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One Total Maximum Daily Load for Indicator Bacteria in Oso Creek

Segment 2485A

Assessment Unit 2485A_01

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Indicator Bacteria in Oso Creek"
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Abbreviations

AU	assessment unit
BMP	best management practice
CCN	Certificate of Convenience and Necessity
CCS	Center for Coastal Studies
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWSS	Center for Water Supply Studies
DSLP	days since last precipitation
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
FDC	flow duration curve
GIS	Geographic Information System
I&I	inflow and infiltration
I-Plan	implementation plan

LA	load allocation
LDC	load duration curve
MCM	minimum control measure
MGD	million gallons per day
mL	milliliter
MOS	margin of safety
MPN	most probable number
MS4	Municipal Separate Storm Sewer System
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
s/d	seconds per day
SSO	sanitary sewer overflow
SSURGO	Soil Survey Geographic
SWMP	Stormwater Management Program
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
USGS	United States Geological Survey
WLA	waste load allocation
WQBEL	water quality-based effluent limits
WQMP	Water Quality Management Plan
WUG	Water User Group
WWTF	wastewater treatment facility

One TMDL for Indicator Bacteria in Oso Creek

Executive Summary

This document describes a total maximum daily load (TMDL) for the tidal segment of Oso Creek where concentrations of indicator bacteria exceed the criteria used to evaluate attainment of the contact recreation use. The Texas Commission on Environmental Quality (TCEQ) first identified the bacteria impairment in 2002 and then in each subsequent edition of the *Texas Integrated Report of Surface Water Quality for the federal Clean Water Act Sections 305(b) and 303(d)* (Texas Integrated Report) through 2014. This document will consider bacteria impairments in one water body segment, consisting of one assessment unit (AU):

- Oso Creek (AU 2485A_01)

The Oso Creek watershed is 209.1 square miles in area and is located along the Texas Gulf Coast, immediately southwest of the City of Corpus Christi and includes portions of the city. The creek flows into Oso Bay, and then into Corpus Christi Bay.

Four facilities within the Oso Creek watershed treat domestic wastewater. One industrial facility treats low-volume wastes and once-through cooling water associated with a natural gas power plant facility. This facility does not have a human waste component. An additional industrial facility is permitted only for stormwater discharge.

Three municipal separate storm sewer system (MS4) permits are held in the Oso Creek watershed, of which two are Phase I individual permits and one is a Phase II general permit. The area included within these permits was used to estimate the area under stormwater regulation for construction, industrial, and MS4 permits.

Four concrete production facilities and three pesticide permittees covered by general permits are also located within the watershed. The discharges authorized by the industrial wastewater and stormwater permits are considered intermittent and variable (subject to precipitation and runoff), and no flow limit is specified in the permits. Given the circumstances of the permits, these outfalls will be treated as part of the regulated stormwater discharge in the wasteload allocations (WLAs).

Escherichia coli (*E. coli*) are widely used as an indicator bacteria to assess attainment of the contact recreation use in freshwater bodies, while Enterococci are used as the indicator bacteria in saltwater. Enterococci are the relevant

indicator for the Oso Creek segment, because it is considered a tidal stream. The criteria for assessing attainment of the contact recreation use are expressed as the number (or "counts") of Enterococci bacteria, typically given as the most probable number (MPN). The primary contact recreation use is not supported when the geometric mean of all Enterococci samples exceeds 35 MPN per 100 milliliters (mL).

Enterococci data, collected at seven monitoring stations over the seven-year period of December 1, 2005 through November 30, 2012, were used in assessing attainment of the primary contact recreation use, as reported in the 2014 Texas Integrated Report (TCEQ, 2015). The 2014 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criterion of 35 MPN/100 mL for Enterococci.

A load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria. The WLA for wastewater treatment facilities (WWTFs) was established as the full permitted discharge flow rate multiplied by the instream geometric criterion and reduced to account for the required margin of safety (MOS). Future growth of existing or new domestic point sources was determined using population projections.

Within the Oso Creek watershed, the most probable sources of indicator bacteria are expected to be regulated stormwater, industrial sources, and nonpoint sources. Nonpoint source loading enters the impaired segment through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities, livestock, land application fields, failing on-site sewage facilities (OSSFs), unmanaged and feral animals, and domestic pets.

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

Compliance with this TMDL is based on keeping the indicator bacteria concentrations in the selected waters below the geometric mean criterion of 35 MPN/100 mL.

Introduction

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

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

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

This TMDL addresses impairment of the primary contact recreation use due to exceedances of indicator bacteria in Oso Creek (Segment 2485A). It takes a watershed approach to address the indicator bacteria impairment. While TMDL allocations were developed only for the impaired AU identified in this report, the entire project watershed (Figure 1) and all WWTFs that discharge within it are included within the scope of this TMDL.

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

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

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

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

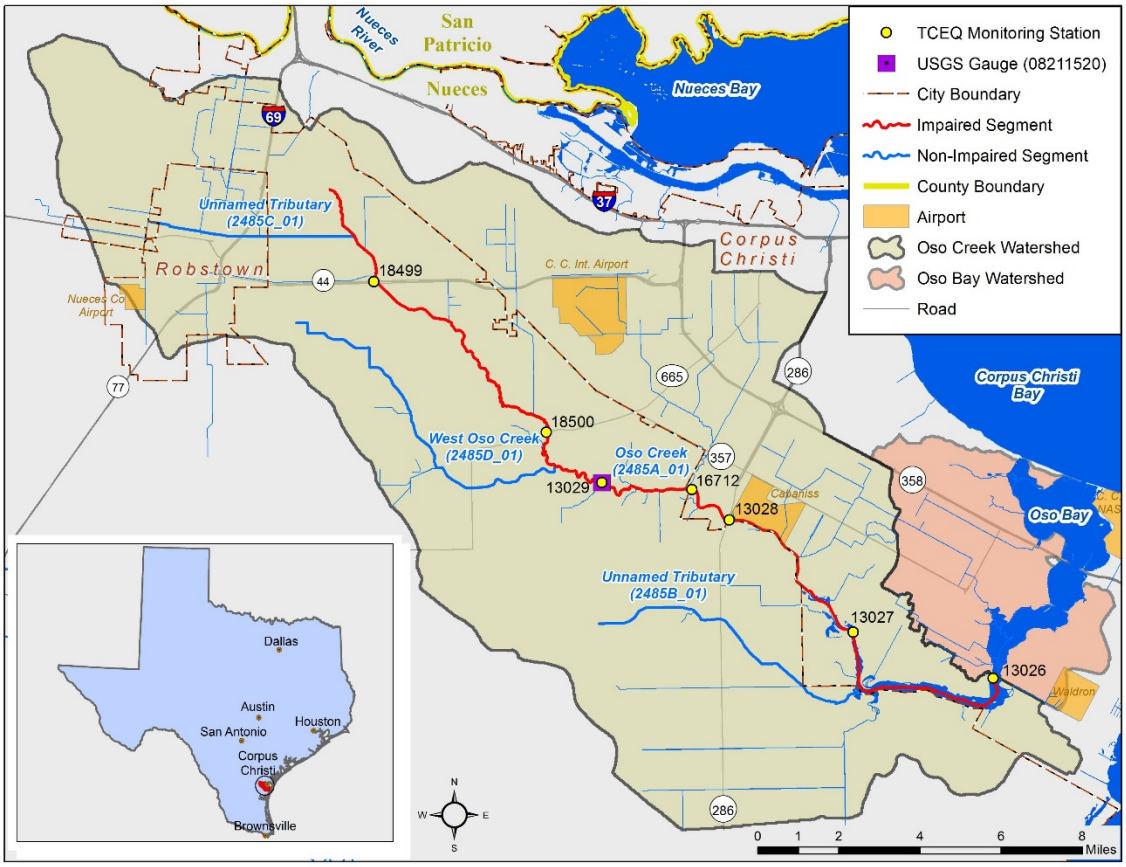

Figure 1. Overview map showing the Oso Creek segment/AU and watershed (including the Oso Bay watershed), and TCEQ water quality monitoring stations.

Problem Definition

The TCEQ first identified the bacteria impairment within Oso Creek (Segment 2485A) in 2002, and then in each subsequent edition of the Texas Integrated Report through 2014.

This document will consider the bacteria impairment in one segment, consisting of a single AU:

- Oso Creek (AU 2485A_01)

Because the impaired segment is comprised of only one AU that encompasses the entire segment, the terms AU and segment may be used interchangeably throughout this report.

Ambient Indicator Bacteria Concentrations

Recent environmental bacteria monitoring in AU 2485A_01 has occurred at seven TCEQ monitoring stations within the watershed (Table 1 and Figure 1). Enterococci data, collected at these stations over the seven-year period from December 1, 2005 through November 30, 2012, were used in assessing attainment of the primary contact recreation use as reported in the 2014 Texas Integrated Report (TCEQ, 2015). The 2014 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criterion of 35 MPN/100 mL for Enterococci.

Table 1. 2014 Texas Integrated Report summary for the impaired AU.

Stations ordered upstream to downstream

Water Body	Segment Number	AU	Parameter	Stations	Number of Samples	Geometric Mean[a] (MPN/100 mL)
Oso Creek	2485A	2485A_01	Enterococci	18499	11	407
				18500	11	437
				13029	11	292
				16712	11	217
				13028	38	132
				13027	11	35
				13026	11	30
				All Stations	104	144

[a] The geometric mean criterion for primary contact recreation use is 35 MPN/100 mL for Enterococci.

Watershed Overview

Oso Creek, located along the Texas Gulf Coast immediately southwest of the City of Corpus Christi and including portions of the city, is comprised of one segment that has a length of 42.6 km (26.5 mi). Oso Creek is designated as Segment 2485A, and the Oso Creek watershed is a major portion of the Oso Bay (Segment 2485) watershed. At its mouth, Oso Creek drains 209.1 square miles (133,833 acres) exclusively within Nueces County. This TMDL incorporates a watershed approach where the entire drainage area of Segment 2485A is considered (Figure 1). A bacteria TMDL for Oso Bay (Segment 2485) was adopted by TCEQ in 2007 and approved by EPA in 2008 (TCEQ, 2007).

The 2014 Texas Integrated Report (TCEQ, 2015) provides the following segment and AU description for Oso Creek:

- Segment 2485A: Oso Creek

- From the Oso Bay confluence in southern Corpus Christi to a point 4.8 km (3 mi) upstream of SH 44, west of Corpus Christi in Nueces County
- Segment Type: Tidal Stream
- AU 2485A_01 - From the Oso Bay confluence in southern Corpus Christi to a point 4.8 km (3 mi) upstream of SH 44, west of Corpus Christi

Oso Creek is considered a tidal stream for TCEQ assessment purposes. The creek, however, transitions in the upstream direction from its mouth into a non-tidal, freshwater stream for the upper two-thirds of its length.

Watershed Climate

The Oso Creek watershed is located in the southern part of Texas near the Gulf Coast (Figure 1) in a climatological region designated humid subtropical. Typically, summers are characterized by warm, humid mornings with clear afternoons achieving highs in the mid-90s (˚F) that are moderated by afternoon coastal breezes. These conditions typically extend into the fall months of September and October. Temperatures seldom exceed 100 ˚F during the summer months near the bay and occur more frequently farther inland. Likewise, winters are considered mild, as freezing temperatures rarely occur in the bay area, with more frequent sub-32 ˚F temperatures materializing farther inland. First and last frosts generally happen in early November and mid-March, respectively. High relative humidity is present year-round. The hurricane season lasts from June to November, with August and September observed as prime hurricane months. September is the peak precipitation month with precipitation totals largely influenced by hurricanes and tropical storms. However, periods of dry weather patterns lasting several months are frequent. Snowfall events are rare, occurring only once every couple of years, and generally last for 24 hours or less (NOAA, 2016a). For the period from 1981–2010, average annual precipitation in the Oso Creek watershed was 31.0 inches (Figure 2; PRISM, 2012).

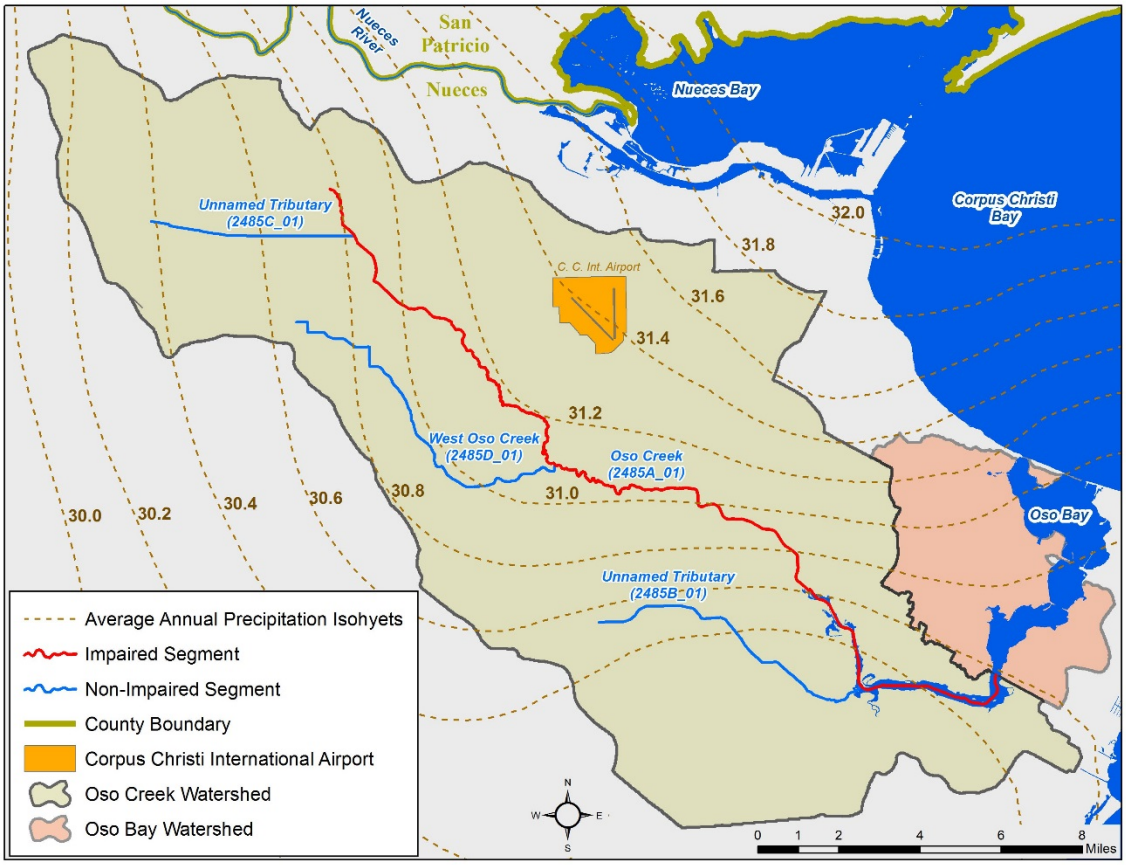

Figure 2. Annual average precipitation isohyets (in inches) in the Oso Creek watershed (1981-2010).

For the more recent 15-year period from 2001–2015 at Corpus Christi International Airport, centrally located in the Oso Creek watershed, the highest temperatures generally occur in August with an average monthly high of 95.8 ˚F and an average monthly low of 75.6 ˚F (NOAA, 2016b). During winter, the lowest temperatures generally bottom out in January with an average monthly high of 67.8 ˚F and an average monthly low of 47.2 ˚F. September is indicated to be the wettest month, averaging 6.1 inches of precipitation, with December (1.1 inches) observed to be the driest month (Figure 3).

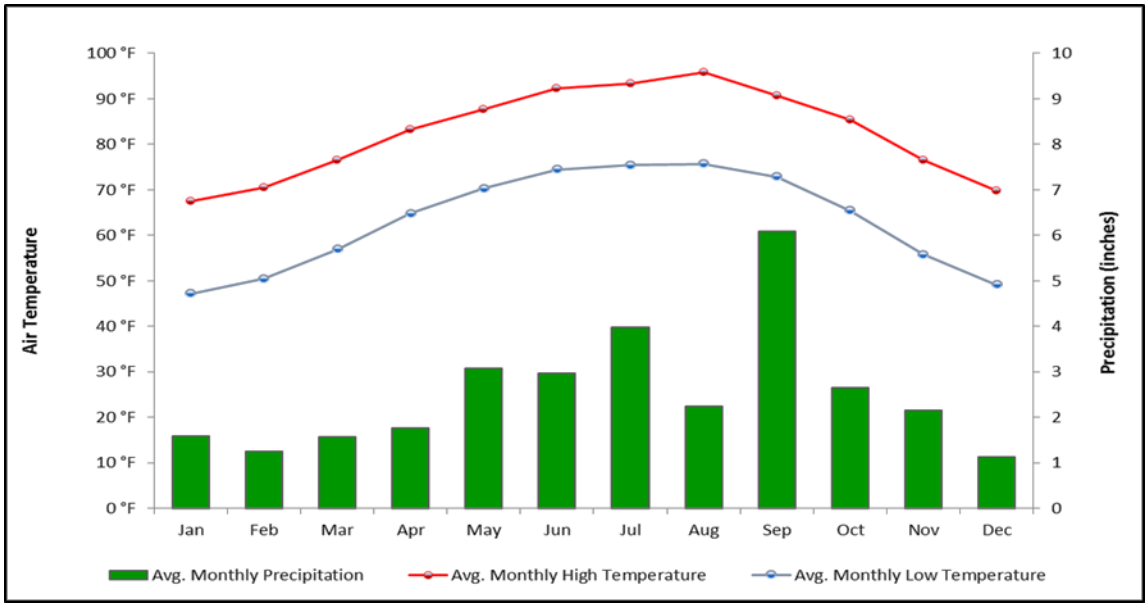

Figure 3. Average minimum and maximum air temperatures and average precipitation by month from 2001-2015 for the Corpus Christi International Airport.

Watershed Population and Population Projections

As depicted in Figure 4, the Oso Creek watershed is geographically located entirely within Nueces County, with 36 percent of the watershed covered by municipal boundaries (Corpus Christi and Robstown) and 64 percent designated as "County Other" areas. According to the 2010 Census (USCB, 2016), the Oso Creek watershed has an estimated population of 119,130 people and an average population density of 570 people per square mile. However, 86.8 percent of the estimated population (103,411 people) is located within the Corpus Christi city limits, followed by Robstown with 9.4 percent (11,237 people), indicating a largely urban watershed population. Figure 4 provides a depiction of the population density per square mile of Oso Creek watershed.

Population projections from 2010-2050 were developed by the Texas Water Development Board (TWDB) based on Water User Groups (WUGs; TWDB, 2015). These data were used to derive the population projections for the Oso Creek watershed and indicate a population increase of 28.4 percent by 2050. Population projection increases range from 8.5 percent to 52.4 percent. The largest population percent increase (52.4 percent) over the 40-year span is anticipated to occur in that portion of the Oso Creek watershed that falls outside of the Corpus Christi and Robstown municipal boundaries. However, this area will contribute only 2,348 additional people by 2050. The Corpus Christi population within the Oso Creek watershed is projected to increase by more than 30,000 people by 2050. Table 2 provides a summary of the 2010–2050 population projections.

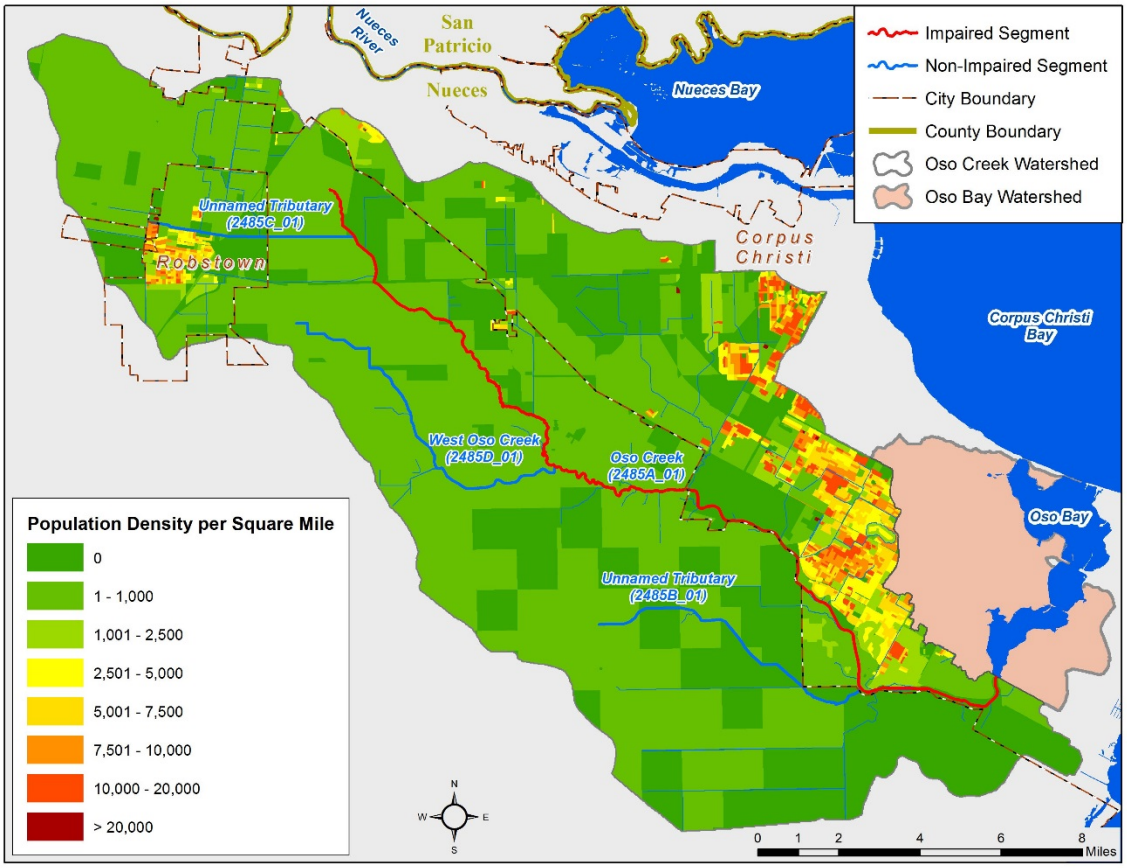

Figure 4. Population density for the Oso Creek watershed based on the 2010 U.S. Census blocks.

Table 2. 2010 Population and 2020-2050 Population Projections for the Oso Creek watershed.

Location in watershed	2010 U.S. Census Population	2020 Population Projection	2030 Population Projection	2040 Population Projection	2050 Population Projection	Projected Population Increase (2010-2050)	Percent Change (2010-2050)
Corpus Christi	103,411	113,726	123,871	130,248	133,982	30,571	29.56%
Robstown	11,237	12,196	12,196	12,196	12,196	959	8.53%
County Other [a]	4,482	5,001	5,917	6,493	6,830	2,348	52.39%
Watershed Total	119,130	130,923	141,984	148,937	153,008	33,878	28.44%

[a] County Other is defined as that portion of the Oso Creek watershed that falls outside of the Corpus Christi and Robstown municipal boundaries.

Water Rights Review

Surface water rights in Texas are administered and overseen by the TCEQ. A search of the TCEQ water rights database file (TCEQ, 2016a) revealed that the Oso Creek watershed contains five permitted surface water rights, as depicted in Figure 5. As noted in Table 3, diverted water uses include irrigation, recreation, industrial, and mining, with an authorized annual total diversion of 958.95 acre-feet.

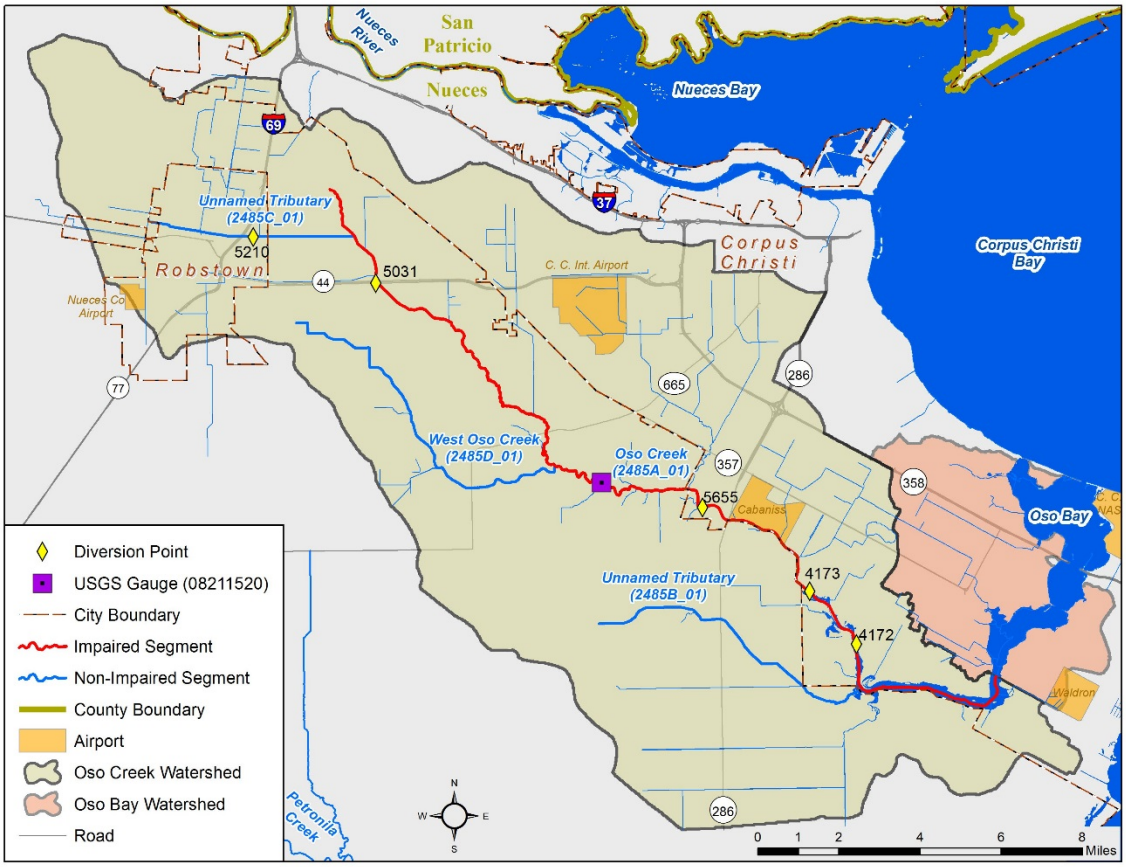

Figure 5. Oso Creek watershed showing diversion points and permit numbers of surface water rights in relation to USGS gauge.

A review of water-use data obtained for the South Texas watermaster area (I. Spaeth, personal communication, TCEQ, May 5, 2019) showed some reported diversions over the period of 1990 through 2015. As explained under the Load Duration Curve Analysis section of this report, diversions that could impact the development of TMDL allocations would be those occurring within the period of 2000 through 2015, during high streamflow conditions, and from a water-right above the U.S. Geological Survey (USGS) gauge 08211520 on Oso Creek (Figure 5). No diversions occurred meeting all these requirements. In fact, only one diversion (0.33 acre-feet) occurred upstream of the gauge during the 2000-2015

time period. Additionally, water rights permits allow withdrawals of water, as opposed to discharges, and do not need to be assigned loadings in a TMDL.

Table 3. Permitted annual diversion amounts for water rights in the Oso Creek watershed.

Permit No.	Owner Name	Use	Diversion Located Above/Below USGS Gauge 08211520	Authorized Diversion Amount (acre-feet/year)
WR 4172 [a]	Oso Creek Properties LC	Irrigation	Below	682
WR 4173 [a]	King's Crossing Holdings, LP	Recreation	Below	127
WR 5031	St Anthony's Catholic Church	Irrigation	Above	1
WR 5210 [a]	Bernsen Farms, Ltd.	Irrigation	Above	81.75
WR 5655	City of Corpus Christi	Industrial & Mining	Below	67.20
Total Authorized Diversions				958.95

[a] Some of the diverted water can be stored in an off-channel reservoir.

Land Use

The land use/land cover data for the Oso Creek watershed was obtained from the USGS 2011 National Land Cover Database (NLCD; Homer et al., 2015 and USGS, 2014).

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

- **Open Water** – areas of open water, generally with less than 25 percent cover of vegetation or soil.
- **Developed, Open Space** – areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- **Developed, Low Intensity** – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 to 49 percent of total cover. These areas commonly include single-family housing units.
- **Developed, Medium Intensity** – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover. These areas commonly include single-family housing units.

- **Developed High Intensity** – highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.
- **Barren Land (Rock/Sand/Clay)** – areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
- **Deciduous Forest** – areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
- **Evergreen Forest** – areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
- **Mixed Forest** – areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
- **Shrub/Scrub** – areas dominated by shrubs less than five meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
- **Grassland/Herbaceous** – areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
- **Pasture/Hay** – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
- **Cultivated Crops** – areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
- **Woody Wetlands** – areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- **Emergent Herbaceous Wetlands** – areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

The 2011 NLCD land use/land cover data is provided for the Oso Creek watershed in Figure 6. A summary of the land use/land cover data is provided in Table 4. The dominant land uses are Cultivated Crops (62.7 percent) and

Developed (open space, low intensity, medium intensity, and high intensity; 20.1 percent) comprising 82.8 percent of the land use/land cover. To summarize, the land use coverage indicates a mostly rural, agricultural watershed with areas of intense urbanization.

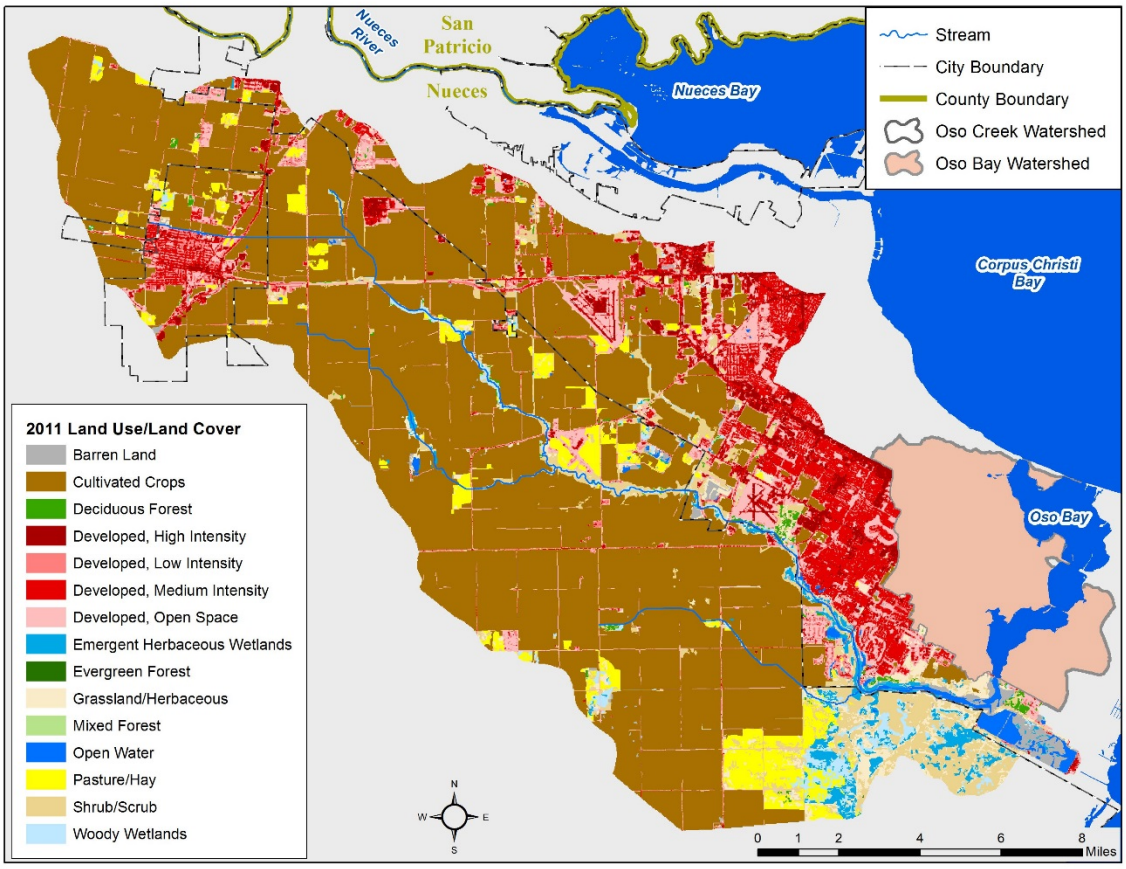

Figure 6. 2011 NLCD land use/land cover within the Oso Creek watershed.

Soils

Soils within the Oso Creek watershed were categorized by septic tank absorption field ratings. These data were obtained through the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS, 2015).

Soil properties and features such as saturated hydraulic conductivity, flooding, depth to bedrock, depth to cemented pan, ponding, rocks, fractured bedrock, subsidence, and excessive slope can affect septic tank effluent absorption, construction and maintenance, and public health (NRCS, 2015). The dominant soil condition within a septic drainage field can be used to identify soils that may prove problematic regarding septic system installation/performance and potentially lead to system failures such as effluent surfacing or downslope seepage.

Table 4. Land use/land cover within the Oso Creek watershed.

Source: USGS (2014)

2011 NLCD Classification	Area (Acres)	Percent of Total
Open Water	1,144.3	0.86%
Developed, Open Space	8,293.7	6.20%
Developed, Low Intensity	5,755.4	4.30%
Developed, Medium Intensity	9,475.0	7.08%
Developed, High Intensity	3,323.6	2.48%
Barren Land	1,424.6	1.06%
Deciduous Forest	494.7	0.37%
Evergreen Forest	2.8	0.00%
Mixed Forest	3.8	0.00%
Shrub/Scrub	7,157.8	5.35%
Grassland/Herbaceous	3,195.8	2.39%
Pasture/Hay	5,380.1	4.02%
Cultivated Crops	83,882.7	62.68%
Woody Wetlands	2,248.7	1.68%
Emergent Herbaceous Wetlands	2,049.8	1.53%
Total	133,832.8	100.00%

Soils are rated based on the conditions affecting proper effluent drainage and filtering capacity. Soil conditions for septic tank drainage fields are expressed by the following rating terms and definitions (NRCS, 2015):

- **Not Limited** – Indicates that the soil has features that are very favorable for the specific use. Good performance and very low maintenance can be expected.
- **Somewhat Limited** – Indicates that the soil has one or more features that are moderately favorable for the specified use. The limitations can be overcome or minimized with special planning, design, and installation procedures. Fair performance and moderate maintenance can be expected.
- **Very Limited** – Indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive

installation procedures. Poor performance and high maintenance can be expected.

- **Not Rated** – Indicates insufficient data exists for soil limitation interpretation.

Within the Oso Creek watershed, approximately 97 percent of the soils are rated as "Very Limited" based on the dominant soil condition for septic drainage field installation and operation (conditions are shown in Figure 7).

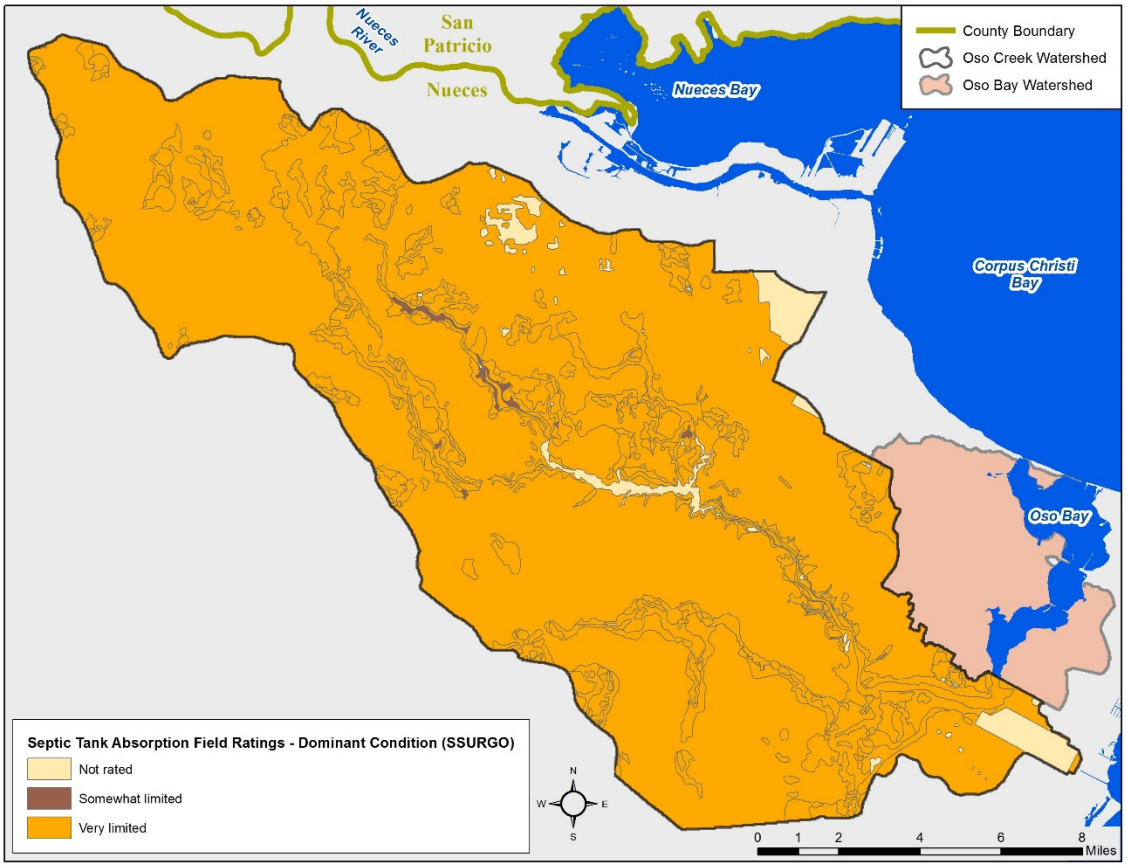

Figure 7. Septic tank absorption field limitation ratings for soils within the Oso Creek watershed.

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 TMDL in this report is to maintain concentrations of Enterococci below the geometric mean criterion of 35 MPN/100 mL, which is the

criterion in the 2010 Texas Surface Water Quality Standards (TCEQ, 2010) for primary contact recreation in saline water bodies.

Source Analysis

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

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

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

Regulated Sources

The regulated sources in the TMDL watershed include domestic and industrial WWTFs and stormwater discharges from industry, construction, and MS4s.

Domestic and Industrial Wastewater Treatment Facilities

As of July 2016, six facilities with TPDES/NPDES permits were operating within the watershed (Figure 8 and Table 5). Four facilities within the watershed treat exclusively domestic wastewater, one industrial facility (Barney M. Davis, LP) treats low-volume wastes and contains once-through cooling water associated with a natural gas power plant facility with no human waste component, and one industrial facility (Equistar Chemicals, LP) is permitted only for stormwater discharges. As noted in Table 5, three facilities discharge directly into Oso Creek. Discharge units are reported in million gallons per day (MGD).

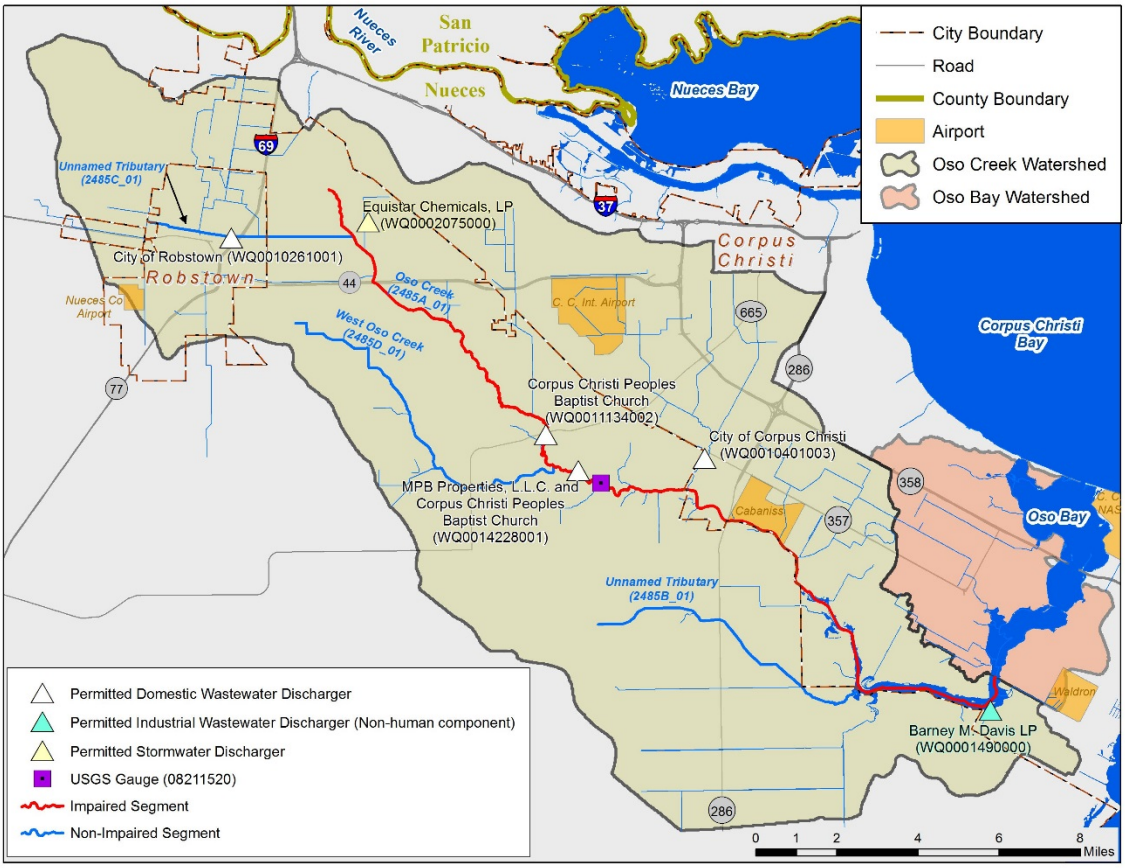

Figure 8. Oso Creek watershed showing permitted domestic and industrial regulated discharge facilities (WWTFs, industrial wastewater and stormwater) and USGS gauging station.

TPDES General Wastewater Permits

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

- TXG110000 – concrete production facilities,
- TXG130000 – aquaculture production facilities,
- TXG340000 – petroleum bulk stations and terminals,
- TXG500000 – quarries in John Graves Scenic Riverway,
- TXG670000 – hydrostatic test water discharges,
- TXG830000 – water contaminated by petroleum fuel or petroleum substances,
- TXG870000 – pesticides,
- TXG920000 – concentrated animal feeding operations,

Table 5. Permitted domestic and industrial WWTFs in the Oso Creek watershed.

AU	Entity/Permittee (Facility Name)	TPDES Permit No.	NPDES Permit No.	Receiving Waters	Discharge Type	Permitted Discharge (MGD)	Recent Discharge 2015-2017 (MGD) [a]
2485C_01	City of Robstown (Robstown WWTF)	WQ0010261001	TX0020389	unnamed ditch; thence to Oso Creek	Domestic Wastewater	3.0 (annual avg)	1.2
2485A_01	Corpus Christi People's Baptist Church (Roloff WWTF)	WQ0011134002	TX0136620	Oso Creek	Domestic Wastewater	0.02 (daily avg)	0.008
2485A_01	City of Corpus Christi (Greenwood WWTF)	WQ0010401003	TX0047074	unnamed tributary; thence to Oso Creek	Domestic Wastewater	16.0 (annual avg)	5.5
2485A_01	MPB Properties, L.L.C. and Corpus Christi People's Baptist Church (Cuddihy Airfield WWTF)	WQ0014228001	TX0123676	Oso Creek	Domestic Wastewater	0.06 (daily avg)	0.004
2485A_01	Barney M. Davis, LP (Barney M. Davis Power Station)	WQ0001490000	TX0008826	Oso Creek	Industrial - low volume wastewater, metal cleaning wastes, and stormwater	Intermittent and variable	–
					Industrial - once through cooling water and previously monitored effluents	540 (daily avg)	280
2485A_01	Equistar Chemicals, LP (Corpus Christi Complex)	WQ0002075000	TX0076996	Outfall 003 – unnamed ditch; thence to Oso Creek	Stormwater [b]	Intermittent and variable	–

[a] Three- year average (avg) measured data from January 2015 through December 2017 from Discharge Monitoring Report data (EPA, 2018)

[b] Equistar Chemicals is permitted for three different outfalls. Outfall 001(treated process and wastewater) and Outfall 002 (stormwater runoff) discharge directly into Corpus Christi Inner Harbor (Segment 2484). Outfall 003 (stormwater runoff) discharges as described above via an unnamed ditch, thence into Oso Creek.

- WQG100000 – wastewater evaporation, or
- WQG20000 – livestock manure compost operations (irrigation only).

A review performed August 11, 2016 of active general permit coverage (TCEQ, 2016b) in the Oso Creek watershed discovered four concrete production facilities and three pesticide permittees covered by general permits. The concrete production facilities and pesticide management areas do not have bacteria reporting or limits in their permits. These authorizations were assumed to result in inconsequential amounts of indicator bacteria; therefore, it was unnecessary to allocate a bacteria load to these authorizations. No other active general wastewater permit facilities or operations were found.

Sanitary Sewer Overflows

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

City of Corpus Christi SSO data from 2008-2013 containing estimates of the total gallons spilled, responsible entity, and a general location of the spill were provided by the Center for Water Supply Studies (CWSS, 2016). SSO incidents for this dataset were refined by CWSS by assigning latitude and longitude coordinates to each SSO event and plotted using Geographic Information System (GIS) software (Figure 9) to characterize the frequency and magnitude of SSO events within the Oso Creek watershed. A summary of the CWSS refined data within the Oso Creek watershed is shown in Table 6.

Table 6. Summary of SSO incidences reported in the Oso Creek watershed from 2008–2013.

Watershed	No. of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
Oso Creek	1,715	228,773	133	1	100,000

TPDES-Regulated Stormwater

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

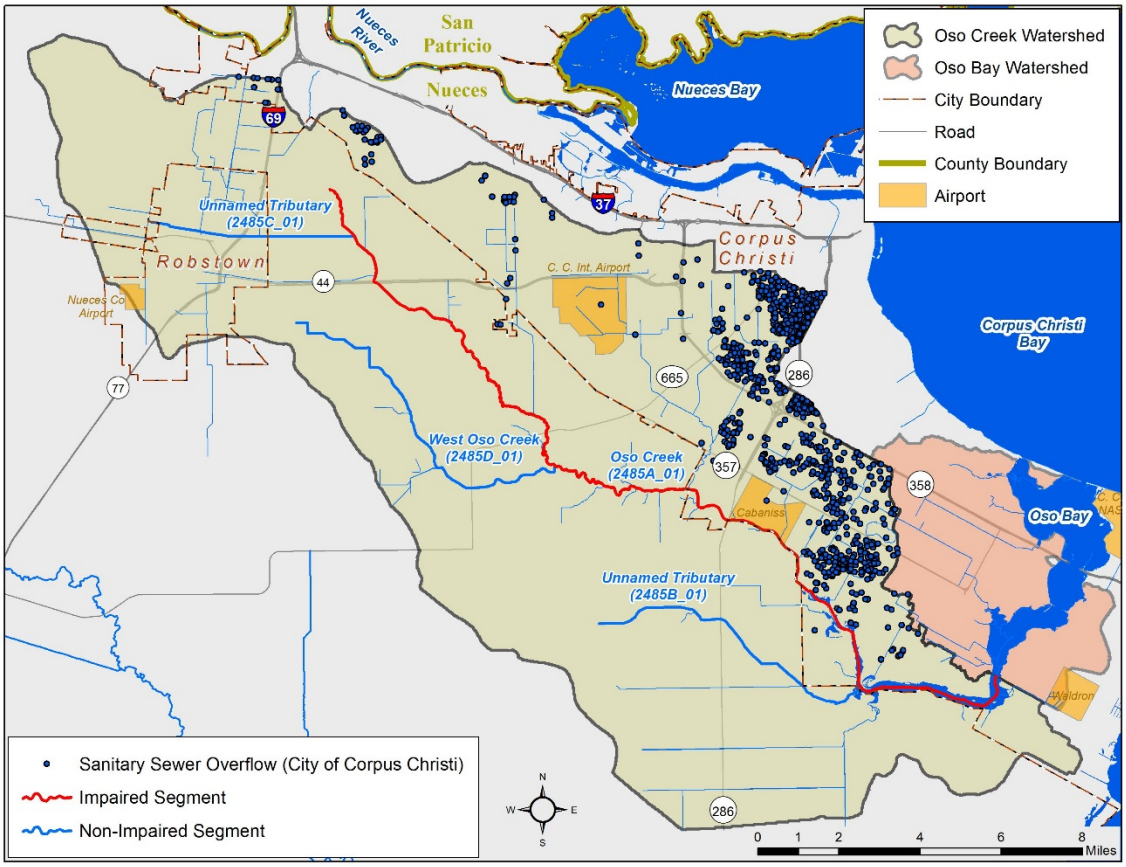

Figure 9. SSOs for the City of Corpus Christi from 2008-2013 within the Oso Creek watershed.

1) stormwater subject to regulation, which is any stormwater originating from TPDES/NPDES-regulated municipal separate storm sewer system (MS4), industrial facilities, and construction activities; or

2) stormwater runoff not subject to regulation.

The TPDES/NPDES 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 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 general permit regulates smaller communities within a U.S. Census-defined urbanized area. The purpose of an MS4 permit is to reduce discharges of pollutants in stormwater to the "maximum extent practicable" by developing and implementing a Stormwater Management Program (SWMP). The SWMP describes the stormwater control practices that will be implemented consistent with permit requirements to minimize the discharge of pollutants from an MS4. The

permits require that the 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 reduction of pollutants discharged into receiving waters. Phase II MS4 MCMs include:

- Public education outreach and involvement;
- Illicit discharge detection and elimination;
- Construction site runoff control;
- Post-construction stormwater management in new development and redevelopment;
- Pollution prevention and good housekeeping for municipal operations; and
- Industrial stormwater sources.

Phase I MS4 individual permits have similar MCMs organized a little differently and are further required to perform water quality monitoring.

A search of the TCEQ central registry for active regulated stormwater entities for MS4 permit coverage (TCEQ, 2016c) in the Oso Creek watershed revealed two Phase I permits and one Phase II permit (Table 7). The Phase I permits are held by the Texas Department of Transportation and the City of Corpus Christi with associated entities, and the Phase II permit is held by Nueces County.

The geographic region of the Oso Creek watershed covered by Phase I and II MS4 permits is that portion of the area within the jurisdictional boundaries of the regulated entities. For Phase I individual permits, the jurisdictional area was defined by the area of the Corpus Christi city limits within the watershed, and for Phase II general permit authorizations, the jurisdictional area is defined as the intersection or overlapping areas of the MS4 boundaries and the 2000 or 2010 U.S. Census Urbanized Area (USCB, 2010). Based on this geospatial analysis, 31.24 percent of the Oso Creek watershed is under regulated stormwater coverage (Figure 10).

Table 7. TPDES and NPDES MS4 permits in the Oso Creek watershed.

Entity	TPDES Permit	NPDES Permit
City of Corpus Christi, Del Mar College District, Port of Corpus Christi Authority, Texas A&M University – Corpus Christi	WQ0004200000	TXS000601
Texas Department of Transportation	WQ0005011000	TXS002101
Nueces County	Phase II General Permit (TXR040000)	TXR040054

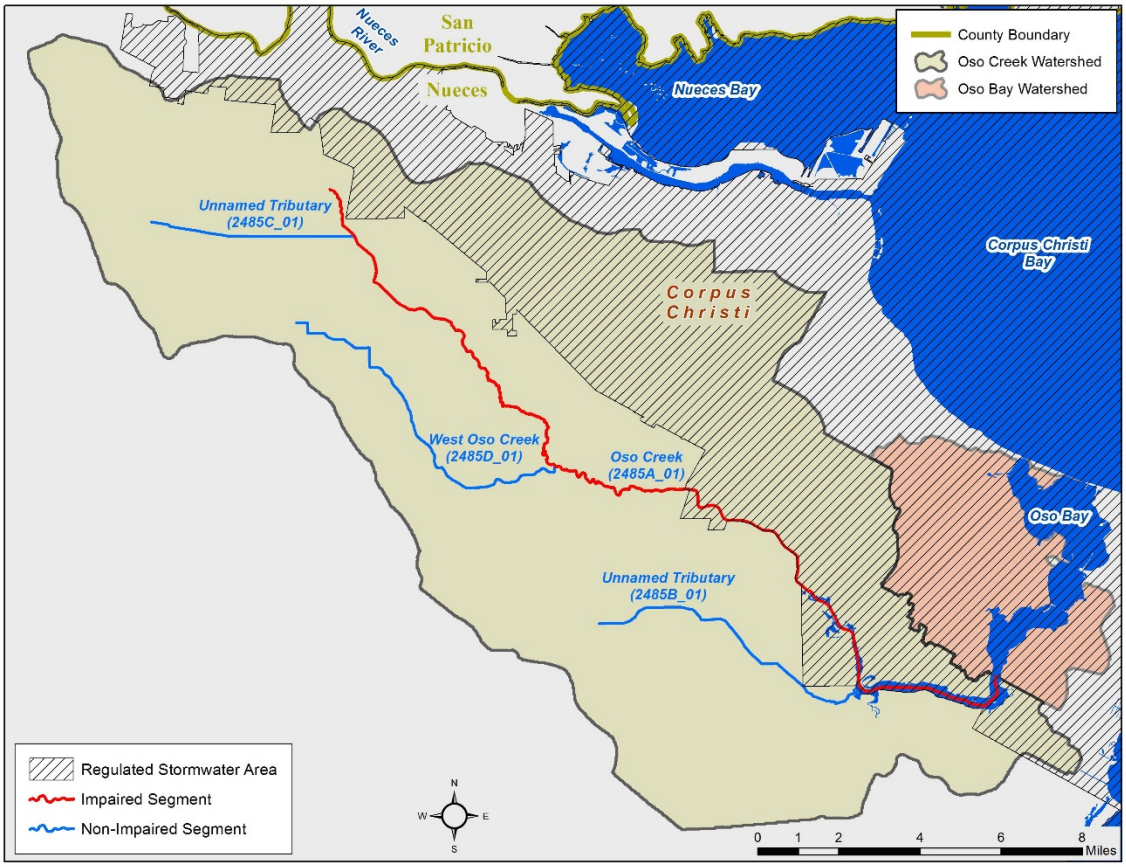

Figure 10. Regulated stormwater area based on Phase I and Phase II MS4 permits within the Oso Creek watershed.

Illicit Discharges

Pollutant loads can enter streams from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry and wet weather conditions. The term "illicit discharge" is defined in TPDES General Permit Number 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; and
- a cross-connection between the sanitary sewer and storm sewer systems.

Indirect illicit discharges:

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

Unregulated Sources

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

Additionally, a previous multi-year bacteria source tracking study confirmed that livestock, wildlife (non-avian), and birds were contributing sources of bacteria to Oso Creek (Mott et al., 2012).

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 would be expected to contribute virtually no fecal bacteria to surface waters. For example, it has been reported that less than 0.01 percent of fecal coliforms originating in household wastes move further than 6.5 feet down gradient of the drain field of a septic system (Weikel et al., 1996). Reed, Stowe, and Yanke LLC (2001) provide information on estimated failure rates of OSSFs for different regions of Texas. Oso Creek is located within the east-central Texas region, which has a reported failure rate of about 12 percent, providing insights into expected failure rates for the area.

Estimates of the number of OSSFs in the Oso Creek watershed were based on 2010 Census block data. OSSFs were estimated to be households that were outside of either a Certificate of Convenience and Necessity (CCN) sewer area (PUCT, 2016) or a city boundary, although it is noted that some OSSFs may exist

within these boundaries. The total estimate is shown in Table 8 and the OSSF density is depicted in Figure 11.

Additionally, OSSFs located adjacent to Oso Creek AU 2485A_01 and colonias existing within the Oso Creek watershed were identified by the CWSS and are included in Figure 11 (CWSS, 2016). Colonias are generally described by the Texas Secretary of State as low-income residential areas located in rural and urban areas that can lack common living conveniences such as potable water, electricity, and sewage systems (TSS, 2016).

Table 8. OSSF estimate for the Oso Creek watershed.

Watershed	Estimated OSSFs
Oso Creek	1,020

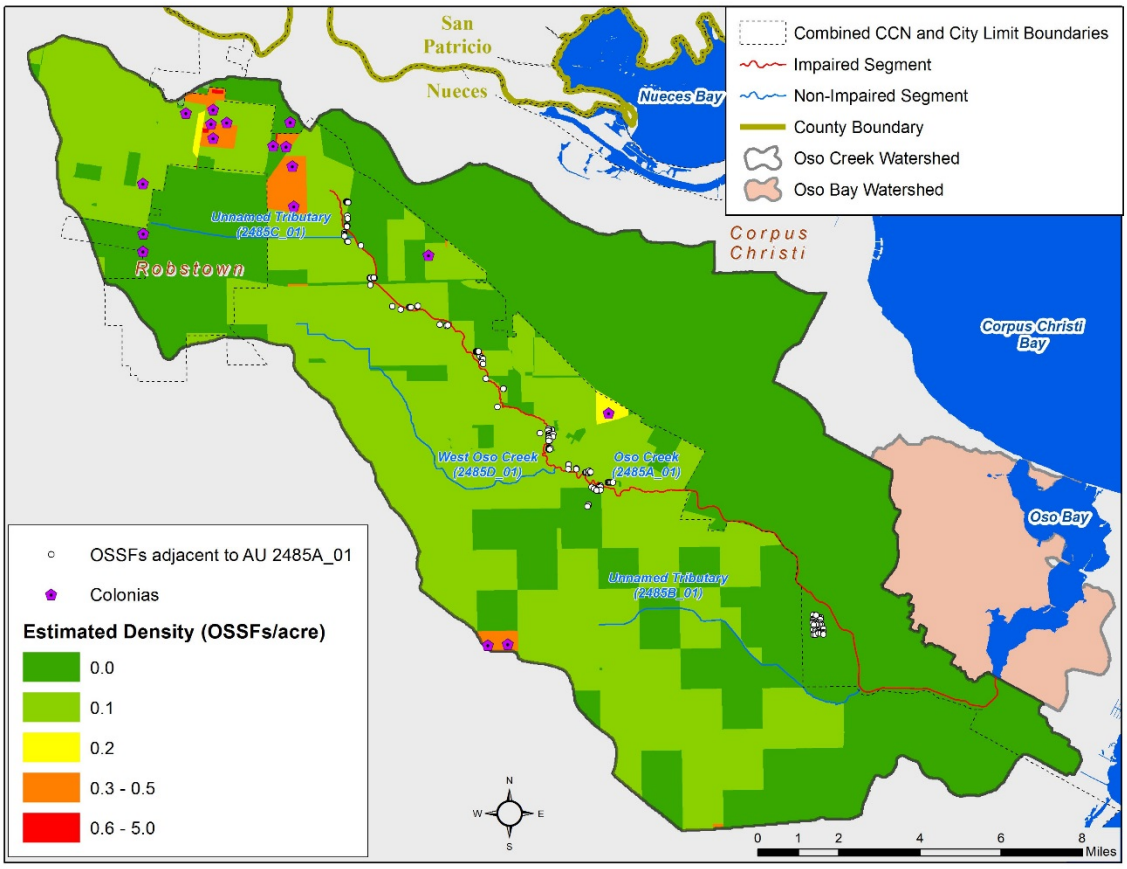

Figure 11. OSSF densities, OSSFs located adjacent to Oso Creek, and colonias within the Oso Creek watershed.

Wildlife and Unmanaged Animal Contributions

Fecal indicator bacteria such as Enterococci and *E. coli* 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 streams and rivers. With direct access to the stream channel, the direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Fecal bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff.

Quantitative estimates of wildlife are rare, inexact, and often limited to discrete taxa groups or geographical areas of interest so that even county-wide approximations of wildlife numbers are difficult or impossible to acquire. This holds true especially when considering potential wildlife bacteria contributors such as birds. While it is noted that Oso Creek lies within the Central Flyway for migrating birds in North America (Shackelford et al., 2005) and migratory locations that provide rest areas and food sources (e.g., row crop fields) exist within the watershed (TPWD, 2016a), no data are available for avian population densities for the Oso Creek watershed.

However, population estimates for feral hogs and deer are readily available for the Oso Creek watershed. For feral hogs, the Texas Parks and Wildlife Department (TPWD) estimated the average feral hog densities within the Oso Creek watershed to be 36.81 hogs per square mile of suitable habitat, with heavier densities in the southeastern portion of the watershed (TPWD, 2016b). The TPWD hog density estimate was multiplied by the total suitable habitat identified within the Oso Creek watershed (11.19 square miles). Based upon TPWD guidance, habitat deemed suitable for hogs was identified from the 2011 NLCD (USGS, 2014) and include: shrub/scrub, grassland/herbaceous, deciduous forest, evergreen forest, and mixed forest land covers outside of the city limits of Corpus Christi. Using this methodology, there are an estimated 412 feral hogs in the Oso Creek watershed.

The same methodology used for feral hog population estimates was used to obtain the population of white-tailed deer within the Oso Creek watershed. The TPWD estimated the white-tailed deer average density to be 41.86 deer per square mile of suitable habitat (TPWD, 2016b). Based upon TPWD guidance, the suitable deer habitat was considered identical to that for feral hogs (11.19 square miles). Applying the deer density to the suitable habitat yielded an estimated white-tailed deer population of 468 deer for the Oso Creek watershed.

Unregulated Agricultural Activities and Domesticated Animals

The number of livestock that are found within the Oso Creek watershed was estimated from county level data obtained from the 2012 Census of Agriculture (USDA NASS, 2014). The county level data were refined to better reflect actual numbers within the impaired AU watershed. Using the 2011 NLCD, the refinement was performed by determining the total area of the suitable

livestock land cover categories of grassland/herbaceous and hay/pasture within the Oso Creek watershed and Nueces County. A ratio was then computed by dividing the livestock total land use area of the watershed by the livestock total land use area of the county. The county level agricultural census data were then multiplied by the ratio to determine the estimated Oso Creek watershed domestic animal populations (Table 9). Based on information provided by the Texas State Soil and Water Conservation Board (TSSWCB), the number of cattle and calves in Table 9 was estimated based on stocking densities for the land uses of grassland/herbaceous, hay/pasture, and scrub/shrub.

Activities such as livestock grazing close to water bodies can contribute fecal indicator bacteria to nearby water bodies. The livestock numbers in Table 9 are provided to demonstrate that livestock are a potential source of bacteria in the Oso Creek watershed. These numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Table 9. Estimated distributed domesticated animal populations within the Oso Creek watershed, based on proportional area.

Watershed	Cattle and Calves	Hogs and Pigs	Sheep and Lambs	Goats	Horses and Ponies	Mules, Burros, and Donkeys	Poultry
Oso Creek	1,342	60	84	158	170	12	11

Fecal matter from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 10 summarizes the estimated number of dogs and cats for the TMDL watershed. Pet population estimates were calculated as the estimated number of dogs (0.584) and cats (0.638) per household (AVMA, 2012). The actual contribution and significance of fecal coliform loads from pets is unknown.

Table 10. Estimated households and pet populations for the Oso Creek watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
41,818	24,422	26,680

Other Source Considerations

Supporting this TMDL was the availability of studies performed in the watershed targeting potential sources of indicator bacteria to Oso Creek. Specifically groundwater, subsurface seepage, and soil from agricultural fields were investigated as potential sources of Enterococci.

Generally, groundwater is considered more of a pathway for dissolved pollutant loadings, but can be considered a potential source of bacteria loadings if pollutant transport to surface waters is determined. In a previous study, the

CWSS monitored groundwater in the Oso Creek watershed for Enterococci, determined the hydraulic properties of the aquifer, and subsequently modeled bacteria fluxes into Oso Creek in an effort to determine if groundwater was a contributing source of indicator bacteria contamination (Hay, 2011). Results of the CWSS study indicated that Enterococci concentrations were lower (by orders of magnitude) in groundwater than historical surface water concentrations and, while present in the aquifer, the potential for significant Enterococci transport into Oso Creek from adjacent groundwater was very low due to insufficient hydraulic properties (i.e., low hydraulic conductivity and gradient).

In a separate study, but similar to the CWSS study previously mentioned, Mott et al. (2012) further investigated groundwater pollutant transport including sub-surface seepage into Oso Creek. Results of this study indicated that groundwater and subsurface seepage were unlikely sources of Enterococci contamination to Oso Creek, supporting the CWSS study conclusions.

Additionally, Mott et al. (2012) investigated soil from agricultural fields with different cover crops (e.g., cotton, sorghum, sesame, and pasture) as a potential source of Enterococci contamination, based on occurrences of high Enterococci and sediment concentrations from agricultural field runoff observed in a previous study by Ockerman and Fernandez (2010). It was concluded that a potential contributor of indicator bacteria during wet weather, high-sediment runoff events was soils containing indigenous bacteria and bacteria originating from the feces of wildlife (non-avian) and birds (Mott et al., 2012).

Bacteria Survival and Die-off

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

likely to be point sources and direct fecal material deposition into the water body. During ambient flows, these inputs to the system will increase pollutant concentrations depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources and direct deposition is typically diluted, and would therefore be a smaller part of the overall concentrations.

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

Load Duration Curve Analysis

LDC analyses were used to examine the relationship between instream water quality and the broad sources of indicator bacteria loads, and are the basis of the TMDL allocations. The strength of this TMDL is the use of the LDC method to determine the TMDL allocations. LDCs are a simple statistical method that provides a basic description of the water quality problem. This tool is easily developed and explained to stakeholders, and uses available water quality and flow data. The LDC method does not require any assumptions regarding loading rates, stream hydrology, land use conditions, and other conditions in the watershed.

The weaknesses of the LDC method include the limited information it provides regarding the magnitude or specific origin of the various sources. Only limited information is gathered regarding point and nonpoint sources in the watershed. The general difficulty in analyzing and characterizing Enterococci in the environment is also a weakness of this method.

Typically for applications of the LDC method to tidal streams, a modification of the method is used to account for the additional assimilative capacity from tidally-forced seawater in the stream. This modified LDC method has, for example, been applied on the bacterial TMDLs for the tidal segments of the Mission and Aransas Rivers (TCEQ, 2016d). Analyses of available information and data on Oso Creek revealed, however, that the creek in the vicinity of station 13028, where the most relevant LDC analyses were performed, was most likely not strongly tidally influenced. In the technical support document to this TMDL, it was concluded that Oso Creek in the vicinity of station 13028 is either not tidally influenced or is only weakly tidally influenced, and that any tidal influence is offset by the relatively high baseflow from WWTF discharges such

that reversal of flow direction and seawater intrusion does not occur at this creek location under normal conditions (Adams and Hauck, 2017). Based on these analyses, application of the LDC method without modifications to account for additional assimilative capacity from seawater was found to be appropriate.

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

Data requirements for the LDC are minimal, consisting of continuous daily streamflow records and historical bacteria data. A 16-year period of record from January 1, 2000 through December 31, 2015 was selected for LDC development, which included the vast majority of collection dates for Enterococci data available at the time of this report. While the number of Enterococci observations required to develop a flow duration curve (FDC) is not rigorously specified, the curves are usually based on more than five years of observations and encompass inter-annual and seasonal variation. For this report, adequacy of data was defined as any station having at least 40 Enterococci measurements.

The relevant LDC was constructed for Surface Water Quality Monitoring (SWQM) station 13028 within the Oso Creek segment. The station was selected as the location for TMDL calculations because it has the most historical Enterococci data, and is the only station on Oso Creek that has been monitored in recent years that is scheduled for continued sampling.

On numerous creeks and rivers in Texas, USGS streamflow gauging stations have been in operation for a sufficient period to provide long-term streamflow records. USGS streamflow gauge 08211520 (Oso Creek at Corpus Christi, Texas) was used for LDC development (see USGS gauge location on Figure 1).

The required daily streamflow record for the LDC was estimated based on application of a drainage area ratio approach. Prior to application of the drainage area ratio, the USGS gauge record was corrected by removing (subtracting) upstream WWTF discharges based on discharge monitoring report information and estimated in-channel losses of flow. After multiplication of the corrected streamflow record by the drainage area ratio, a final adjustment occurred for the purposes of pollutant load computations. The hydrologic records were adjusted to reflect full permitted flows from all upstream WWTFs and future growth flows that account for the probability that additional flows from WWTF discharges may occur as a result of population increases.

The FDC was generated by:

1) ordering the daily streamflow data for the location from highest to lowest values and assigning a rank to each data point (one for the highest flow, two for the second highest flow, and so on);
2) computing the percent of days each flow was exceeded by dividing each rank by the total number of data points plus one; and
3) plotting the corresponding flow data against exceedance percentages.

Exceedance values along the x-axis represent the percent of days that flow was at or above the associated flow value on the y-axis. Exceedance values near 100 percent occur during low flow or drought conditions, while values approaching 0 percent occur during periods of high flow or flood conditions.

Bacteria LDCs were developed by multiplying each streamflow value along the FDCs by the Enterococci geometric mean criterion (35 MPN/100 mL) and by the conversion factor to convert to loading in colonies per day. This effectively displays the LDC as the curve of maximum allowable loading:

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

Where:

> Criterion = 35 MPN/100 mL (Enterococci)
>
> Conversion factor (to MPN/day) = 283.168 100 mL/ft^3 * 86,400 seconds/day (s/d)

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

For the LDC developed for station 13028, historical bacteria data obtained from the TCEQ SWQM Information System (SWQMIS) database were superimposed on the allowable bacteria LDC. Each historical Enterococci measurement was associated with the flow on the day of measurement and converted to a bacteria load. The associated flow for each bacteria loading was compared to the FDC data to determine its value for "percent days flow exceeded", which becomes the "percent of days load exceeded" value for purposes of plotting the Enterococci loading. Each load was then plotted on the LDC at its percent exceedance. This process was repeated for each Enterococci measurement. Points above the LDC represent exceedances of the bacteria criterion and their associated loadings.

As a further refinement, the historical Enterococci points on the LDCs were symbolized according to whether the sampling event was considered to be a wet or non-wet weather event based on antecedent rainfall. A sample was determined to be influenced by a wet weather event based on the "days since

last precipitation" (DLSP) as noted on field data sheets associated with each sampling event. DSLP (TCEQ water quality parameter code 72053) is a field parameter that may be noted during a sampling event to inform data users of the general climatic conditions. A wet weather event was defined as a sample collected on any date with DSLP of four days or less.

The flow exceedance frequency can be subdivided into hydrologic condition classes to facilitate the diagnostic and analytical uses of FDCs and LDCs. The hydrologic classification scheme utilized for the TMDL watershed is as follows: 0-10 percent (highest flow); 10-60 percent (mid-range flow); and 60-100 percent (lowest flows). Additional information explaining the LDC method may be found in Cleland (2003) and Nevada Division of Environmental Protection (2003). The median loading of the high flow regime (0-10 percent exceedance) is used for the TMDL calculations.

The 5 percent exceedance or median loading of the high flow regime (0-10 percent exceedance range) is used for the TMDL calculations of the impaired AU. The 5 percent exceedance is used for the TMDL calculations, because it represents a reasonable yet high value for the allowable pollutant load allocation.

More details on the methods used to develop the LDC may be found in the *Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in Oso Creek* (Adams and Hauck, 2017).

Load Duration Curve Results

For developing the TMDL allocation, an LDC was constructed for the SWQM station within Oso Creek where recent bacteria data collection has occurred: station 13028 (Oso Creek at State Highway 286; Figure 12), which is also the station with the most bacteria data. Geometric mean loadings for the data points within each flow regime have also been distinguished on Figure 12 to aid interpretation. The LDC provides a means of identifying the streamflow conditions under which exceedances in Enterococci concentrations have occurred. The LDC depicts the allowable loadings at the station under the geometric mean criterion (35 MPN/100 mL) and shows that existing loadings often exceed the criterion. For purposes of the pollutant load computations, the hydrologic records for the FDC and subsequent allowable loads from the LDC are adjusted to reflect future capacity estimates that account for the probability that additional flows from WWTF discharges may occur as a result of future population increases in the TMDL watershed.

Based on this LDC (Figure 12), with historical Enterococci data added to the graphs, the following broad linkage statements can be made. The historical Enterococci data indicate that elevated bacteria loadings occur under all flow conditions, but become most elevated under the highest flows, followed by mid-

range flows, with some moderation in elevated loadings occurring at the lowest flow regime. Additionally, regulated stormwater comprises a significant portion of the Oso Creek watershed and must be considered a contributor of bacteria loadings during high flow events, with unregulated sources contributing as well, and possibly to an even greater degree than the regulated sources given the regulated stormwater area comprises 31 percent of the entire watershed. Elevated concentrations of Enterococci at the lower flow regimes indicate point (i.e., WWTFs) and direct deposition sources such as wildlife (avian and non-avian), feral hogs, and livestock. These conclusions are further supported by previous studies indicating direct bacteria deposition occurring from known inflows such as permitted dischargers and stormwater drains (Mott and Hay, 2009) and wildlife (avian and non-avian) contributions (Mott et al., 2012). The actual contribution of bacteria loadings attributable to these direct sources of fecal material deposition cannot be determined using LDCs.

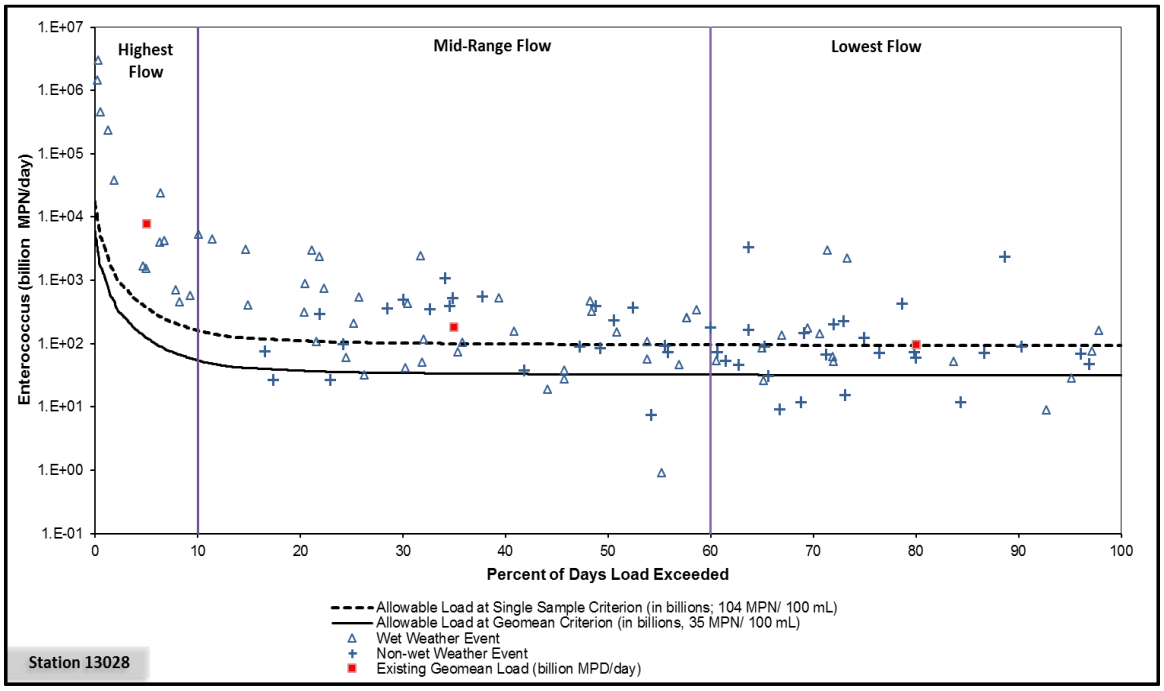

Figure 12. Load duration curve at Station 13028 on Oso Creek (Segment 2485A) for the period of January 1, 2000 through December 31, 2015.

Margin of Safety

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

1) implicitly incorporating the MOS using conservative model assumptions to develop allocations; or

2) explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

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

The TMDL covered by this report incorporates an explicit MOS by setting a target for indicator bacteria loads that is 5 percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for Enterococci of 33.3 MPN/100 mL. The net effect of the TMDL with a MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

Pollutant Load Allocation

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

TMDL = WLA + LA + FG + MOS

Where:

TMDL = total maximum daily load

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

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

FG = loadings associated with future growth from potential permitted facilities

MOS = margin of safety load

As stated in 40 CFR §130.2(1), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For Enterococci, TMDLs are expressed as MPN/day.

The TMDL component for the impaired AU covered in this report is derived using the median flow within the high flow regime (or 5 percent exceedance) of the LDC developed for the downstream SWQM station (13028) in the Oso Creek

segment. The following sections will present an explanation of the TMDL component, followed by the results of the calculation for that component.

AU-Level TMDL Computations

The bacteria TMDL for the Oso Creek segment was developed as a pollutant load allocation based on information from the LDC for SWQM station 13028 (Figure 12). Effectively, the "allowable load" displayed in the modified LDC at 5 percent exceedance (the median value of the highest-flow regime) is the TMDL:

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

Where:

Criterion = 35 MPN/100 mL (Enterococci)

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

At 5 percent load duration exceedance, the TMDL values are provided in Table 11.

Table 11. Summary of allowable loading calculations for Oso Creek AU 2485A_01.

5% Exceedance Flow (cfs)	5% Exceedance Load (MPN/day)	Indicator Bacteria	TMDL (Billion MPN/day)
142.552	1.22068E+11	Enterococci	122.068

Margin of Safety

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

MOS = 0.05 * TMDL

Where:

MOS = margin of safety load

TMDL = total maximum daily load

Since the MOS is based solely on the TMDL term, the calculation is straightforward (Table 12).

Table 12. Margin of safety calculations for the Oso Creek watershed.

Indicator Bacteria	TMDL (Billion MPN/ day)	MOS (Billion MPN/ day)
Enterococci	122.068	6.103

Wasteload Allocation

The WLA consists of two parts—the waste load that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the waste load that is allocated to regulated stormwater dischargers (WLA_{SW}).

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

Wastewater Treatment Facilities

TPDES-permitted WWTFs are allocated a daily waste load (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by the instream geometric criterion and also reduced to account for the required MOS. The saltwater Enterococci criterion (35 MPN/100mL) is used as the WWTF target. The WLA_{WWTF} term is also calculated for the freshwater *E. coli* primary contact recreation geometric mean criterion of 126 MPN/100 mL, since WWTF bacteria permit limits are often expressed in terms of *E. coli*. This is expressed in the following equation:

$$WLA_{WWTF} = Criterion * Flow * Conversion\ Factor * (1 - F_{MOS})$$

Where:

Criterion= 35 MPN/100 mL for Enterococci; 126 MPN/100 mL for *E. coli*

Flow = full permitted flow (MGD)

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

F_{MOS} = fraction of loading assigned to margin of safety (5 percent or 0.05)

Thus, the daily allowable loading of Enterococci and *E. coli* assigned to WLA_{WWTF} was determined based on the full permitted flow of each WWTF and summed for the watershed. Table 13 presents the WLAs for each individual WWTF located within the Oso Creek watershed. Since the pollutant load allocation is developed in terms of Enterococci as the indicator bacteria, it is the Enterococci loadings from Table 13 that will be used in subsequent computations. Barney M. Davis, LP (TPDES permit number WQ0001490000) is not assigned a bacteria permit limit within this TMDL because there is no human waste component associated with its discharge; this facility is not included in Table 13. Equistar Chemicals, LP (TPDES permit number WQ0002075000) has one outfall (Outfall 003) discharging via an unnamed ditch into Oso Creek. No bacteria permit limit was assigned within this TMDL because there is no human waste component associated with this discharge; this facility is not included in Table 13.

Table 13. Wasteload allocations for domestic WWTFs in the Oso Creek watershed.

AU	TPDES Permit No.	NPDES Permit No.	Facility	Full Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (Billion MPN/ day)	Enterococci WLA_{WWTF} (Billion MPN/ day)
2485A_01	WQ0010261001	TX0020389	Robstown WWTF	3.0	13.593	3.776
2485A_01	WQ0011134002	TX0136620	Roloff WWTF	0.02	0.091	0.025
2485A_01	WQ0010401003	TX0047074	Greenwood WWTF	16.0	72.498	20.138
2485A_01	WQ0014228001	TX0123676	Cuddihy Airfield WWTF	0.06	0.272	0.076
Oso Creek Watershed Total					86.454	24.015

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for these areas was used in the development of this TMDL due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of the land area included in the Oso Creek watershed that is under the jurisdiction of stormwater permits 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 LA component of the TMDL corresponds to unregulated nonpoint 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 follows:

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

Where:

WLA_{SW} = sum of all permitted or regulated stormwater loads

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

FG = sum of future growth loads from potential permitted facilities

MOS = margin of safety load

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

To calculate the WLA_{SW} component of the TMDL, the FDA_{SWP} must be determined. The FDA_{SWP} was calculated based on the combined area under regulated stormwater permits (Table 14). As indicated in Figure 10 and Table 7, both Phase I and Phase II MS4 permits exist within the Oso Creek watershed and their areas were used to estimate the areas under stormwater regulation for construction, industrial, and MS4 permits.

Table 14. Regulated-stormwater based calculation of the FDA_{SWP} term for the Oso Creek watershed.

Water Body	Estimated Area Under Stormwater Regulation (acres)	Total Watershed Area (acres)	FDA_{SWP}
Oso Creek	41,815	133,833	31.24%

In order to calculate WLA_{SW}, the future growth term must be known. The calculation for the future growth term is presented later in the computations, but the results will be included here for continuity. Table 15 provides the information needed to compute WLA_{SW}.

Table 15. Regulated stormwater calculations for the Oso Creek watershed.

Load units expressed as billion MPN/day Enterococci

TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
122.068	24.015	6.328	6.103	31.24%	26.748

Once the WLA_{SW} and WLA_{WWTF} terms are known, the WLA term can be calculated as the sum of the two parts, as shown in Table 16.

Table 16. Wasteload allocation calculations for the Oso Creek watershed.

Load units expressed as billion MPN/day Enterococci

WLA_{WWTF}	WLA_{SW}	WLA
24.015	26.748	50.763

An iterative, adaptive management approach will be used to address stormwater discharges. This approach encourages the implementation of structural or non-structural controls, implementation of mechanisms to evaluate the performance

of the controls, and finally, allowance to make adjustments (e.g., more stringent controls or specific BMPs) as necessary to protect water quality.

Implementation of WLAs

The TMDL in this document will result in protection of existing beneficial uses and conform to Texas's 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.

The TCEQ intends to implement the individual WLAs through the permitting process as monitoring requirements and/or effluent limitations, as required by the amendment of Title 30, Texas Administrative Code (30 TAC) Chapter 319, which became effective November 26, 2009. WWTFs discharging to the TMDL segments will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in 30 TAC §319.9.

The permit requirements will be implemented during the routine permit renewal process. However, there may be a more economical or technically feasible means of achieving the goal of improved water quality and circumstances may warrant changes in individual WLAs after 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 at a permit amendment or permit renewal. These interim limits will allow a permittee time to modify effluent quality in order to attain the final effluent limits necessary to meet the TCEQ- and EPA-approved TMDL allocations. The duration of any interim effluent limits may not be any longer than three years from the date of permit re-issuance. New permits will not contain interim effluent limits because compliance schedules are not allowed for a new permit.

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

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

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

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

Updates to WLAs

This TMDL is, by definition, the total of the sum of the WLAs, the sum of the LAs, and the MOS. Changes to individual WLAs may be necessary in the future in order to accommodate growth or other changing conditions. These changes to individual WLAs do not ordinarily require a revision of the TMDL document; instead, changes will be made through updates to the TCEQ'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 load from unregulated sources, and is calculated as:

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

Where:

LA = allowable loads from unregulated sources within the AU

TMDL = total maximum daily load

WLA_{WWTF} = all WWTF loads

WLA_{SW} = all regulated stormwater loads

FG = future growth loads from potential permitted facilities

MOS = margin of safety load

The calculation results are shown in Table 17.

Table 17. Load allocation calculation for the Oso Creek watershed.

Load units expressed as billion MPN/day Enterococci

TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
122.068	24.015	26.748	6.328	6.103	58.874

Allowance for Future Growth

The future growth component of the TMDL equation addresses the requirement to account for future loadings that may occur due to population growth, changes in community infrastructure, and development. Specifically, this TMDL component takes into account the probability that new flows from WWTF discharges may occur in the future.

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

The future growth component of the Oso Creek watershed was based on the percent population increase information between 2010 and 2050 (provided previously in Table 2) and the existing full permitted discharge for each WWTF within a WUG. While the future growth allowance is computed using information from existing WWTF permits, it is not intended to restrict any future assignments of this allocation solely to expansions at these facilities. Rather, the future growth allocation is purposed for any new facilities that may occur and expansions of existing facilities.

$$FG = Criterion * [\%POP_{2010\text{-}2050} * WWTF_{FP}] * Conversion\ Factor * (1\text{-}F_{MOS})$$

Where:

Criterion = 35 MPN/100 mL Enterococci or 126 MPN/100 mL for *E. coli*

$\%POP_{2010\text{-}2050}$ = estimated percent increase in population between 2010 and 2050

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

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

F_{MOS} = fraction of loading assigned to margin of safety (5 percent or 0.05)

The calculation results for the Oso Creek watershed are shown in Table 18.

Table 18. Future growth calculations for the Oso Creek watershed.

WUG	Full Permitted Flow by WWTF (MGD)	% Increase (2010-2050)	FG (MGD)	FG (*E. coli* Billion MPN/ day)	FG (Enterococci Billion MPN/ day)
Corpus Christi	16.0	29.56%	4.730	21.431	5.953
Robstown	3.0	8.53%	0.256	1.159	0.322
County Other	0.08	52.39%	0.042	0.191	0.053
Oso Creek Total			5.028	22.781	6.328

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

Summary of TMDL Calculations

Table 19 summarizes the TMDL calculations for Oso Creek (2485A_01). The TMDL was calculated based on the median flow in the 0-10 percentile range (5 percent exceedance, high flow regime) for flow exceedance from the LDC developed for SWQM station 13028. Allocations are based on the current geometric mean criterion for Enterococci of 35 MPN/100 mL for each component of the TMDL.

The final TMDL allocations (Table 20), needed to comply with the requirements of 40 CFR §130.7, include the FG component within the WLA_{WWTF}.

In the event that the criterion changes due to future revisions in the state's surface water quality standards, Appendix A provides guidance for recalculating the allocations in Table 20. Figure A-1 was developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant LAs change in relation to a number of proposed water quality criteria for Enterococci. The equations provided, along with Figure A-1, allow calculation of a new TMDL and pollutant LA based on any potential new water quality criterion for Enterococci.

Table 19. TMDL allocation summary for the Oso Creek watershed (AU 2485A_01).

Load units expressed as billion MPN/day Enterococci

AU	Stream Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA[e]	FG[f]
2485A_01	Oso Creek	122.068	6.103	24.015	26.748	58.874	6.328

[a] TMDL = Median flow (highest flow regime) * 35 MPN/100 mL * Conversion Factor, where the Conversion Factor = 283.168 100 mL/ft^3 * 86,400 s/d; Median (5 percent exceedance) (Flow from Table 11)

[b] MOS = 0.05 * TMDL (Table 12)

[c] WLA_{WWTF} = 35 MPN/day * Flow (MGD) * Conversion Factor * (1 – F_{MOS}), where Flow is the full permitted flow from regulated discharging facilities; Conversion Factor = 1.547 cfs/MGD * 283.168 100 mL/ft^3; F_{MOS} = 5 percent or 0.05 (Table 13)

[d] WLA_{SW} = (TMDL - WLA_{WWTF} - FG - MOS) * FDA_{SWP} (Tables 14 and 15)

[e] LA = TMDL - WLA_{WWTF} - WLA_{SW} - FG - MOS (Table 17)

[f] FG = 35 MPN/100 mL * [%POP2010-2050 * $WWTF_{FP}$] * Conversion Factor * (1 – F_{MOS}); Conversion Factor = 1.547 cfs/MGD * 283.168 100 mL/ft^3 ($WWTF_{FP}$ is full permitted flows and %POP2010-2050 is from Table 18)

Table 20. Final TMDL allocations for the Oso Creek watershed (AU 2485A_01).

Load units expressed as billion MPN/day Enterococci

AU	TMDL	WLA_{WWTF}[a]	WLA_{SW}	LA	MOS
2485A_01	122.068	30.343	26.748	58.874	6.103

[a] WLA_{WWTF} includes the FG component

Seasonal Variation

Seasonal variation (or seasonality) occurs when there is a cyclic pattern in streamflow and, more importantly, in water quality constituents. Federal regulations [40 CFR §30.7(c)(1)] require that TMDLs account for seasonal variation in watershed conditions and pollutant loading.

Seasonal differences in indicator bacteria concentrations were assessed by comparing Enterococci concentrations obtained from routine monitoring collected in the warmer months (May–September) against those collected during the cooler months (November–March). The months of April and October were considered transitional between the warm and cool seasons and were excluded from the seasonal analysis. Differences in Enterococci concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log transformed dataset. This analysis of Enterococci data indicated that there was a significant difference (α=0.05, p=0.0320) in indicator bacteria between cool and warm weather seasons for Oso Creek, with the warm season having the higher concentrations.

Public Participation

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

The TCEQ and the Center for Coastal Studies (CCS) are jointly providing coordination of public participation for development of both the TMDL and implementation plan (I-Plan). The I-Plan is being developed for the combined Oso Creek and Oso Bay watersheds. A series of public meetings have been held since 2016 to keep the public aware of the TMDL and to engage public participation in the development of the I-Plan.

Stakeholders provided input on the documents associated with the TMDL project. Notices of meetings were posted on the project webpages for both the CCS and TCEQ and on the TCEQ TMDL program's online calendar.

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that wasteload allocations 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, the TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the Commission. Based on the TMDL and I-Plan, the TCEQ will propose and certify WQMP updates to establish required WQBELs necessary 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, the TCEQ

revises its MS4 permits as needed to require the implementation of other specific revisions in accordance 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. The TCEQ is committed to supporting implementation of all TMDLs adopted by the Commission.

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

Key Elements of an 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.

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

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the I-Plan that is approved may not approximate the predicted loadings identified category-by-category in the TMDL and its underlying assessment. The

I-Plan is adaptive for this very reason; it allows for continuous update and improvement.

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

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

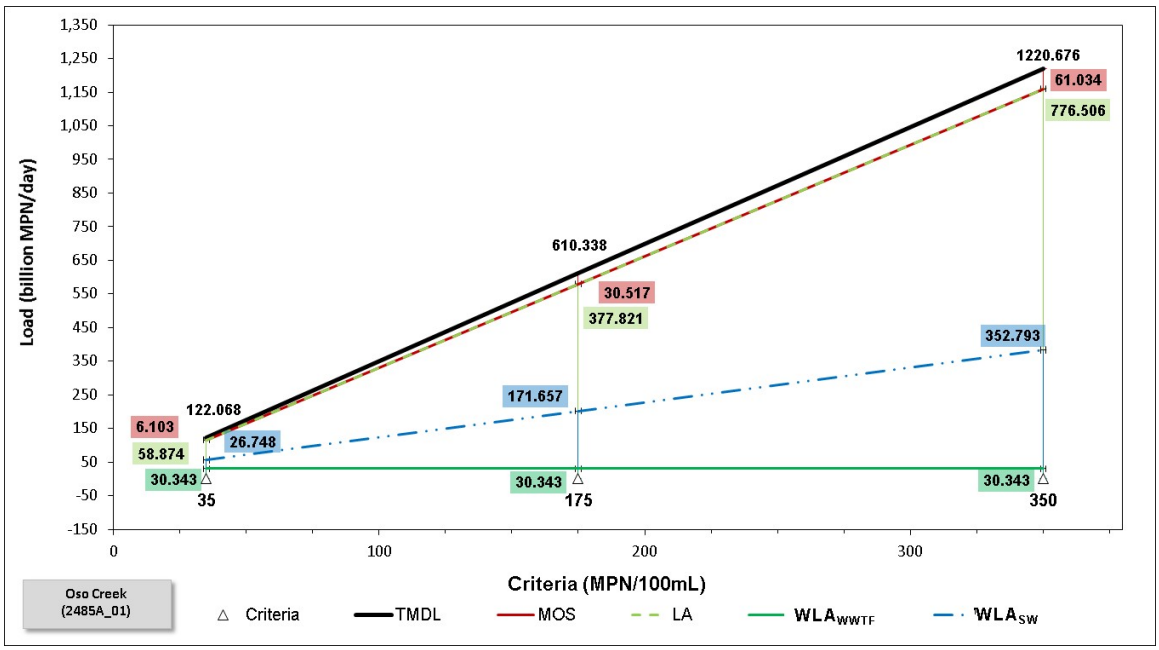

Figure A-1. Allocation loads for Oso Creek (2485A_01) as a function of water quality criteria.

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

TMDL = 3.487644 * Std

MOS = 0.174384 * Std

LA = 2.278196 * Std – 20.863098

WLA_{WWTF} = 30.343

WLA_{sw} = 1.035063 * Std – 9.4791803

Where:

Std = revised contact recreation standard

MOS = margin of safety

LA = total load allocation (unregulated source contributions)

WLA_{WWTF} = wasteload allocation (permitted WWTF load + future growth)

[Note: WWTF load held at primary contact criterion (35 MPN/ 100 mL)]

WLA_{SW} = wasteload allocation (permitted stormwater)