 for the 2022 Texas Integrated Report, and therefore the assessment data shown for AU 1202J_02 in Table 1 is from the 2018 Texas Integrated Report. Data assessed indicate non-support of primary contact recreation 1 use, because the geometric mean concentrations of available samples exceed the geometric mean criterion of 126 cfu/100 mL for *E. coli*, as summarized in Table 1.

Table 1. Texas Integrated Report Summary for Big Creek (1202J)

Water Body	AU	Parameter	TCEQ SWQM Station	Data Range	Number of Samples	Geometric Mean (cfu/100 mL)
Big Creek	1202J_01	*E. coli*	16353	12/01/13-11/30/20	53	282.88
Big Creek	1202J_02	*E. coli*	17551	11/1/2007 to 11/30/2016	20	178.05

Watershed Overview

The Big Creek watershed (Figure 1) occupies 222 sq mi of Fort Bend County in the Houston-Galveston region of southeastern Texas. It falls within the greater Brazos River watershed as part of Segment 1202, the Brazos River Below Navasota River, and is within the Houston-The Woodlands-Sugar Land Metropolitan Statistical Area.

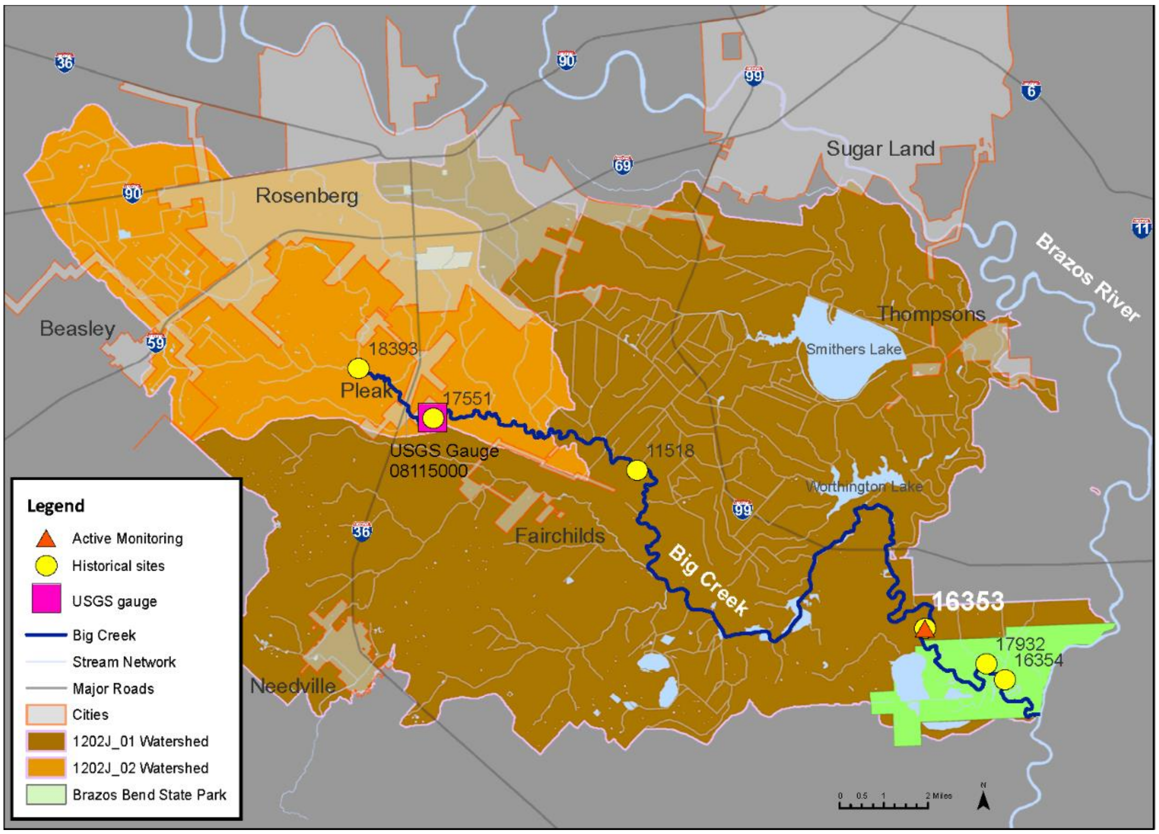

Figure 1. Map of the Big Creek Watershed

The main stem of this freshwater stream is approximately 34 miles long and includes a varied tributary network. The headwaters of the waterway lie in ephemeral drainage and minor streams of the primarily rural areas south and west of the City of Rosenberg. Additional headwaters areas south of the City of Sugar Land area feed tributaries (e.g., Rabbs Bayou) that enter the main channel lower in the system. The official start of the water body is at the confluence of Cottonwood and Coon Creeks and receives flow from a variety of other smaller tributaries. For much of its length, Big Creek is a small to medium sized stream that has been heavily modified in many areas to act as a drainage conveyance or as part of agricultural improvements (e.g., berms in riparian edges of fields). The creek's terminal end is at its confluence with the Brazos River at the eastern edge of Brazos Bend State Park. Unlike the channel upstream, the waterway within the confines of the park is relatively unmodified and has more natural riparian areas.

The 2022 Texas Integrated Report (TCEQ, 2022a) provides the following water body and AU descriptions:

- 1202J (Big Creek) – From the confluence of the Brazos River upstream to the confluence of Cottonwood Creek and Coon Creek.
  - AU 1202J_01 – Big Creek from the confluence of the Brazos River upstream to the confluence of an unnamed tributary 2.1 kilometers downstream of Farm-to-Market Road 2977 south of Rosenberg.
  - AU 1202J_02 – Big Creek Appendix D intermittent stream with perennial pools section from the confluence with an unnamed tributary 2.1 kilometers downstream of Farm-to-Market Road 2977 upstream to the confluence of Cottonwood Creek and Coon Creek.

The historic meanders of the Brazos River have greatly influenced the lands and waterways of the system. Additionally, nearly all the waterways of the system have seen appreciable human modification for drainage and other uses, including a historically prominent role of agriculture in the watershed. The system contains several major impoundments, including Smithers Lake, which serves as a cooling water forebay for the W.A Parish electrical generating station, and Worthington Lake, which impounds water in a recreational lake. A small diversion exists east of the Richmond/Rosenberg area via Middle Creek, and a substantially larger diversion channel is designed to shunt excess flow from the downstream component of the system due north of Brazos Bend State Park directly to the Brazos River corridor.

Climate and Hydrology

Average precipitation for the watershed is 45.19 inches per year over the last 15 years (and 49.66 inches over the last five years), based on data from the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center for station GHCND:USC00418996 in the village of Thompsons (NOAA, 2019). Average monthly precipitation over the same timeframe ranges from 2.55 inches to 5.35 inches. This average obscures the impacts of several high rainfall events breaking historical records in recent years and exacerbating flooding issues in the watershed.

Rainfall occurs throughout the year, with the winter months seeing lower average rainfall while the summer months typically see the greatest rainfall due to tropical disturbances. August stands out with the highest average rainfall. Average monthly air temperature ranges from slightly above 51ºF in January to slightly below 81ºF in August. Figure 2 demonstrates climatic variation over the course of the 15-year period.

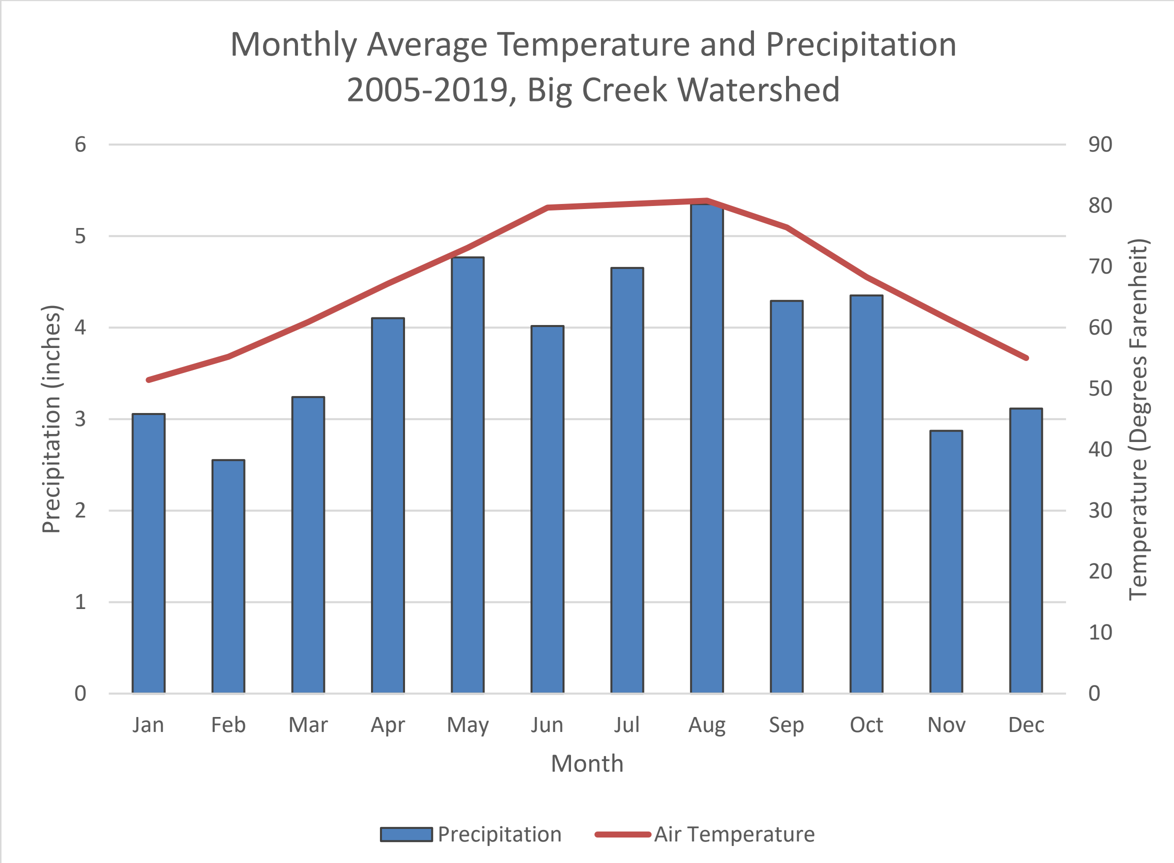

Figure 2. Monthly Average Temperatures and Precipitation from 2005 through 2019 at Station GHCND: USC00418996

Population and Population Projections

Watershed population estimates were developed using the Houston-Galveston Area Council's (H-GAC) Regional Growth Forecast; an analysis of the U.S. Census Bureau's (USCB) 2020 Decadal Census (USCB, 2020). As of 2020, the Big Creek watershed contained an estimated population of 66,851 (Table 2). However, based on the H-GAC Regional Growth Forecast[b] demographic projections, the population of the watershed is expected to increase dramatically by 2050, at which point it is estimated it will be 392,381, representing a 486.95% increase (H-GAC, 2022a). Much of the expected growth will likely take place in the north and northeastern portions of the watershed near and within the cities of Sugar Land, Richmond, and Rosenberg, along the Interstate 69 corridor.

[b] More information on the Regional Growth Forecast can be found at http://www.h-gac.com/regional-growth-forecast/default.aspx.

Table 2. Population estimates and population projections

Watershed	2020 U.S. Census	2050 Population Projection	Project Population Increase	Percentage Change
1202J_01	48,174	310,120	261,946	543.75%
1202J_02	18,677	82,261	63,584	340.44%
Total	**66,851**	**392,381**	**325,530**	**486.95%**

Additional information on the development of watershed population estimates is found in Appendix A.

Land Cover

As with many urban centers nationwide, areas surrounding the City of Houston have experienced an increase in development associated with urban sprawl, especially along transportation corridors.

In 2018, H-GAC used LANDSAT imagery to categorize the Houston–Galveston region into 10 classes of land cover (H-GAC, 2018). The definitions for the land cover types are as follows:

1. Developed - High Intensity: Contains significant land area that is covered by concrete, asphalt, and other constructed materials. Vegetation, if present, occupies < 20% of the landscape. Constructed materials account for 80% to 100% of the total cover. This class includes heavily built-up urban centers and large constructed surfaces in suburban and rural areas with a variety of land uses.

2. Developed - Medium Intensity: Contains area with mixture of constructed materials and vegetation or other cover. Constructed materials account for 50% to 79% of the total area. This class commonly includes multi- and single-family housing areas, especially in suburban neighborhoods, but may include all types of land use.

3. Developed - Low Intensity: Contains areas with a mixture of constructed materials and substantial amounts of vegetation or other cover. Constructed materials account for 20% to 49% of total area. This subclass commonly includes single-family housing areas, especially in rural neighborhoods, but may include all types of land use.

4. Developed - Open Space: Contains areas with a mixture of some constructed materials, but mostly managed grasses or low-lying vegetation planted in developed areas for recreation, erosion control, or aesthetic purposes. These areas are maintained by human activity such as

fertilization and irrigation, are distinguished by enhanced biomass productivity, and can be recognized through vegetative indices based on spectral characteristics. Constructed surfaces account for less than 20% of total land cover.

5. Cropland: Contains areas intensely managed to produce annual crops. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

6. Pasture/Grassland: This is a composite class that contains both Pasture/Hay lands and Grassland/Herbaceous.

    a. *Pasture/Hay*: Contains 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 and not tilled. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

    b. *Grassland/Herbaceous*: Contains areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.

7. Barren Land: This class contains both barren lands and unconsolidated shore land areas.

    a. *Barren Land*: Contains areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10% of total cover.

    b. *Unconsolidated Shore*: Includes material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Substrates lack vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable.

8. Forest/Shrubs: This is a composite class that contains all three forest land types and shrub lands.

    a. *Deciduous Forest*: Contains areas dominated by trees generally greater than five meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.

    b. *Evergreen Forest*: Contains areas dominated by trees generally greater than five meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.

c. *Mixed Forest*: Contains areas dominated by trees generally greater than five meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover. Both coniferous and broad-leaved evergreens are included in this category.

d. *Scrub/Shrubs*: Contains areas dominated by shrubs less than five meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

9. Open Water: This is a composite class that contains open water and both palustrine and estuarine aquatic beds.

    a. *Open Water*: Include areas of open water, generally with less than 25% cover of vegetation or soil.

    b. *Palustrine Aquatic Bed*: Includes tidal and non-tidal wetlands and deep-water habitats in which salinity due to ocean-derived salts is below 0.5% and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages. Total vegetation cover is greater than 80%.

    c. *Estuarine Aquatic Bed*: Includes tidal wetlands and deep-water habitats in which salinity due to ocean-derived salts is equal to or greater than 0.5% and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, kelp beds, and rooted vascular plant assemblages. Total vegetation cover is greater than 80%.

10. Wetlands: This is a composite class that contains all the palustrine and estuarine wetland land types.

    a. *Palustrine Forested Wetlands*: Includes tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to five meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean derived salts is below 0.5%. Total vegetation coverage is greater than 20%.

    b. *Palustrine Scrub/Shrub Wetlands*: Includes tidal and non-tidal wetlands dominated by woody vegetation less than five meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5%. Total vegetation coverage is greater than 20%. Species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions.

c. *Palustrine Emergent Wetlands (Persistent)*: Includes tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses, or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5%. Total vegetation cover is greater than 80%. Plants generally remain standing until the next growing season.

d. *Estuarine Forested Wetlands*: Includes tidal wetlands dominated by woody vegetation greater than or equal to five meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5%. Total vegetation coverage is greater than 20%.

e. *Estuarine Scrub/Shrub Wetlands*: Includes tidal wetlands dominated by woody vegetation less than five meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5%. Total vegetation coverage is greater than 20%.

f. *Estuarine Emergent Wetlands*: Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). Wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5% and that are present for most of the growing season in most years. Total vegetation cover is greater than 80%. Perennial plants usually dominate these wetlands.

A summary of the land cover data in AUs 1202J_01, 1202J_02, and the total project area is provided in Table 3. As depicted in Table 3 and Figure 3, the dominant land uses for the watershed as a whole are pasture/grasslands and cropland. For AU 1202J_01 there are slightly higher amounts of natural areas (forests and wetlands) than in AU 1202J_02 which has higher amounts of developed areas, reflecting the greater exposure to development along transportation corridors and from the City of Rosenberg area in AU 1202J_02, and the greater amount of natural area (inclusive of Brazos Bend State Park) in AU 1202J_01.

Table 3. Land cover percentage

	1202J_01	1202J_01	1202_02	1202_02	Total	Total
Type	**Area (acre)**	**%**	**Area (acre)**	**%**	**Area (acre)**	**%**
Open Water	2,854.60	2.71%	30.03	0.08%	2,884.62	2.03%
Developed – High Intensity	924.25	0.88%	482.44	1.31%	1,406.69	0.99%
Developed - Medium Intensity	3,345.70	3.17%	1,114.35	3.02%	4,460.05	3.13%
Developed - Low Intensity	9,343.92	8.86%	4,827.72	13.07%	14,171.64	9.95%
Developed - Open Space	3,523.58	3.34%	1,265.59	3.43%	4,789.17	3.36%
Barren Land	12.01	0.01%	6.01	0.02%	18.02	0.01%
Forests/Shrubs	10,561.77	10.02%	3,209.36	8.69%	13,771.14	9.67%
Pasture/Grassland	43,379.69	41.13%	16,186.50	43.83%	59,566.20	41.83%
Cropland	24,764.91	23.48%	9,575.38	25.93%	34,340.29	24.12%
Wetlands	6,747.28	6.40%	229.99	0.62%	6,977.27	4.90%
Total	105,457.71	100.00%	36,927.37	100.00%	142,385.09	100.00%

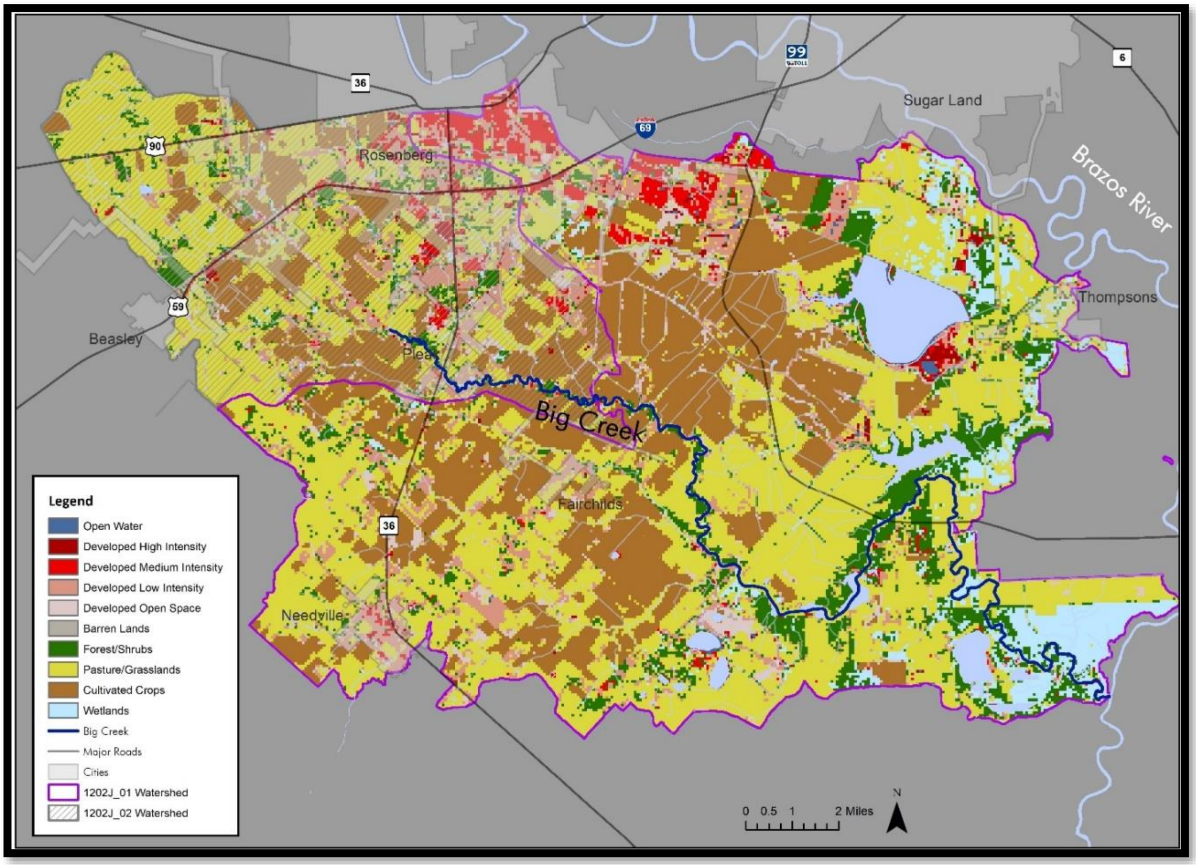

Figure 3. Land cover map

Soils

Soils within the Big Creek watershed are characterized by hydrologic groups that describe infiltration and runoff potential. These data were obtained from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic database (SSURGO; NRCS, 2015). The SSURGO data assigns different soils to one of seven possible runoff potential classifications or hydrologic groups. These classifications are based on the estimated rate of water infiltration when soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The four main groups are A, B, C, and D, with three dual classes (A/D, B/D, C/D). The SSURGO database defines the classifications below.

- **Group A**: Soils having high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well-drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- **Group B**: Soils having a moderate infiltration rate when thoroughly wet. These consist of moderately deep or deep, moderately well-drained or well-

drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

- **Group C**: Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- **Group D**: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.
- Soils with dual hydrologic groupings indicate that drained areas are assigned the first letter, and the second letter is assigned to undrained areas. Only soils that are in group D in their natural condition are assigned to dual classes.

Soil data in the watershed were examined to determine their possible runoff potential classifications or hydrological groups. The Group D soil classification represents 97% of the soils in the Big Creek watershed. The other soils represent less than 3% of the watershed (Table 4, Figure 4). These mostly slow infiltration rate alluvial clay, silt, and loam soils are consistent with the coastal areas of Texas.

Table 4. Hydrologic soil groups

Hydrologic Soil Group	Area (acres)	Percent Area
B	1,759.80	1.24%
C	1,606.86	1.13%
C/D	765.18	0.53%
D	138,251.95	97.10%
Total	142,383.79	100.00%

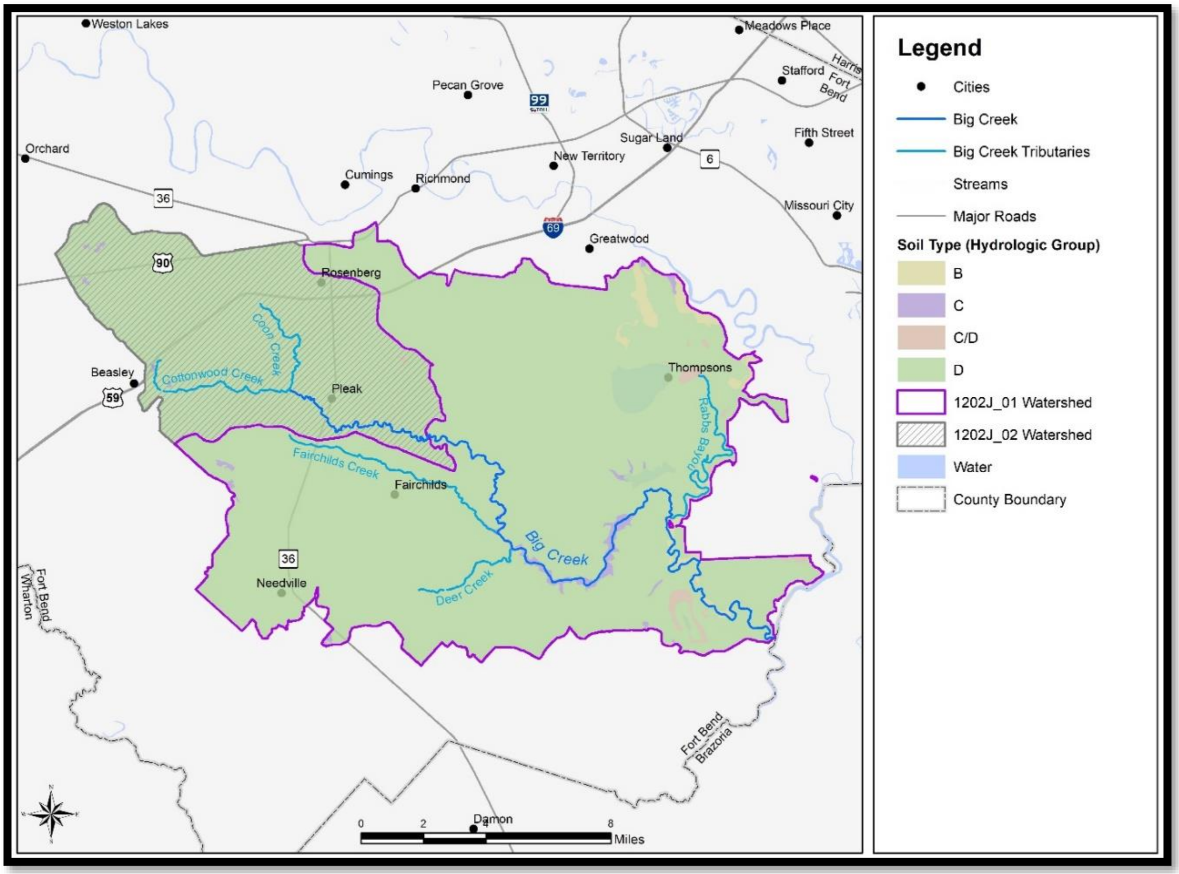

Figure 4. Hydrologic soil group

Water Rights Review

Surface water rights in Texas are administered and overseen by TCEQ. A search of TCEQ's Texas Water Rights Viewer between 2004 and 2020 (TCEQ, 2022c) indicated that there are zero active water rights in the Big Creek watershed above the U.S. Geological Survey (USGS) gage station.

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 the concentrations of *E. coli* below the geometric mean criterion of 126 cfu/100 mL, which is protective of the primary contact recreation 1 use in freshwater (TCEQ, 2018).

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) program. 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 permits.

Except for WWTFs, which receive individual wasteload allocations (WLAs, see the "WLA" 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 program. The regulated sources in the TMDL watershed include WWTF outfalls, stormwater discharges from regulated construction sites, industrial sites and MS4s.

Domestic and Industrial Wastewater Treatment Facilities

There are 17 distinct WWTF permittees in the Big Creek watershed that maintain wastewater discharge permits for 26 wastewater outfalls. This information is based on the EPA's Enforcement and Compliance History Online (EPA, 2022), TCEQ's Central Registry, and TCEQ's Outfall Data Layer. These WWTF outfalls are summarized in Figure 5 and Table 5.

All domestic WWTF permittees in the Big Creek watershed have bacteria limits for *E. coli* in their permits. Three of the permits are industrial and have no bacteria limits[c]. Additionally, two permitted WWTFs with bacteria limits, River Bend RV Park and Resort WWTF and the City of Needville WWTF, exist in the TMDL boundary but discharge outside of the watershed. Therefore, the five permits listed above are not included in the TMDL calculation but are displayed in Figure 5 for reference as potential source of sanitary sewer overflows (SSOs).

[c] Two of the internal end of process regulatory checkpoints (903 and 113) for permit WQ0001038000 have *E. coli* limits. However, both have intermittent and flow variable volumes, and their wastes are mingled with other process flows prior to discharge into a cooling lake.

The maximum permitted discharge flows in million gallons per day (MGD) from each facility were recorded for use in development of the TMDL loading calculation.

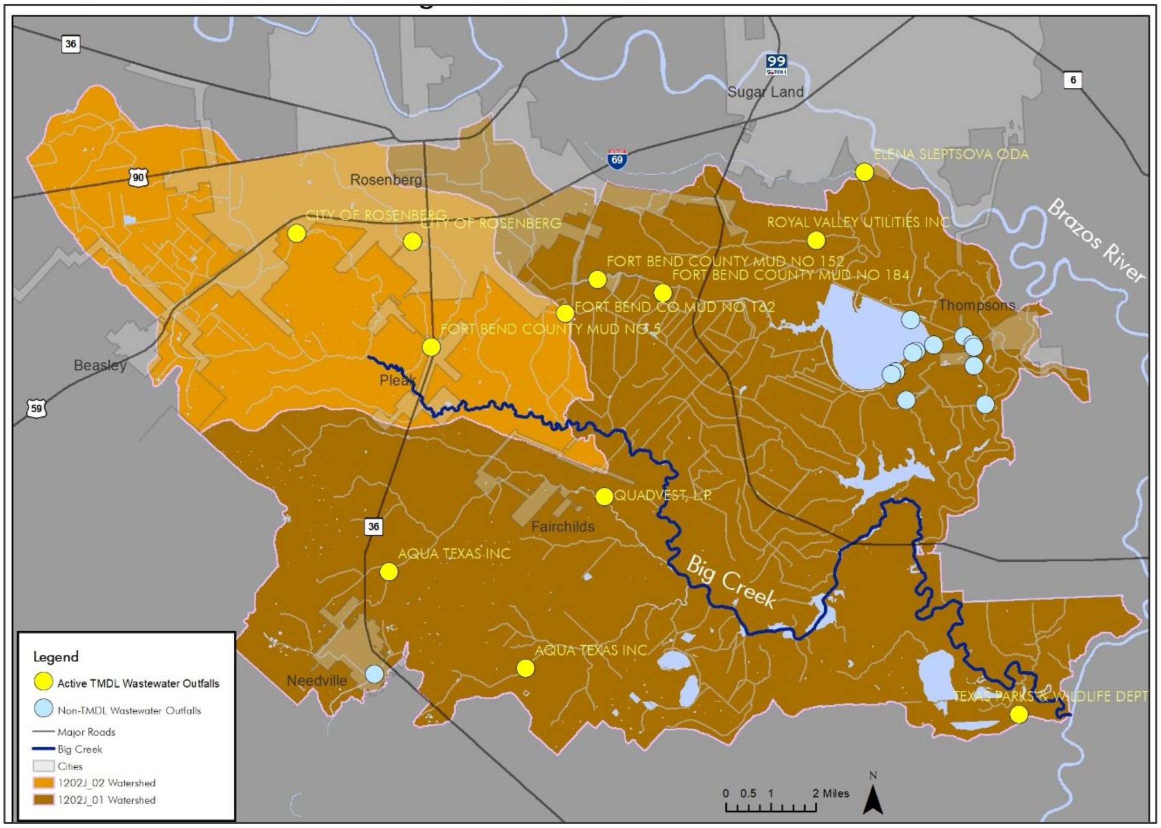

Figure 5. WWTF Outfalls with *E. coli* Limits

Table 5. Permitted domestic and industrial WWTFs

AU	TPDES Number	EPA ID	Facility Name	Permittee	Outfall Number	Bacteria Limits (cfu/100 mL)	Primary Discharge Type	Daily Average Flow – Permitted Discharge (MGD)
1202J_02	WQ0014757001	TX0129194	Fort Bend County MUD[a] 5	Fort Bend County MUD 5	1	126	Domestic	0.5
1202J_02	WQ0010607002	TX0024490	City of Rosenberg Plant No. 2	City of Rosenberg	1	126	Domestic	4.5
1202J_02	WQ0010607004	TX0125512	City of Rosenberg WWTF	City of Rosenberg	1	126	Domestic	0.095
1202J_01	WQ0014564001	TX0127138	Koeblen Road WWTF	Fort Bend County MUD 162	1	126	Domestic	0.45
1202J_01	WQ0012234002	TX0084018	Brazos Bend State Park	Texas Parks and Wildlife	1	126	Domestic	0.016
1202J_01	WQ0013940001	TX0116408	Royal Lakes Estates	Royal Valley Utilities, Inc.	1	126	Domestic	0.2
1202J_01	WQ0014175001	TX0122459	Rose Meadows III WTF	Aqua Texas, Inc.	1	126	Domestic	0.225
1202J_01	WQ0014219001	TX0123595	Needville Manufactured Housing Subdivision WWTF	Aqua Texas, Inc.	1	126	Domestic	0.3
1202J_01	WQ0015449001	TX0136913	Vacek Country Meadows WWTF	Quadvest, L.P.	1	126	Domestic	0.1875
1202J_01	WQ0015295001	TX0135747	Fort Bend County MUD 184	Fort Bend County MUD 184	1	126	Domestic	0.5
1202J_01	WQ0014532001	TX0126829	Fort Bend County MUD 152	Fort Bend County MUD 152	1	126	Domestic	0.98

AU	TPDES Number	EPA ID	Facility Name	Permittee	Outfall Number	Bacteria Limits (cfu/100 mL)	Primary Discharge Type	Daily Average Flow – Permitted Discharge (MGD)
1202J_01	WQ0015798002	TX0139912	Austin Bayou WWTF	The Signorelli Co.	1	126	Domestic	0.9
1202J_01	WQ0005142000	TX0135763	Petra Nova Carbon Capture Plant	Petra Nova CCS I LLC	1	No	Industrial	1.317
1202J_01	WQ0005270000	TX0139190	Braes Bayou Plant	ProEnergy Services, LLC	1-5	No	Industrial	0.189
1202J_01	WQ0001038000	TX0006394	WA Parish Electric Generating Station	NRG TEXAS POWER LLC	1-6	No	Industrial	37
1202J_01	WQ0014319001	TX0124699	River Bend RV Park and Resort WWTF	Elena Sleptsova ODA	1	126	Domestic	0.025
1202J_01	WQ0010343001	TX0027634	City of Needville WWTF	City of Needville	1	126	Domestic	0.4

[a]MUD: Municipal Utility District

TCEQ/TPDES Water Quality General Permits

Certain types of activities must be covered by one of several TCEQ/TPDES wastewater general permits:

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production
- TXG340000 –petroleum bulk stations and terminals
- TXG640000 – conventional water treatment plants
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances
- TXG870000 – pesticides (application only)
- TXG920000 – concentrated animal feeding operations
- WQG100000 – wastewater evaporation
- WQG200000 – livestock manure compost operations (irrigation only)

The following general permit authorizations are not considered to affect the bacteria loading in the TMDL watershed and were excluded from this investigation:

- TXG640000 – conventional water treatment plants
- TXG670000 – hydrostatic test water discharges
- TXG830000 – water contaminated by petroleum fuel or petroleum substances
- TXG870000 – pesticides (application only)
- WQG100000 – wastewater evaporation

A review of active general permit coverage (TCEQ, 2022b) in the Big Creek watershed, as of May 2022, found four concrete production facilities and one aquaculture production facility covered by general permits. These facilities do not have bacteria reporting requirements or limits in their permits and are assumed to contain inconsequential amounts of indicator bacteria in their effluent; therefore, it was unnecessary to allocate bacteria loads to these operations. One aquaculture production facility exists in the watershed. Like concentrated animal feeding operations (CAFOs), the aquaculture operations have control measures in place to address water quality and are not expected to be a significant source of indicator bacteria.

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 permitted system. These overflows in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease, and other debris. Inflow and infiltration are typical causes of SSOs under conditions of high flow in the WWTF system. Blockages in the line may exacerbate the inflow and infiltration problem. Other causes, such as a collapsed sewer line, may occur under any condition.

A review of SSOs reported to TCEQ Region 12 by permit holders in the Big Creek watershed found 38 SSOs reported for the period of 2016-2021 (TCEQ, 2022d) with a total volume estimated at 209,200 gallons. The reported causes for the SSOs were dominated by WWTF operation/equipment malfunction (13 SSOs), blockages (nine SSOs), and rainwater infiltration (seven SSOs).

TPDES-Regulated Stormwater

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

1) Stormwater subject to regulation, which is any stormwater originating from TPDES-regulated MS4 entities, stormwater discharges associated with regulated industrial activities, and construction activities.
2) Stormwater runoff not subject to regulation.

TPDES MS4 Phase I and II rules require municipalities and certain other entities in urban areas to obtain permit coverage for their stormwater systems. A regulated MS4 is a publicly owned system of conveyances and includes ditches, curbs, gutters, and storm sewers that do not connect to a sanitary wastewater collection system or treatment facility. Phase I permits are individual permits for large and medium-sized communities with populations of 100,000 or more based on the 1990 U.S. Census, whereas the Phase II MS4 General Permit (TXR04000) regulates smaller communities within an urbanized area as defined by USCB in the 2000 and 2010 Decennial Censuses.

The purpose of an MS4 permit is to reduce discharges of pollutants in stormwater to the “maximum extent practicable or MEP” by developing and implementing a Stormwater Management Program (SWMP). The SWMP describes the stormwater control practices that the regulated entity will implement, consistent with permit requirements, to minimize the discharge of pollutants. The MS4 permits require that SWMPs specify the best management practices (BMPs) to meet several minimum control measures (MCMs) that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving water bodies. Phase II MS4 MCMs include all of the following:

- Public education, outreach, and involvement.
- Illicit discharge detection and elimination.
- Construction site stormwater runoff control.

- Post-construction stormwater management in new development and redevelopment.
- Pollution prevention and good housekeeping for municipal operations and
- Industrial stormwater sources (only required for MS4s serving a population of 100,000 people or more in the urban area).
- Authorization for construction activities where the small MS4 is the site operator (*optional*).

Phase I MS4 individual permits have their own set of MCMs that are similar to the Phase II MCMs, but Phase I permits have additional requirements to perform water quality monitoring and implement a floatables program. The Phase I MCMs include all of the following:

- MS4 maintenance activities.
- Post-construction stormwater control measures.
- Detection and elimination of illicit discharges.
- Pollution prevention and good housekeeping for municipal operations.
- Limiting pollutants in industrial and high-risk stormwater runoff.
- Limiting pollutants in stormwater runoff from construction sites.
- Public education, outreach, involvement, and participation.
- Monitoring, evaluating, and reporting.

Discharges of stormwater from a Phase II MS4 area, regulated industrial facility, construction area, or other facility involved in certain activities must be covered under the following TCEQ/TPDES general permits:

- TXR040000 – Phase II MS4 General Permit for small MS4s located in Urbanized Areas.
- TXR050000 – MSGP for industrial facilities.
- TXR150000 – Construction General Permit for construction activities disturbing more than one acre or are part of a common plan of development disturbing more than once acre.

The TCEQ Central Registry was reviewed for stormwater permits on October 1, 2021, and again on May 1, 2022 (TCEQ, 2022b). A statewide combined Phase I and II MS4 individual permit held by the Texas Department of Transportation (TxDOT) for rights-of-way in their MS4 regulated areas and ten Phase II MS4 General Permit authorizations were found in the Big Creek watershed (Table 6). These permits represent 15,511.76 acres of USCB urbanized area within the Big Creek watershed.

Table 6. MS4 permit authorizations

Entity	Authorization Type	TPDES Authorization Number / EPA ID	Location
City of Rosenberg	Phase II MS4 General Permit TXR040000	TXR040272/Not applicable	Area within the City of Rosenberg city limits that is located within the Houston Urbanized Area
Plantation MUD	Phase II MS4 General Permit TXR040000	TXR040226/Not applicable	Area within the City of Sugarland Extraterritorial Jurisdiction that is located within the Houston Urbanized Area
Fort Bend County MUD 116	Phase II MS4 General Permit TXR040000	TXR040422/Not applicable	Area within the City of Richmond city limits that is located within the Houston Urbanized Area
Fort Bend County MUD 155	Phase II MS4 General Permit TXR040000	TXR040480/Not applicable	Area within the City of Richmond city limits that is located within the Houston Urbanized Area
Fort Bend County MUD 159	Phase II MS4 General Permit TXR040000	TXR040481/Not applicable	Area within the Fort Bend County MUD 159 limits that is located within the Houston Urbanized Area
Fort Bend County MUD 162	Phase II MS4 General Permit TXR040000	TXR040504/Not applicable	Area within the City of Richmond city limits that is located within the Houston Urbanized Area
Fort Bend County Drainage District	Phase II MS4 General Permit TXR040000	TXR040383/Not applicable	Area within the Drainage District limits that is located within the Houston Urbanized Area
Fort Bend County MUD 144	Phase II MS4 General Permit TXR040000	TXR040588/Not applicable	Area within the Fort Bend County MUD 144 limits that is located within the Houston Urbanized Area
Fort Bend County MUD 147	Phase II MS4 General Permit TXR040000	TXR040582/Not applicable	Area within the Fort Bend County MUD 147 limits that is located within the Houston Urbanized Area
Fort Bend County MUD 167	Phase II MS4 General Permit TXR040000	TXR040551/Not applicable	Area within the Fort Bend County MUD 167 limits that is located within the Houston Urbanized Area
TxDOT	Combined Phase I and Phase II MS4	WQ0005011000/ TXS002101	TXDOT rights-of-way located within Phase I MS4 areas and Phase II MS4 Urbanized Areas

[a]NPDES: National Pollutant Discharge Elimination System

The Big Creek watershed's general permit authorizations were obtained from the TCEQ Central Registry on May 1, 2022 (TCEQ, 2022b). Numerous MSGP-regulated facilities and construction activities were found in the TMDL watershed in locations regulated by the Phase II MS4 permit authorizations. Construction activities found in the watershed are constantly changing due to the short-term nature of most construction activities. The permit data is only considered accurate for the date the data was accessed. A review of the TCEQ Central Registry on May 1, 2022 found 85 active stormwater CGP authorizations (TCEQ, 2022b). However, areas authorized under the MSGP and CGP inside MS4 areas were not specifically determined since they occur in an MS4 area. These areas are already accounted for in the aggregate area of regulated stormwater.

The area of regulated stormwater is approximately 20,608.35 acres or 14.47% of the Big Creek watershed.

Illicit Discharges

Pollutant loads can enter water bodies 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 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* (NEIWPCC, 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.
- 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.
- 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 water body through distributed, nonspecific locations, which may include urban runoff not covered by a permit. Potential sources, detailed below, include wildlife, feral hogs, various agricultural activities, agricultural animals, urban runoff not covered by a permit, failing OSSFs, 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. Activities, such as livestock grazing close to water bodies and the use of manure as fertilizer, can contribute *E. coli* to nearby water bodies. Livestock are present throughout the more rural portions of the project watershed. While there are no permitted CAFOs in the Big Creek watershed, livestock and other agricultural pressures should be considered in estimating bacterial source loads.

Table 7 provides estimated numbers of selected livestock in the TMDL watershed based on the 2017 Census of Agriculture conducted by USDA (2017). 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 appropriate land cover types in the watershed, based on the 2018 H-GAC land cover dataset (H-GAC, 2018). These livestock numbers, however, were not used to develop an allocation of allowable bacteria loading to livestock.

Table 7. Estimated livestock population

Area Name	Area (Acres)	Cattle and Calves	Hogs and Pigs	Sheep and Goats	Equine	Poultry
Fort Bend	197,123	31,605	54	983	2,027	2,796
1202J_01	43,380	6,955	12	216	446	615
1202J_02	16,187	2,595	4	81	166	230

Fecal matter from dogs and cats is transported to water bodies by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 8 summarizes the estimated number of dogs and cats for the TMDL watershed. Pet population estimates were calculated as the estimated number of dogs (0.614) and cats (0.457) per household (AVMA, 2018). The actual contribution and significance of bacteria loads from pets reaching the water bodies of the watershed is unknown.

Table 8. Estimated households and pet population

AU	Estimated Households	Estimated Dog Population	Estimated Cat Population
1202J_01	15,655	9,612	7,154
1202J_02	5,844	3,588	2,671
Total	**21,499**	**13,200**	**9,825**

Wildlife and Unmanaged Animals

Fecal 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, by watershed, the potential for bacteria contributions from wildlife. Wildlife are naturally attracted to riparian corridors of water bodies. 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 water bodies by rainfall runoff.

Most avian and mammalian wildlife, including invasive species, are difficult to estimate, as long-term monitoring data or literature values indicating historical baselines are lacking. However, the White-Tailed Deer Program of the Texas Parks and Wildlife Department (TPWD) estimates deer populations for their Resource Management Units. In the ecoregion surrounding Big Creek, TPWD deer population estimates recorded from 2008 through 2019 average one deer for every 25.27 acres (TPWD, 2020). By applying this factor to the acreage of appropriate land cover in the Big Creek watershed, the white-tailed deer population can be estimated at 5,634 (Table 9).

Feral hogs are a non-native, invasive species, which likely impact the watershed with fecal waste contamination. Like deer, factors for estimating feral hog populations based on land area are available. These factors vary depending on land cover types and range between 8.9 and 16.4 hogs per square mile (Timmons et al., 2012). Feral hog population estimates may be weighted more heavily in riparian areas where animals are protected from the stresses associated with development and have more direct access to water resources. Considering these factors, in addition to insights from local stakeholders, feral hog populations were estimated to be 8.9 per square mile in low intensity development, barren land, and cropland, 16.4 per square mile in pasture/grassland, developed open space, forest/shrubs, and wetlands, and assuming no hogs in other developed areas or open water. The hog populations were distributed between the AUs based on the proportional amount of appropriate land cover in each AU. The total number of feral hogs for the watershed is estimated to be 2,854 (Table 10).

Table 9. Estimated deer population

AU Watershed	Area (acres)	Estimated Deer Population
1202_01	105,457.73	4,173
1202_02	36,927.36	1,461
Total	**142,385.09**	**5,634**

Table 90. Estimated feral hog population

AU Watershed	Low Quality (acres)	Feral Hogs	High Quality (acres)	Feral Hogs	Total
1202J_01	34,120.84	474	64,212.33	1,645	2,119
1202J_02	14,409.11	200	20,891.44	535	735
Total	**48,529.95**	**674**	**85,103.78**	**2,180**	**2,854**

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. 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 ground and surface waters if the systems are not properly operating. Properly designed and operated, however, OSSFs contribute virtually no fecal bacteria to surface waters. For example, less than 0.01% of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drain field of a septic system (Weiskel et al., 1996). Reed, Stowe, and Yanke LLC (2001) provide estimated failure rates of OSSFs for different regions of Texas. The Big Creek watershed is located within the Region IV area, which has a reported failure rate of about 12%, providing insights into expected failure rates for the area.

Within the Big Creek Watershed, 4,227 permitted OSSFs have been documented (H-GAC, 2022b). Non-registered OSSF locations were estimated using H-GAC's geographic information database of potential OSSF locations in the Houston-Galveston area using known OSSF locations, 911 addresses, and WWTF service boundaries. An estimated additional 2,598 non-registered OSSFs added to the

4,227 permitted systems equal a total of 6,825 units (H-GAC, 2022c, Table 11 and Figure 6).

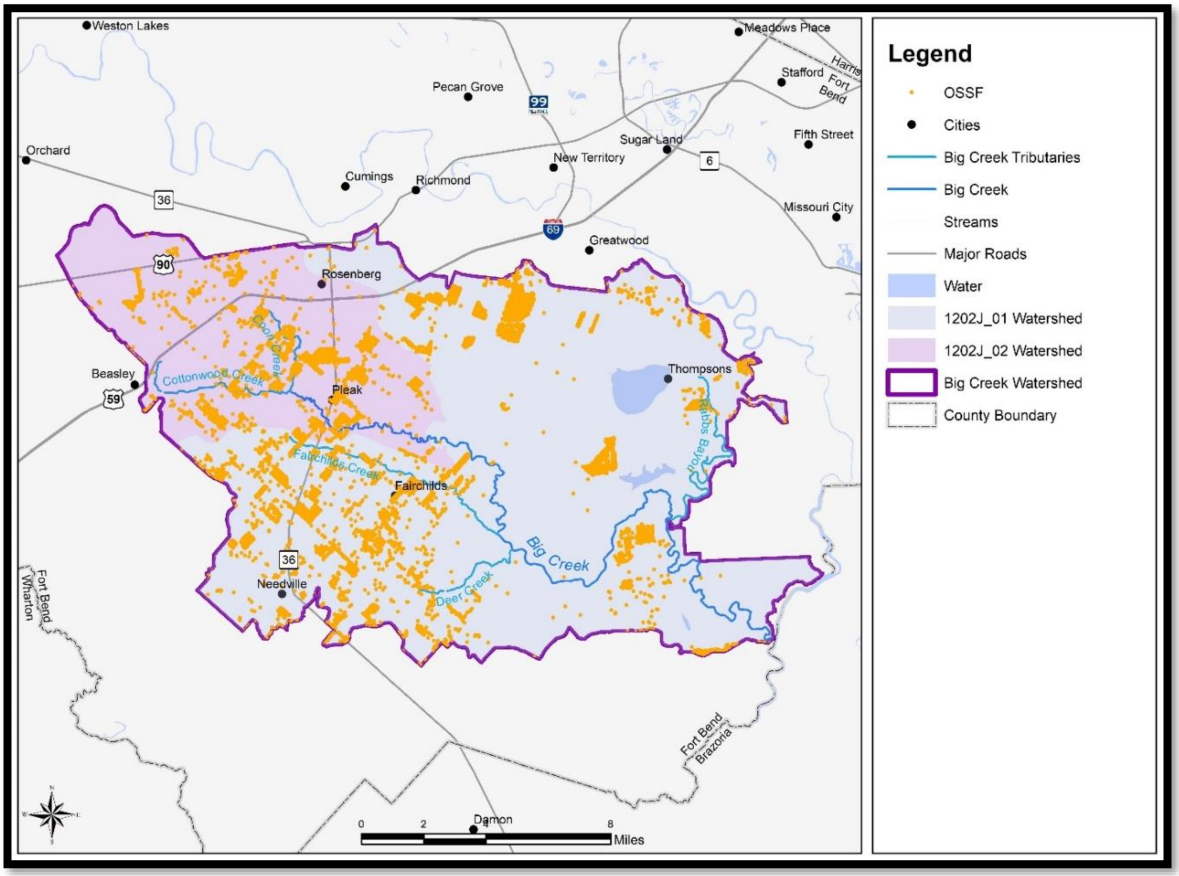

Figure 6. Estimated OSSFs

Table 11. Estimated OSSFs

AU	Permitted OSSF	Unpermitted OSSF	Total
1202J_01	2,832	2,024	4,856
1202J_02	1,395	574	1,969
Total	4,227	2,598	6,825

OSSFs can be an appreciable source of fecal waste when not sited or functioning properly, especially when they are in close proximity to water bodies. Many factors including soil type, design, age, and maintenance can influence the likelihood of an OSSF failure. By applying the 12% estimate of failure rates to the number of OSSFs estimated in the watershed area, 819 OSSFs are projected to be failing.

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 they can survive and replicate in organic-rich materials such as improperly treated compost and sewage sludge (or biosolids). While die-off of bacteria has been demonstrated in natural water systems due to the presence of sunlight and predators, the potential for their re-growth is less well understood. Both replication and die-off are instream processes and are not considered in the bacteria source loading estimates in the TMDL watershed.

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 flows in the absence of runoff events, the main contributing sources are likely to be point sources and direct deposition (such as direct fecal 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 like 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 water body. Generally, this loading follows a pattern of higher concentrations in the water body as the first flush of storm runoff enters the receiving water body. 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.

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 direct relationship between pollutant load sources (regulated and unregulated) and instream loads. Further, this one-to-one relationship was also inherently assumed when using LDCs to define the TMDL pollutant load allocation. That allocation was based on the flows associated with the watershed areas under stormwater regulation, and the remaining portion was assigned to the unregulated stormwater.

Load Duration Analysis

LDCs are graphs of the frequency distribution of loads of pollutants in a water body. LDC analyses are used to examine the relationship between instream water quality and broad sources of bacteria loads which are the basis of the TMDL allocations (Cleland, 2003). In the case of these TMDLs, the loads shown are of *E. coli* bacteria in cfu/day.

LDCs are derived from flow duration curves (FDCs). LDCs shown in the following figures represent the maximum acceptable load in the water bodies that will result in achievement of the TMDL water quality target. The basic steps to generate LDCs involve all of the following:

- Generating a daily flow record – The USGS's LoadEst program was used to generate flow records that have incorporated the full permitted discharges for WWTFs and FG at TCEQ SWQM stations chosen for analysis (Runkel et. al., 2004).
- Developing the FDC – the mean daily streamflow is plotted against the exceedance probability of the mean daily streamflow for each day.
- Converting the FDCs to LDCs – the mean daily streamflow for each day is multiplied by the primary contact recreation 1 use geometric mean criterion and a conversion factor to produce a graph of the frequency distribution of allowable loads.
- Estimating existing indicator bacteria loading – Overlay the LDC with the available ambient water quality data collected at the stations selected for analysis.
- Interpreting LDCs to understand under what flow conditions indicator bacteria loading exceeds the primary contact recreation 1 use geometric mean criterion and the relative contributions of regulated and unregulated sources.

Load Duration Curve Results

LDCs were developed for the most representative downstream station for each of the AUs.

The LDC for TCEQ SWQM Station 17551 in AU 1202J_02 (Figure 7) indicated a load regression curve that was primarily in excess of the geometric mean curve in the highest flow conditions, although there were exceedances across all flow conditions.

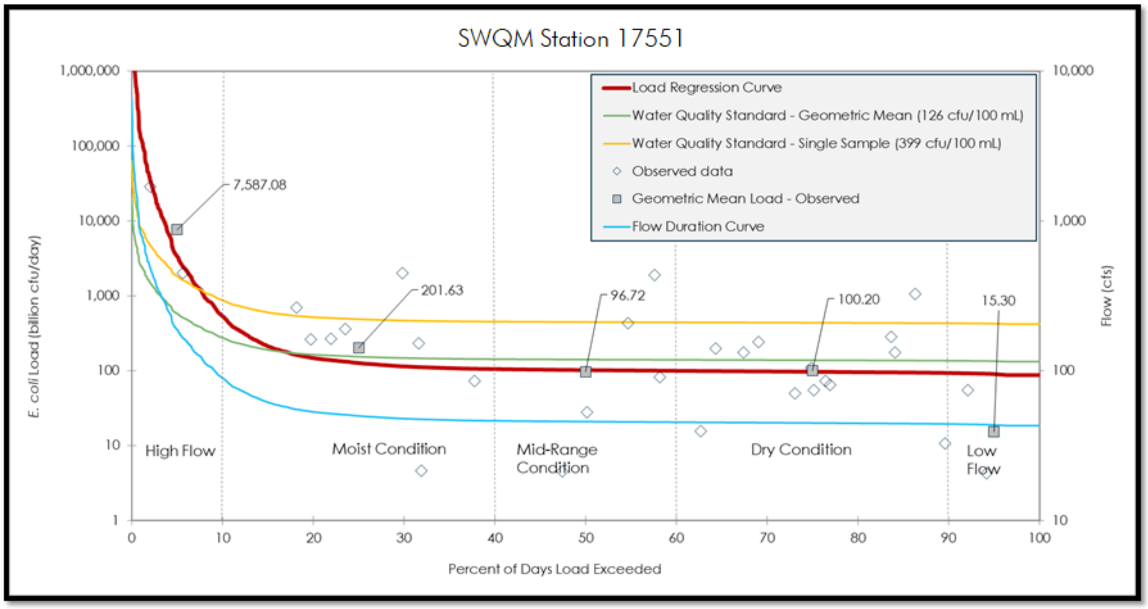

Figure 7. LDC for AU 1202J_02 at TCEQ SWQM Station 17551

The LDC for TCEQ SWQM Station 16353, AU 1202J_01, (Figure 9) indicated a load regression curve in excess of the bacteria geometric mean for all flow conditions, although results were more consistently in exceedance in higher flow conditions.

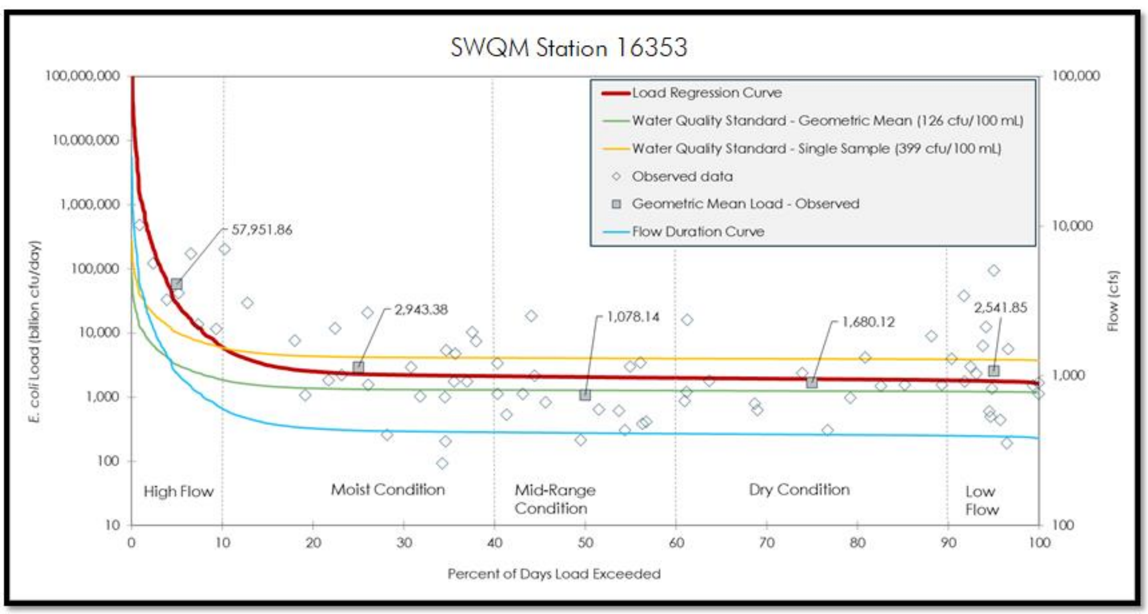

Figure 8. LDC for AU 1202J_01 at TCEQ SWQM Station 16353

Margin of Safety

The margin of safety (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. 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.

According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using either of the following two methods:

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

These TMDLs incorporate an explicit MOS of 5% of the total TMDL allocation.

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 allocations, the amount of pollutant allowed by regulated dischargers

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

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety load

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

- The TMDL components for the impaired AUs are derived using the median flow within the high-flow regime (or 5% flow) of the LDCs developed for each of the TMDL watersheds. For the remainder of this report, each section will present an explanation of the TMDL component first, followed by the results of the calculation for that component. Also, please note that some calculations completed in the remainder of this report have been rounded and may not lead to the exact final amounts listed in the text, tables, or figures.

Assessment Unit-Level TMDL Calculations

The TMDLs for the impaired AUs were developed as pollutant load allocations based on information from the LDCs developed for TCEQ SWQM stations 17551 (AU 1202J_02) and 16353 (AU 1202J_01) (Figures 9 and 10). The bacteria LDCs were developed by multiplying the streamflow value along the FDCs by the primary contact recreation 1 use geometric mean criterion (126 cfu/100 mL) and by the conversion factor to convert to loading in cfu per day. This effectively displays the LDCs as the TMDL curve of maximum allowable loading:

TMDL (billion cfu/day) = Criterion * Flow * Conversion Factor

Where:

Criterion = 126 cfu/100 mL *E. coli*

Flow = 5% exceedance flow from FDC in cubic feet per second (cfs)

Conversion Factor (to billion cfu/day) = 28,316.846 mL/cubic foot (ft^3) * 86,400 seconds/day (s/d) ÷ 1,000,000,000

Table 12 shows the TMDL values at the 5% load duration exceedance.

Table 12. Summary of allowable loadings

AU	5% Exceedance Flow (cfs)	TMDL (Billion cfu/day)
1202J_01	1,038.968	3,202.806
1202J_02	187.971	579.454

Margin of Safety Formula

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

MOS = 0.05 * TMDL

Where:

TMDL = total maximum daily load

The MOS calculations for each AU are shown in Table 13.

Table 13. MOS calculations

AU	TMDL	MOS
1202J_01	3,202.806	160.140
1202J_02	579.454	28.973

All loads are expressed in billion cfu/day.

Wasteload Allocation

The WLA is the sum of loads from regulated sources. The WLA consists of two parts – the wasteload that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the wasteload that is allocated to regulated stormwater dischargers (WLA_{SW}).

$$WLA = WLA_{WWTF} + WLA_{SW}$$

Wastewater Treatment Facilities

Determination of the WLA_{WWTF} requires development of a daily WLA for each TPDES-permitted facility. The full permitted daily average flow of each WWTF is multiplied by the instream geometric criterion for the waterbody and the conversion factor. This calculation is expressed by:

$$WLA_{WWTF} \text{ (billion cfu/day)} = \text{Criterion} * \text{Flow} * \text{Conversion Factor}$$

Where:

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

Flow = full permitted flow (MGD)

Conversion Factor (to billion cfu/day) = 3,785,411,800 mL/million gallons ÷ 1,000,000,000

Using this equation, each WWTF's allowable loading was calculated using the permittee's full permitted flow. The individual results were summed for each AU. The criterion was applied based on the indicator bacteria designated for the segment.

Table 14 shows the load allocations for each WWTF and sums the load allocations, providing a total WLA_{WWTF} for the AUs.

Table 14. Wasteload allocations for TPDES-permitted facilities

AU	TPDES Number	Permittee	Bacteria Limit (cfu/100 mL)	Full Permitted Flow (MGD)	WLA_{WWTF} (billion CFU/day)
1202J_02	WQ0014757001	Fort Bend County MUD 5	126	0.50	2.385
1202J_02	WQ0010607002	City of Rosenberg	126	4.50	21.463
1202J_02	WQ0010607004	City of Rosenberg	126	0.095	0.453
			Total	**5.095**	**24.301**
1202J_01	WQ0012234002	Texas Parks and Wildlife	126	0.016	0.076
1202J_01	WQ0013940001	Royal Valley Utilities, Inc.	126	0.200	0.954
1202J_01	WQ0014175001	Aqua Texas, Inc.	126	0.225	1.073
1202J_01	WQ0014564001	Fort Bend County MUD 162	126	0.450	2.146
1202J_01	WQ0014219001	Aqua Texas, Inc.	126	0.300	1.431
1202J_01	WQ0015449001	Quadvest, L.P.	126	0.188	0.894
1202J_01	WQ0015295001	Fort Bend County MUD 184	126	0.500	2.385
1202J_01	WQ0014532001	Fort Bend County MUD 152	126	0.980	4.674
1202J_01	WQ0015798002	The Signorelli Co.	126	0.900	4.293
			Total	**3.759**	**17.927**

Regulated Stormwater

Stormwater discharges from MS4s, industrial facilities, and construction activities 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_{SW} 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 (i.e., defined as the area designated as urbanized area in the 2010 U.S. Census) is used to estimate the amount of the overall runoff load that should be allocated as the regulated stormwater contribution in the WLA_{SW} component of the TMDL. The load allocation (LA) component of the TMDL corresponds to direct nonpoint source runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}.

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

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

Where:

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 load

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

The FDA_{SWP} must be calculated to arrive at the fractional proportion of the drainage area under jurisdiction of stormwater permits. The FDA_{SWP} was calculated by first totaling the area of each stormwater permit and authorization. The stormwater sources and area estimates were discussed in the "TPDES-Regulated Stormwater" section. Those area estimates were determined for each category and summed up to determine the total area under stormwater jurisdiction in each AU watershed. To arrive at the proportion, the area under stormwater jurisdiction was then divided by the total watershed area. The estimated areas in Table 15 are cumulative, each AU accounts for the upstream area contribution by adding the total area of regulated stormwater for the AU and that of the upstream AU and then dividing by the watershed area.

Table 15. Regulated stormwater FDA_{SWP} calculations

AU	MS4 Area	MSGP Area	CGP Area	Concrete Production Facilities Area	Total Area of Permits	Watershed Area	FDA_{SWP}
1202J_01	15,511.76	3,658.38	1,428.96	9.25	20,608.35	142,385.09	0.1447
1202J_02	5,970.03	86.99	918.69	0.00	6,975.71	36,927.36	0.1889

All areas are expressed in acres

A value for FG is necessary to complete the WLA_{SW}. The calculation for FG is presented in the later section “Allowance for Future Growth,” but the results will be included here for continuity. The WLA_{SW} calculations are presented in Table 16.

Table 16. Regulated stormwater load calculations

AU	TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
1202J_01	3,202.806	42.228	180.207	160.140	0.1447	408.191
1202J_02	579.454	24.301	82.731	28.973	0.1889	83.769

All loads are expressed in billion cfu/day. With the WLA_{SW} and WLA_{WWTF} terms, the total WLA term can be determined by adding the two parts (Table 17).

Table 17. WLA calculations

AU	WLA_{WWTF}	WLA_{SW}	WLA
1202J_01	42.228	408.191	450.419
1202J_02	24.301	83.769	108.07

In areas currently regulated by an MS4 permit, development, or re-development, or both, of land must include the implementation of the control measures/programs outlined in an MS4's approved SWMP. Although additional flow may occur from development or re-development, loading of the pollutant of concern should be controlled or reduced through the implementation of BMPs as specified in both the TPDES permit and the approved SWMP.

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 adjust (e.g., more stringent controls or specific BMPs) as necessary to protect water quality.

Implementation of Wasteload Allocations

The TMDLs in this document will result in protection of existing uses and conform to Texas' antidegradation policy. The three-tiered antidegradation policy in the Texas Surface 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.

TCEQ intends to implement the individual WLAs through the permitting process as monitoring requirements, effluent limitations, or both as required by the amendment of Title 30, Texas Administrative Code (TAC), which became effective November 26, 2009. WWTFs discharging to TMDL water bodies will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in 30 TAC Section 319.9.

Permit requirements are 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 this TMDL is 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 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 TPDES-regulated MS4s, 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 (EPA, 2014) 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 this TMDL.

Updates to Wasteload Allocations

This TMDL is, by definition, the total of the sum of the WLA (including FG), 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 report; 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 – FG – MOS

Where:

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 load

Table 18 summarizes the LA.

Table 18. LA calculations

AU	TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
1202J_01	3,202.806	42.228	408.191	180.207	160.140	2,412.04
1202J_02	579.454	24.301	83.769	83.731	28.973	359.68

All loads are expressed in billion cfu/day.

Allowance for Future Growth

The FG 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, this TMDL component considers the probability that new flows from WWTF discharges may occur in the future. The assimilative capacity of water bodies increases as the amount of flow increases.

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

To account for the FG component of the impaired AUs, the loadings from WWTFs are included in the FG computation, which is based on the WLA_{WWTF} formula. The FG equation contains an additional term to account for project population growth within WWTF service areas between 2020 and 2050, based on H-GAC's Regional Growth Forecast (H-GAC, 2022a).

The FG for this TMDL is calculated as follows:

FG (billion cfu/day) = Criterion * ($\%POP_{2020\text{-}2050}$ * $WWTF_{FP}$) * Conversion Factor

Where:

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

$\%POP_{2020\text{-}2050}$ = estimated percentage increase in population between 2020 and 2050

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

Conversion Factor (to billion cfu/day) = 3,785,411,800 mL/million gallons ÷ 1,000,000,000

The calculation results for the impaired TMDL watersheds are shown in Table 19.

Table 19. FG calculations

AU	Full Permitted Flow by WWTF (MGD)	Percentage Population Increase (2020-2050)	FG Flow (MGD)	FG (*E. coli*)
AU 1202J_01	3.759	543.75%	20.437	97.4759
AU 1202J_02	5.095	340.44%	17.345	82.7311
Total	**8.854**	**-**	**37.782**	**180.207**

All loads are expressed in billion cfu/day.

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. FGs of existing or new point sources is not limited by these TMDLs if the sources do not cause bacteria to exceed the limits. The assimilative capacity of water bodies increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The LDCs and tables in this TMDL report will guide determination of the assimilative capacity of the water body under changing conditions, including FG.

Summary of TMDL Calculations

The TMDLs were calculated based on the median flow (5%) in the high flow range for flow exceedance from the LDCs developed for TCEQ SWQM stations 16353 (AU 1202J_01) and 17551 (AU 1202J_02).

Allocations are based on the current geometric mean criterion for *E. coli* of 126 cfu/100 mL for each component of the TMDLs. The TMDL allocation summaries for the Big Creek watershed is summarized in Table 20.

Table 20. TMDL allocations

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	FG	MOS
1202J_01	3,202.806	42.228	408.191	2,412.04	180.207	160.140
1202J_02	579.454	24.301	83.769	359.68	82.731	28.973

All loads are expressed in billion cfu/day.

The final TMDL allocations (Table 21) needed to comply with the requirements of 40 CFR 103.7 include the FG component within the WLA_{WWTF}.

Table 21. Final TMDL allocations

AU	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
1202J_01	3,202.806	222.435	408.191	2,412.04	160.410
1202J_02	579.454	107.032	83.769	359.68	28.973

All loads are expressed in billion cfu/day.

Seasonal Variation

Federal regulations require that TMDLs account for seasonal variation in watershed conditions and pollutant loading [40 CFR 130.7(c)(1)].

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from 14 years (2006 through 2020) of routine monitoring data collected in the warmer months (May through September) against those collected during the cooler months (November through March). The months of April and October were considered transitional between 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 (also known as the “Mann-Whitney” test). This analysis of *E. coli* data indicated that there was no significant difference (α=0.05) in indicator bacteria between cool and warm weather seasons for Big Creek. Seasonal variation was also addressed by using all available flow and *E. coli* records (covering all seasons) from the period of record used in LDC development for this project.

Public Participation

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.

TCEQ and H-GAC held a series of meetings (Table 22) with stakeholders to get their advice on elements of the project and to keep them informed of progress. Notices of meetings were posted on the project webpage and on the TMDL program's online calendar.

The TMDL process started with the development of a Watershed Characterization Report in 2019. Stakeholders were brought together to provide insight about the watershed and review water quality data related to Big Creek. After the Technical Support Document phase of the project initiated in 2020, H-GAC sought stakeholder feedback on information related to the document draft. Stakeholders also began early planning for implementation strategies to include in a future Implementation Plan (I-Plan) for Big Creek.

Date	Meeting Type	Purpose
7/11/19	Public Meeting	Stakeholder group met for project overview, to review preliminary data and provide insight
8/22/19	Public Meeting	Stakeholder group met to review the Watershed Characterization Report draft and provide feedback
2/27/20	Public Meeting	Stakeholder group met to review project progress and information related to the Technical Support Document draft and provide feedback
6/23/20	Public Meeting (virtual)	Stakeholder group met to review project progress and information related to the Technical Support Document draft and provide feedback
7/27/21	Public Meeting (virtual)	Stakeholder group met to review project progress and information related to the Technical Support Document draft and provide feedback
6/9/22	Public Meeting	A discussion of the TMDL/TSD progress and feedback from stakeholders moving into implementation planning
8/31/22	Public Meeting (virtual)	A discussion of project progress and volunteer monitoring opportunities
2/23/23	Public Meeting (virtual)	A discussion of project updates and strategies to develop an I-Plan for the Big Creek TMDL

Table 2210. Big Creek stakeholder meetings

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that WLAs 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 TMDL does not reflect or direct specific implementation by any single pollutant discharger, TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the commission. Based on the TMDL and I-Plan, TCEQ will propose and certify WQMP updates to establish required WQBELs for specific TPDES wastewater discharge permits.

For MS4 entities, where numeric effluent limitations are infeasible, the permits require that the MS4 develop and implement BMPs under each MCM, which are a substitute for effluent limitations, as allowed by federal rules. How a regulated MS4 meets each MCM is not prescribed in detail in the MS4 permits but is included in the permittee's SWMP. During the permit renewal process, TCEQ revises its MS4 permits as needed to require a revised SWMP or to require the implementation of other specific BMPs or controls consistent with an approved TMDL and 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. 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 I-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.

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, TCEQ will also work in close partnership with TSSWCB when developing the I-Plan. 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 identifies the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the approved I-Plan 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.

References

AVMA. (American Veterinary Medical Association) 2018. 2017-2018 U.S. Pet Ownership Statistics. www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics.

Cleland, B. 2003. TMDL Development From the “Bottom Up” - Part III: Duration Curves and Wet-Weather Assessments. Online. www.researchgate.net/publication/228822472_TMDL_Development_from_the_Bottom_Up-_PART_III_Durations_Curves_and_Wet-Weather_Assessments.

EPA. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. https://www.epa.gov/sites/default/files/2018-10/documents/guidance-water-tmdl-process.pdf.

EPA. 2014. Memorandum from OWM and OWOW: Revisions to the November 22, 2002 Memorandum “Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs” (PDF). November 26, 2014. https://www.epa.gov/tmdl/establishing-total-maximum-daily-load-tmdl-wasteload-allocations-wlas-storm-water-sources-and.

EPA. 2022. Enforcement and Compliance History Online (ECHO). Accessed October 24, 2022. https://echo.epa.gov/.

H-GAC. 2018. 2018 10 Class Land Cover Data Set. https://www.h-gac.com/land-use-and-land-cover-data.

H-GAC. 2022a. 2021 H-GAC Regional Growth Forecast. USCB Decadal Census (www.census.gov/programs-surveys/decennial-census.html). Houston-Galveston Area Council. datalab.h-gac.com/rgf2018.

H-GAC. 2022b. OSSF Information System. Permitted OSSF within the H-GAC planning area. datalab.h-gac.com/ossf/.

H-GAC. 2022c. OSSF Information System-Non-Registered. Non-registered OSSF within the H-GAC planning area, non-published data 2022.

H-GAC. 2023. Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in Big Creek. https://www.tceq.texas.gov/downloads/water-quality/tmdl/big-creek-recreational-122/tsd-122-big-creek-bacteria-as-479.pdf

NOAA. 2019. National Climatic Data Center. National Climate Data Center Climate Data Online. Accessed on May 1, 2022, from: https://www.ncdc.noaa.gov/cdo-web/.

NEIWPCC (New England Interstate Water Pollution Control Commission). 2003. Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities. https://www.neiwpcc.org/neiwpcc_docs/iddmanual.pdf.

Reed, Stowe & Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. Texas On-site Wastewater Treatment Council. https://www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf.

Runkel, Robert L., Charles G. Crowford, and Timothy A. Cohn. 2004. Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Streams and Rivers.

TCEQ. 2002. 2002 Texas Water Quality Inventory Texas 303(d) List. https://wayback.archive-it.org/414/20190907172412/https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/02twqi/02_303d.pdf

TCEQ. 2008. 2006 Texas Water Quality Inventory and 303(d) List. https://www.tceq.texas.gov/waterquality/assessment/06twqi/twqi06.html.

TCEQ. 2015. 2014 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/waterquality/assessment/14twqi/14txir.

TCEQ. 2018. Texas Surface Water Quality Standards, 2018, 30 TAC 307. texreg.sos.state.tx.us/public/readtac%24ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=307&rl=Y.

TCEQ. 2022a. 2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d). https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2022/2022-303d.pdf.

TCEQ. 2022b. TCEQ Central Registry. Accessed May 1, 2022. https://www15.tceq.texas.gov/crpub/.

TCEQ. 2022c. Water Rights Viewer. https://www.tceq.texas.gov/gis/water-rights-viewer. Accessed May 15, 2022.

TCEQ. 2022d. Personal written communication with Jason Leifester regarding sanitary sewer overflows in the Big Creek watershed. March 16, 2022.

Timmons J., Higginbotham B., Lopez R., Cathey J., Mellish J., Griffin J, Sumrall A., Skow, K. 2012. Feral Hog Population Growth, Density, and Harvest in Texas. August 2012. agrilife.org/feralhogs/files/2010/04/FeralHogPopulationGrwothDensityandHervestinTexasedited.pdf.

TPWD. 2020. Personal communication regarding estimation of deer populations in Texas. August 19, 2020.

USCB. 2020. USCB Decadal Census www.census.gov/programs-surveys/decennial-census.html.

USDA National Agricultural Statistics Survey. 2017. 2017 Census of Agriculture. https://www.nass.usda.gov/AgCensus/

USDA NRCS. 2015. SSURGO/STATSGO2 Structural Metadata and Documentation. www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053631.

Weiskel, P.K., B.L. Howes, and G.R. Heufelder. 1996. Coliform Contamination of Coastal Embayment: Sources and Transport Pathways. Environmental Science and Technology, 30, 1872-1881 https://pubs.acs.org/doi/10.1021/es950466v.

Appendix A.

Population and Population Projections

The following steps detail the method used to estimate the 2020 and projected 2050 populations in the TMDL Project watershed.

1. Obtained USCB 2020 Decadal Census data from the USCB at the block level.
2. Used census block data to develop population estimates for a hexagonal grid of three-square miles each (H3M) for the H-GAC region.
3. Determined the 2020 population for H3Ms that do not lie entirely in the watershed by multiplying the H3M population by the portion of the H3M located within the watershed assuming equal distribution.
4. Obtained population projections for the year 2050 from the H-GAC regional forecast based on H3M data.
5. Determined the 2045 population projections for H3Ms that do not lie entirely in the watershed by multiplying the H3M population by the portion of the H3M located within the watershed assuming equal distribution.
6. Subtracted the 2020 watershed population from the 2050 population projection to determine the projected population increase. Subsequently, the projected population increase was divided by the 2020 watershed population to determine the percent population increase for the TMDL Project watershed.