San Fernando and Petronila Creek Watershed Protection Plan

A document developed by the stakeholders of the San Fernando and Petronila Creek watersheds to restore and protect water quality in the San Fernando Creek (segment 2492), Petronila Creek (segment 2204), and Petronila Creek Tidal (segment 2203) segments that feed into Baffin Bay.

San Fernando and Petronila Creek Watershed Protection Plan

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Texas Water Resource Institute

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Acknowledgements

This document presents the strategies developed by the San Fernando and Petronila Creek watershed stakeholders to restore and protect water quality in the creeks and in Baffin Bay, into which they ultimately flow. Stakeholders dedicated considerable time and effort discussing the watershed, influences on water quality and potential methods to address water quality concerns during the process to select appropriate strategies to improve water quality.

Special appreciation is extended to the many individual watershed landowners and residents who participated in numerous meetings and events to provide direct input to the plan. The direct involvement of landowners and residents was critical to ensuring the plan included feasible management measures that address sources of water quality impairments in the watershed. The time and effort of landowners and residents are greatly appreciated and their efforts are reflected in the contents of this plan.

Local and regional government agencies and organizations also played key roles in plan development. Representatives provided insight regarding their specific focus areas and ensured the inclusion of plan contents appropriate for the watershed.

Contributing Stakeholder Groups and Agencies

Aqua Strategies
Baffin Bay Stakeholders Group
City of Kingsville
Clean Coast Texas
Coastal Bend Bays & Estuaries Program
Duval, Jim Wells, Kleberg and Nueces Counties
Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi
King Ranch, Inc.
Nueces River Authority
Soil and Water Conservation Districts
- Agua Poquita SWCD #321
- Jim Wells Country SWCD #355
- Kleberg-Kenedy SWCD #356
- Nueces SWCD #357

Texas A&M AgriLife Extension Service
Texas A&M AgriLife Research
Texas A&M University -Corpus Christi Faculty
Texas Commission on Environmental Quality
Texas Department of Transportation
Texas Parks and Wildlife Department
Texas Sea Grant
Texas State Soil and Water Conservation Board
The Voices of the Colonias
USDA Natural Resource Conservation Service

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Table of Abbreviations

Acronym	Meaning
ac	Acre
AgriLife Extension	Texas A&M AgriLife Extension Service
AnU	Animal Unit
AU	Assessment Units
AVMA	American Veterinary Medical Association
BMP	Best Management Practice
cfu	Colony Forming Unit
cfs	Cubic Feet Per Second
CP	Conservation Plan
CRP	Clean Rivers Program
CWA	Clean Water Act
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
GIS	Geographic Information System
I&I	Inflow and Infiltration
LDC	Load Duration Curve
LIP	Landowner Incentive Program
LULC	Land Use and Land Cover
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
mL	Milliliter
MPN	Most Probable Number
MSL	Mean Sea Level
NASS	National Agricultural Statistics Service
NLCD	National Land Cover Database
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NRA	Nueces River Authority
OSSF	On-site Sewage Facility
RCPP	Regional Conservation Partnership Program
SEP	Supplemental Environmental Projects
SSO	Sanitary Sewer Overflow
SWCD	Soil and Water Conservation District
Texas Integrated Report	*Texas Integrated Report of Surface Water Quality*
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USCB	U. S. Census Bureau
USGS	U. S. Geological Survey
WPP	Watershed Protection Plan
WQMP	Water Quality Management Plan
WWTF/P	Wastewater Treatment Facility/Plant

Executive Summary

This document presents a plan to restore and protect water quality in the San Fernando Creek and Petronila Creek watersheds. By approaching water quality issues at the watershed level rather than political boundaries, this plan holistically identifies potential pollutant sources and solutions. This approach also incorporates the values, visions, and knowledge of individuals with a direct stake in water quality conditions.

Problem Statement

Water quality monitoring indicates that sections of the San Fernando and Petronila Creeks do not meet water quality standards for recreation because of elevated levels of *Escherichia coli (E. coli)* and enterococci. The tidal and above tidal segments of Petronila Creek were first identified as impaired in the *2016* and *2010 Texas Integrated Report and 303(d) List*, respectively, while San Fernando Creek was first identified as impaired in the *2006 Texas Integrated Report and 303(d) List.*

With water quality impairments, a need to plan and implement measures that restore water quality and ensure safe and healthy water for stakeholders arises. To meet this need, an assessment and planning project was undertaken to develop the Baffin Bay Watershed Protection Plan.

Action Taken

A detailed watershed land and water resource analysis was conducted to provide stakeholders with current information on watershed characteristics and uses. Potential bacteria pollution sources were identified and quantified using local, state and federal data and local stakeholder knowledge. Data were evaluated using several tools to determine the types and sources of impairment-causing pollutants in the watershed with the highest potential water quality impacts.

Watershed Protection Plan Overview

This document is a culmination of a stakeholder process to identify pollution sources and methods to reduce pollutant loads in San Fernando and Petronila Creeks. By comprehensively considering multiple potential pollutant sources, this plan describes management strategies that will cost effectively reduce pollutant loadings when implemented. Despite extensive amounts of information gathered during watershed protection plan development, a better understanding of the watershed and the effectiveness of management measures will undoubtedly develop over time. As such, this plan is a living document that will evolve as needed through the adaptive management process.

Pollutant Sources

Stakeholder input, backed by credible science, was used to identify potential sources of fecal-derived bacteria pollutants and dissolved oxygen depressing nutrient pollutants. Sources of bacteria loading identified in the watershed include cattle and other livestock, household pets, deer, on-site sewage facilities, feral hogs, wastewater treatment facilities and urban runoff. While other sources of bacteria are likely present in the watershed, available information was insufficient to reliably estimate loadings.

Recommended Actions

Seven primary recommended actions were made to improve water quality in the San Fernando and Petronila Creek watersheds. Individual recommendations were crafted to address bacteria and nutrient pollution but in many cases will have ancillary effects on other pollutants as well. A summary of these actions follows:

Water Quality Management Plans or Conservation Plans

To manage bacteria and nutrient loadings from cattle and other livestock more effectively, voluntary implementation of site-specific water quality management plans and conservation plans are recommended. These plans include technical assistance to help landowners implement best management practices that improve land stewardship and protect water quality. These plans may help landowners obtain some financial assistance to implement recommended BMPs. Each plan is unique to the individual landowner's needs and property. Example management practices are brush management, alternate water and shade areas for livestock, fencing and buffer strips.

Feral Hog Control

Feral hog management was identified as important in the San Fernando and Petronila Creek watersheds. Active and passive management controls will be implemented throughout the watersheds to help control populations and reduce damage to lands and riparian areas. Landowners will be encouraged to continue voluntary trapping and removal of feral hogs on their own and with assistance from various agencies. Educational programs will be brought to the watershed to discuss proper management techniques.

On-Site Sewage Systems

Failing on-site sewage facilities, especially those located close to a waterbody, are known to contribute to water quality impairments. Strategies to improve on-site sewage facilities management includes educational programs on how to operate and maintain septic systems. Priority will also be given to identify, repair and replace failing on-site sewage facilities as funds are available.

Pet Waste

Pet waste was identified as a significant potential contributor of bacteria and nutrient loading in the watershed. Outreach and education are key components to proper pet waste management by owners. Increasing the amount of pet waste stations in public parks and apartment complexes will also increase the likelihood of proper waste disposal.

Sanitary Sewer Overflows

Although infrequent, sanitary sewer overflows and unauthorized wastewater treatment facility discharges can contribute to bacteria loads. Identifying and repairing or replacing failing infrastructure is important to prevent unauthorized discharges. Education and outreach are also important to teach homeowners about proper fats, oils, grease and other non-flushable disposal to prevent damage to sewer collection systems.

Illicit Dumping

Illicit dumping is difficult to quantify in terms of impact on bacteria and nutrient loadings but, it can cause health and safety issues throughout the watershed. Educational signage will be increased at bridges and road crossings to try to reduce dumping at these locations. Hazardous waste collection events are recommended across the watershed to provide an appropriate means of hazardous material disposal.

Chapter 1 Introduction to Watershed Management

The Watershed Approach

The watershed approach is widely accepted by state and federal water resource management agencies to facilitate water quality management. The U.S. Environmental Protection Agency (EPA) describes the watershed approach as "a flexible framework for managing water resource quality and quantity within a specified drainage area or watershed" (EPA 2008). The watershed approach requires engaging stakeholders to make management decisions supported by sound science (EPA 2008). One critical aspect of the watershed approach is that it focuses on hydrologic boundaries, rather than political boundaries, to address potential water quality impacts to all potential stakeholders.

A stakeholder is anyone who lives, works, has interest within the watershed or may be affected by efforts to address water quality issues. Stakeholders may include individuals, groups, businesses, organizations or agencies. Continuous involvement of stakeholders throughout the watershed approach is critical for effectively selecting, designing and implementing management measures that address watershed water quality.

Watershed Protection Plan

Watershed protection plans (WPPs) are locally driven mechanisms to voluntarily address complex water quality problems across political boundaries. A WPP serves as a framework to better leverage and coordinate private, non-profit, local, state and federal agency resources.

The San Fernando and Petronila Creek WPP follows the EPA's nine key elements, which are designed to provide guidance for development of an effective WPP (EPA 2008). WPPs vary in methodology, content and strategy based on local priorities and needs. However, common fundamental elements are included in successful plans and include (see Appendix C – Elements of Successful Watershed Protection Plans):

1: Identification of causes and sources of impairment
2: Expected load reductions from management strategies

3: Proposed management measures
4: Technical and financial assistance needed to implement management measures
5: Information, education and public participation needed to support implementation
6: Schedule for implementing management measures
7: Milestones for progress of WPP implementation
8: Criteria for determining successes of WPP implementation
9: Water quality monitoring

Adaptive Management

Adaptive management consists of developing a natural resource management strategy to facilitate decision-making based on an ongoing science-based process. Such an approach includes results of continual testing, monitoring, evaluating applied strategies and revising management approaches to incorporate new information, science and societal needs (EPA 2000). An adaptive management strategy allows the management measures recommended in a WPP to adjust their focus and intensity as determined by the plan's success and the dynamic nature of each watershed. Throughout the life of this WPP, water quality and other measures of success will be monitored, and adjustments will be made as needed to the implementation strategy.

Education and Outreach

WPP development and implementation depends on effective education, outreach and engagement efforts to inform stakeholders, landowners and residents of its associated activities and practices. Education and outreach events provide an information delivery platform for stakeholders throughout the WPP implementation process. Education and outreach efforts are integrated into many management measures detailed in the WPP.

Chapter 2 Watershed Characterization

Introduction

This chapter provides geographic, demographic, and water quality overviews of the San Fernando and Petronila Creek watersheds which are the focus of this WPP. Information in this chapter draws heavily on state and federal data sources and local stakeholder knowledge and provides context for the remainder of the document. Collating this information allowed a reliable assessment of water quality, identified potential water quality impairment causes, and facilitated development of recommended management measures to address these concerns. Baffin Bay receives water from both creeks and several other smaller tributaries. Harmful algal blooms and declining water quality in Baffin Bay have increased awareness and concern about the impacts of upstream water quality on the bay's aquatic resources. Water quality in Los Olmos, San Fernando and Petronila Creeks together with activities on the shoreline of Baffin Bay that negatively influence water quality constitute the primary concerns for local stakeholders. These stakeholder concerns plus documented water quality impairments in San Fernando and Petronila Creek were the impetus for developing this WPP.

Watershed Description

Petronila Creek

Petronila Creek begins in western Nueces County near County Road 40 and flows approximately 44 miles downstream where it meets Tunas Creek in eastern Kleberg County before flowing into Cayo Del Mazón. Petronila Creek's watershed includes portions of Jim Wells, Nueces and Kleberg counties (Figure 1, Table 1). The watershed covers 675 square miles (mi^2) of predominantly rural landscapes with several towns including Agua Dulce, Driscoll, Orange Grove, and the southern extent of Robstown. Urban sprawl from Corpus Christi is also starting to impact the northeastern portion of the watershed where farmland is being converted to subdivisions. Various smaller communities including colonias are also distributed throughout the watershed. In its upper reaches, Petronila Creek is freshwater but, as it nears Baffin Bay, it becomes brackish due to tidal influence.

San Fernando Creek

San Fernando Creek is a freshwater creek that begins at the confluence of San Diego and Chiltipin Creek in Jim Wells County northeast of Alice. From there, it continues approximately 44 miles downstream to Cayo Del Grullo southeast of Kingsville. San Fernando Creek and its tributaries flow throughout portions of Duval, Jim Wells, Kleberg and Nueces counties (Figure 1, Table 1). Its watershed covers approximately 1,270 mi^2 of largely rural land but does include the cities of Alice and Kingsville. Other communities in the watershed include Benavides, Bishop, San Diego and several colonias.

Los Olmos Creek

The Los Olmos Creek watershed covers approximately 2,202 mi^2 of primarily rural land to the south of the San Fernando Creek watershed. This area is outside of the focus area for this WPP, but it can have a substantial influence on Baffin Bay water quality and is a significant concern for watershed stakeholders. Los Olmos Creek is the third largest tributary into Baffin Bay volumetrically; however, its watershed area is larger than the combined watershed area of San Fernando and Petronila Creek. The influence of Los Olmos Creek must not be discounted when evaluating the overall health of Baffin Bay. Local stakeholder desire is to include Los Olmos Creek in the WPP effort; however, water quality data is limited and does not allow for ample water quality assessment relative to watershed conditions that is necessary for developing an effective WPP. As a result, the Los Olmos Creek watershed is not included in this WPP but, it could be included in the future when sufficient data is available.

Baffin Bay

Los Olmos, San Fernando, Petronila and other small creeks flow into Baffin Bay. An inlet of the larger Laguna Madre, Baffin Bay is considered a crown jewel of the Texas coast for its sport-fishing and recreation potential. This resource has been challenged by fish kills and declining water quality that are influenced by in-bay processes and inputs from the contributing watersheds. Stakeholder concerns over these issues led to the development of the Baffin Bay Stakeholder Group and were a major driver in local support for developing a WPP to address these concerns and pollutants.

Petronila & San Fernando Creek

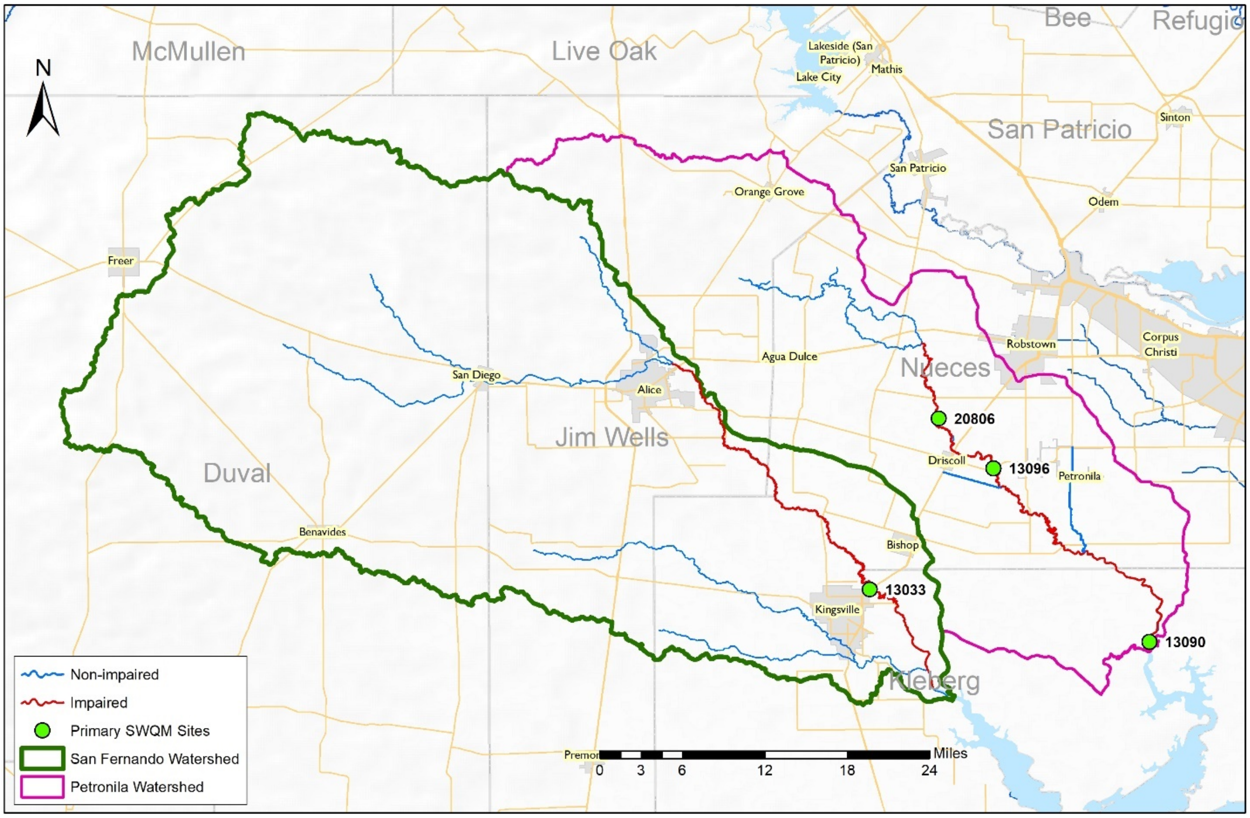


Figure 1. San Fernando and Petronila Creek watershed map

Table 1. County and watershed area summary

County	Area of Total County (Acres)	Area of Watershed Within the County (Acres)	Percent of the Total County Within the Watershed (%)	Percent of the Watershed Within Each County (%)
Duval	1,149,259	421,469	36.7	33.8
Jim Wells	555,730	362,488	65.2	29.1
Kleberg	578,888	189,812	32.8	15.2
Nueces	549,498	273,333	49.7	21.9
Entire Watershed		1,247,102		100

Physical Characteristics

Soils and Topography

Watershed soils and topography are important components of watershed hydrology. Slope and elevation define where water will flow, while slope and soil properties influence water infiltration rates, runoff generation and water movement through the soil. Soil properties may also limit the types of land development and activities that can occur in certain areas.

Watershed elevation ranges from a maximum approximate elevation of 241 feet (ft) above mean sea level (MSL) in the western part of the watershed to a minimum approximate elevation of 1 ft above MSL near the mouths of both San Fernando and Petronila creeks where they ultimately flow into Baffin Bay (Figure 2). Elevation was determined using the U.S. Geological Survey (USGS) 10-m 3D Elevation Program (3DEP, 2019). San Fernando and Petronila Creek watershed topography is comprised of mildly hilly terrain on its northwestern edge, quickly giving way to a gradual smoothing of topography until the watershed meets the coast to the southeast.

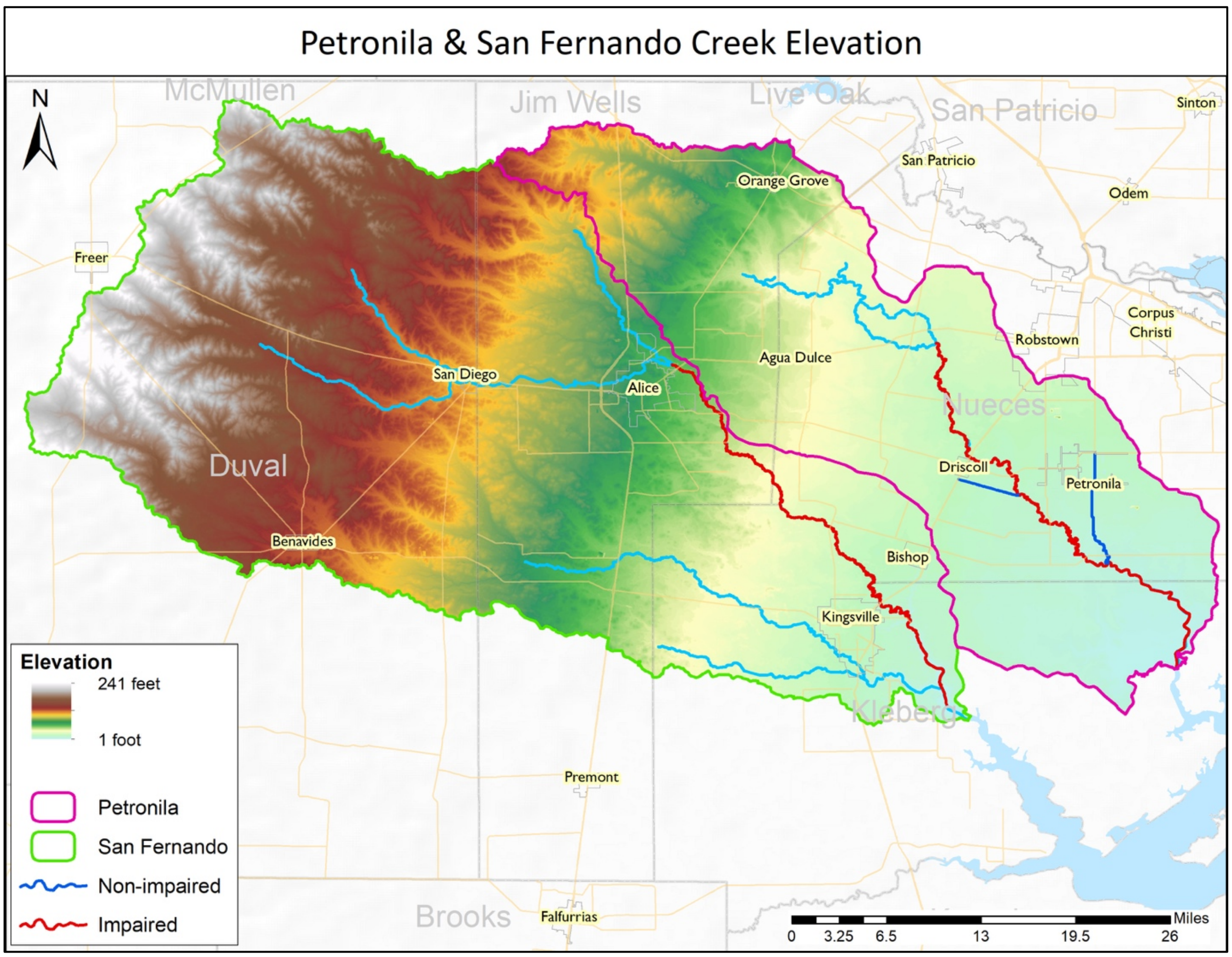


Figure 2. Watershed elevation

Dominant soils in the San Fernando and Petronila Creek watersheds are Alfisols, Inceptisols, Mollisols and Vertisols (Figure 3). Mollisoils (47%; 744,625 acres (ac)) and are characterized by a dark surface layer indicative of high amounts of organic material which make them very fertile and productive for agricultural uses. Vertisols (29%; 464,088 ac), most common in the eastern part of the watershed, are clay-rich and exhibit a shrinking and swelling action with changes in moisture that can lead to wide cracks forming during dry periods. Alfisols (17%; 268,115 ac) tend to be found beneath mixed vegetative cover and are the result of the weathering process leaching clay minerals beneath the surface. Alfisols tend to hold water and provide moisture to plants during moderately dry conditions. Inceptisols (2.2%; 108,404 ac) are common in humid and subhumid regions and are sprinkled throughout the central watershed.

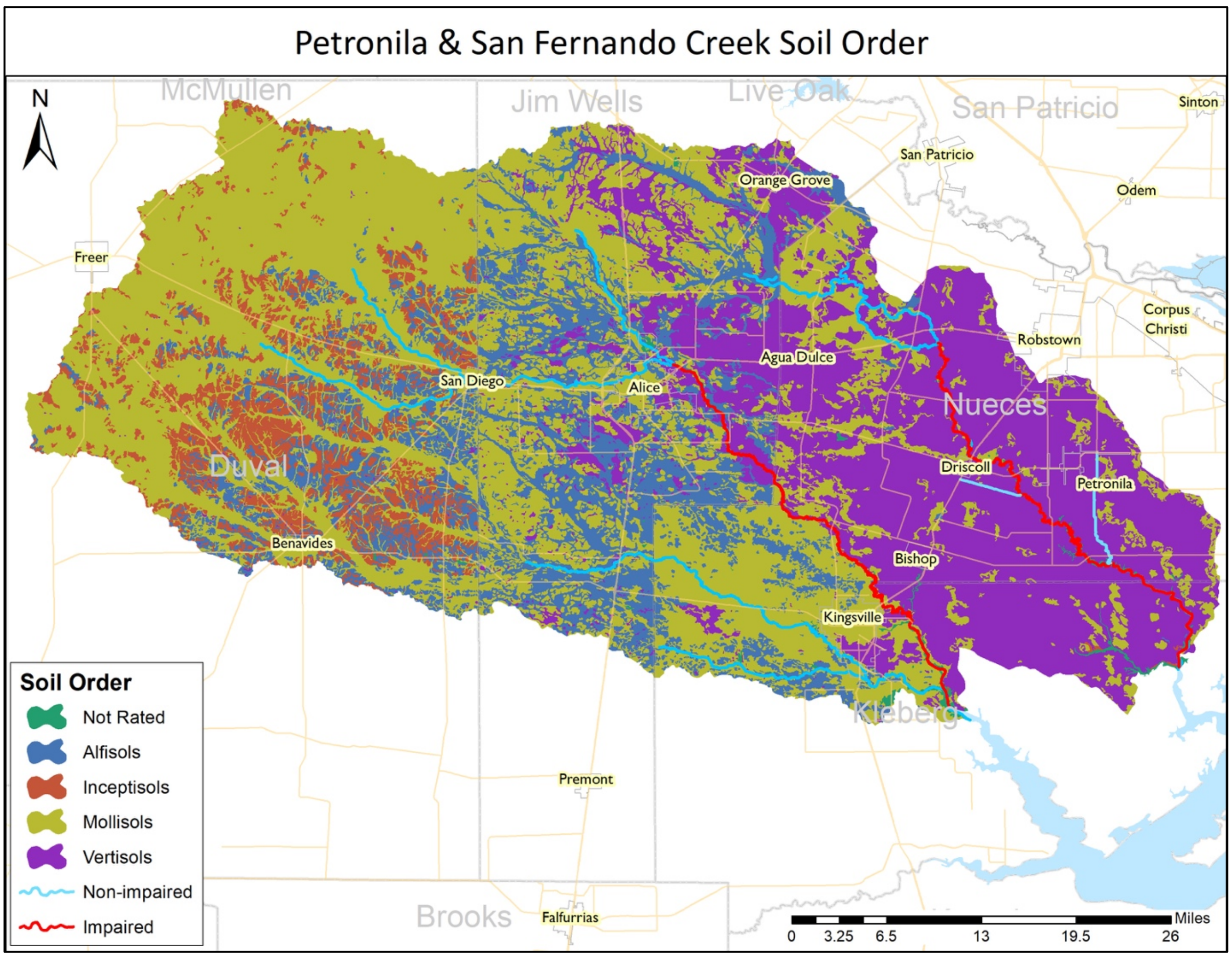


Figure 3. Watershed soil orders

Hydrologic soil groups indicate runoff potential and are determined based on the measure of precipitation, runoff and infiltration (NRCS 2009). There are four primary hydrologic soil groups. Group A is composed of sand, loamy sand or sandy loam with low runoff potential and high infiltration. Group B is well drained with silt loam or loam type soils. Group C consists of finer soils and slower infiltration. Group D has high clay content, low infiltration and high runoff potential. In the Group C/D, C represents the drained areas and D the undrained areas.

The western and central areas of the watershed contain a nearly even split between moderate and high runoff potential soils (Figure 4). The eastern portion of the watershed contains mostly slow infiltration soils with higher runoff potential. Soil Group C (45% of watershed soils), Group B (29% of watershed soils) and Group D (25% of watershed soils) dominate the watershed followed by Groups A and C/D, both at 1% of soils. Distinct difference in soil classifications along the Jim Wells, Nueces and Kleberg County lines are the result of the Soil Survey Geographic Database (SSURGO) model being continually updated by the USDA. Historically, soil survey projects have been conducted within county political boundaries. While the inherent properties of soil bodies have not changed, the human aspect of creating soil survey models has. Baffin Bay watershed soils were mapped between 1965 and 2012. Soil science is a relatively young discipline and tremendous advancements have been made from 1965 to present. Old surveys are being updated with new mapping concepts that follow the natural landscape rather than political boundaries.

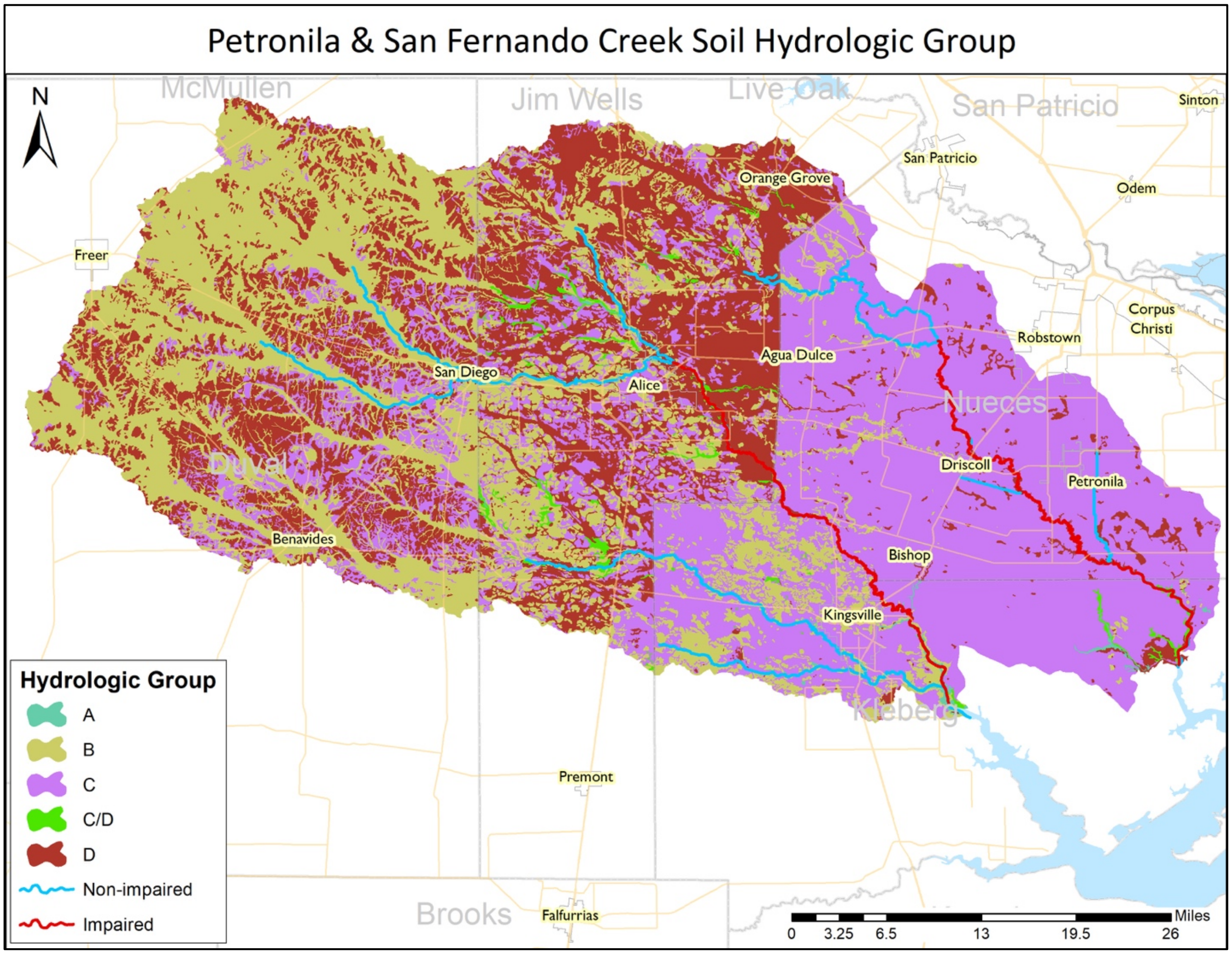


Figure 4. Hydrologic soil groups

Land Use and Land Cover

According to the 2016 National Land Cover Database (NLCD), dominant land use and land cover (LULC) categories are shrub/scrub (45.1%; 562,941 ac), cultivated crop (29.7%; 370,329 ac) and pasture/hay (15.6%; 194,917 ac) (Figure 5;Table 2). Developed, or urban areas, are also present in the watershed but only comprise 4.1% (51,414 ac) of the total land use.

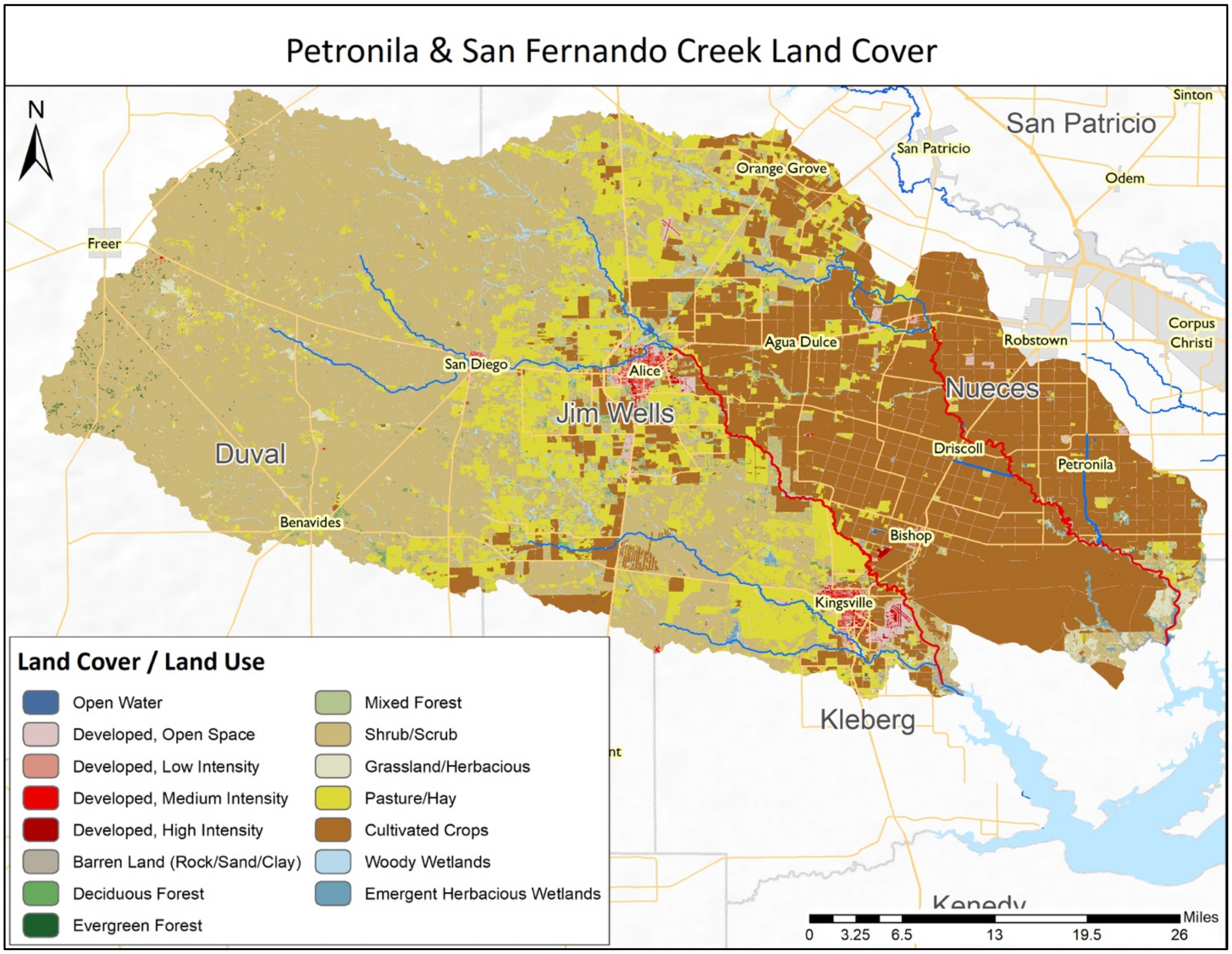


Figure 5. Watershed LULC

Table 2. LULC summary

Land Cover Class	Petronila Watershed Acres (% of Watershed)	San Fernando Watershed Acres (% of Watershed)	Total Acres
Developed	16,201 (3.75%)	35,214 (4.32%)	51,415
Barren	1,868 (0.43%)	1,835 (0.23%)	3,703
Forests	4,371 (1.01%)	13,263 (1.63%)	17,634
Shrub/Scrub	48,207 (11.15%)	514,725 (63.18%)	562,932
Grassland/Herbaceous	6,268 (1.45%)	8,689 (1.07%)	14,957
Pasture/Hay	57,762 (13.36%)	137,163 (16.84)	194,925
Cultivated Cropland	287,546 (66.49%)	82,819 (10.17%)	370,365
Wetland	9,520 (2.20%)	20,199 (2.48%)	29,719
Open Water	735 (0.17%)	762 (0.09%)	1,497
Total Acreage	**432,478**	**814,669**	**1,247,147**

Ecoregions

Ecoregions are land areas that contain similar quality and quantity of natural resources (Griffith 2007). Ecoregions have been delineated into four separate levels; level I is the most unrefined classification while level IV is the most refined. The watershed flows primarily through two ecoregions (level IV ecoregions); the Texas-Tamaulipan Thornscrub (31c) in the western part of the watershed in Duval and Jim Wells counties and into the Southern Subhumid Gulf Coast Prairies (34b) in Kleberg and Nueces counties (Figure 6). At the southern tip of the Petronila Creek watershed, a small area of Laguna Madre Barrier Islands and Coastal Marshes (34i) exists. The dominant soil types are fine, fine-loamy to the west of the watershed transitioning to mostly fine soils to the east.

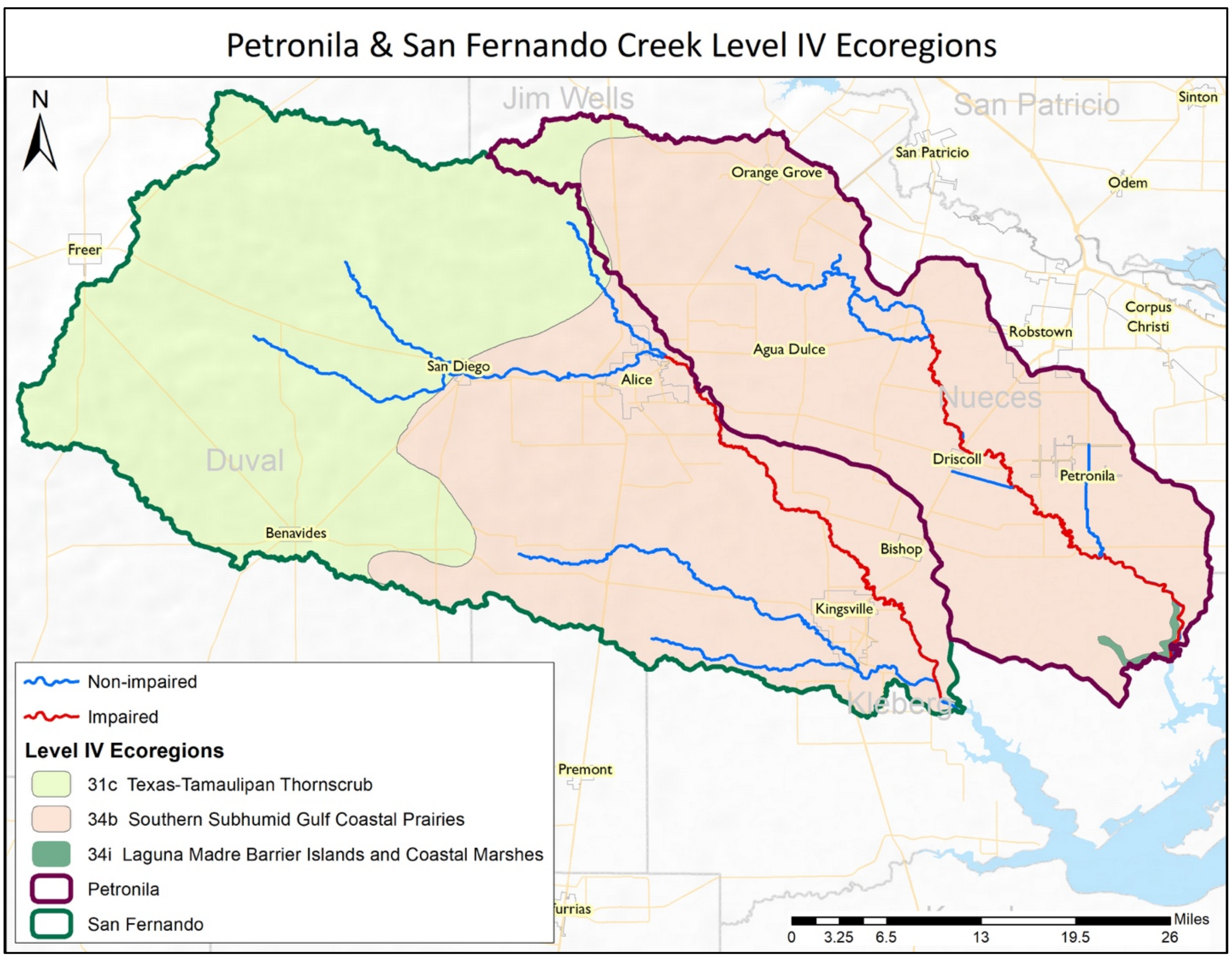


Figure 6. Level IV ecoregions

Climate

The San Fernando and Petronila Creek watershed is characterized as a humid subtropical climate zone, with hot summers and mild winters. Average annual precipitation from 2011 to 2021 ranged between 21 inches (in) to 30 in (Figure 7) across the wateshed. Peak monthly average precipitation occurs in May and September. The driest months are typically January, July and November. The warmest months on average are July and August with an average temperature of 97°F (Figure 8). January is the coldest month with average lows around 47°F (NOAA 2021).

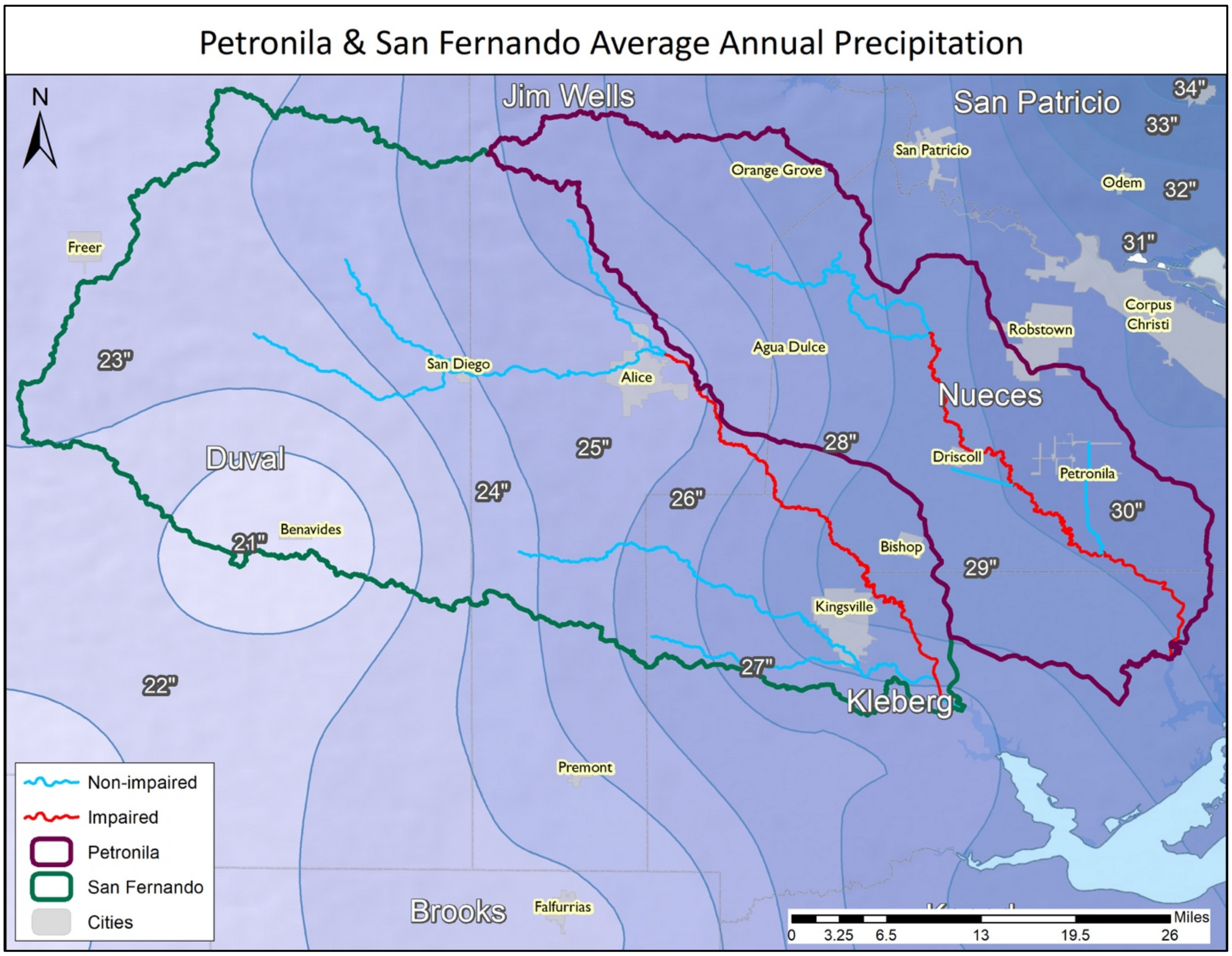


Figure 7. Annual normal precipitation in inches

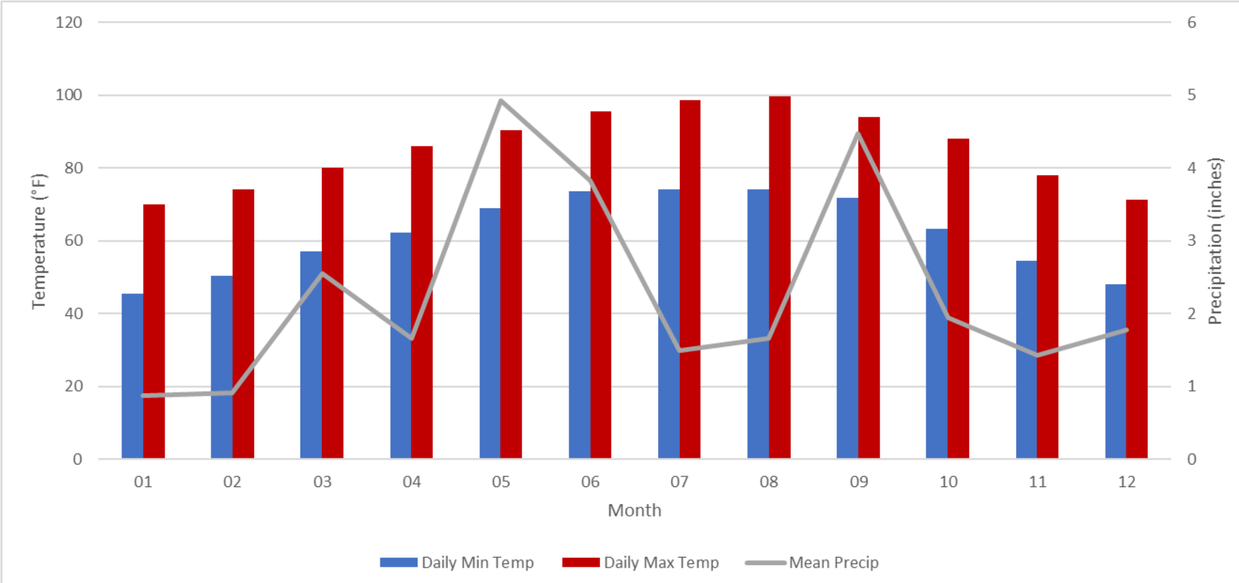


Figure 8. Monthly mean maximum and minimum air temperatures (°F) and monthly mean rainfall (inches) measured at Alice International Airport, TX (NOAA 2021)

Population

According to 2010 Census data, the highest population densities are along SH-44, US-281, and US-77. These highways, along with ancillary roads, connect the major population concentrations found in the cities of Kingsville, Bishop, Driscoll, Petronila, Alice, Agua Dulce, Orange Grove, Banquete, Benavides, San Diego, and a small area of Robstown (Figure 9). The watershed population was approximately 83,846 based on the 2010 Census data from U.S. Census Bureau (USCB). Recent estimates from the USCB (2021) also place an average of 2.89 persons per household across the combined watershed area. Between 2020 and 2070, significant population growth is expected in Duval, Jim Wells, Kleberg, and Nueces counties (Table 3). With this growth, increases in residential and commercial development are expected. This will adversely affect natural watershed function, will further strain existing drainage and wastewater infrastructure, and will generally increase adverse water quality effects across the watershed.

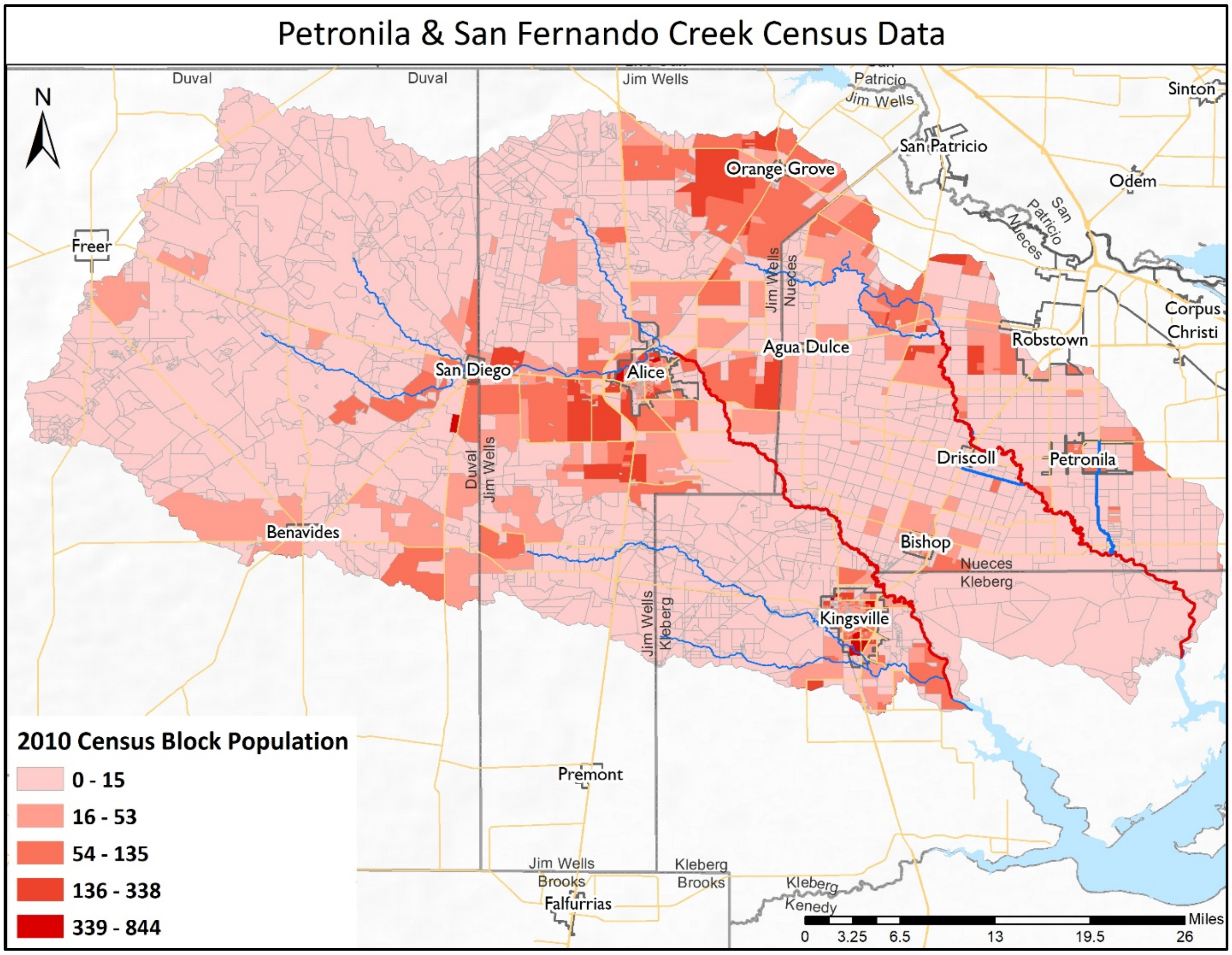


Figure 9 2010 U.S. Census population estimates

Table 3. County population projections through 2070

County	2020	2030	2040	2050	2060	2070	Population Increase
Duval	12,715	13,470	14,098	14,644	15,080	15,435	21%
Jim Wells	44,987	48,690	52,052	55,533	58,600	61,410	37%
Kleberg	35,567	38,963	42,202	45,324	48,251	50,989	43%
Nueces	374,157	407,534	428,513	440,797	449,936	465,056	24%
Total in Watershed	467,426	508,657	536,865	556,298	571,867	592,890	27%

Aquifers

Texas has 9 major and 22 minor aquifers, but only one underlies the San Fernando and Petronila Creek watershed. The Gulf Coast aquifer spans the entire substrate of the watershed. Near the Gulf Coast, the aquifer tends to yield water too high in salinity for irrigation with levels between 1,000 and 10,000 milligrams per liter (mg/L) of dissolved solids. As distance from the coast increases, the aquifer is less impacted by saltwater-intrusion and has a low enough salinity that it can be used for drinking and irrigation.

Chapter 3 Water Quality

Surface water is monitored in Texas to ensure that its quality supports designated uses defined in the Texas Water Code. Designated uses and associated standards are developed by Texas Commission on Environmental Quality (TCEQ) to fulfill requirements of the Clean Water Act (CWA), which addresses toxins and pollution in waterways and establishes a foundation for water quality standards. It requires states to set standards that: (1) maintain and restore biological integrity in the waters, (2) protect fish, wildlife and recreation in and on the water (must be fishable/swimmable) and (3) consider the use and value of state waters for public supplies, wildlife, recreation, agricultural and industrial purposes. The CWA (33 USC § 1251), administered by the EPA (40 CFR § 130.7), requires states to develop a list that describes all water bodies that are impaired and are not within established water quality standards (commonly called "303(d) list" in reference to Texas Water Quality Inventory and 303(d) List).

Waterbody Assessments

TCEQ conducts a waterbody assessment on a biennial basis to satisfy requirements of federal CWA Sections 305(b) and 303(d). The resulting *Texas Integrated Report of Surface Water Quality (Texas Integrated Report)* describes the status of waterbodies throughout the state. The 2020 *Texas Integrated Report* is the most recent version published and includes an assessment of water quality data collected from December 1, 2011 to November 30, 2018.

The *Texas Integrated Report* assesses water bodies at the Assessment Units (AU) level. An AU is a sub-area of a stream segment, defined as the smallest geographic area of use support reported in the assessment (TCEQ 2020). Each AU is intended to have relatively homogeneous chemical, physical and hydrological characteristics, which allows a way to assign site-specific standards (TCEQ 2020). A segment identification number and AUs are combined and assigned to each waterbody to divide a segment. For example, Petronila Creek is segment 2204 and it has two AUs designated 2204_01 and 2204_02. The tidal portion of Petronila Creek, which would be expected to have different characteristics than the non-tidal portions, is assigned a different segment identification number and AU, 2203_01.

In total, there are six AUs in the San Fernando and Petronila watershed (Figure 10). Monitoring stations are located on several of the AUs and typically allow independent water quality analysis for each AU within a segment. At least 10 data points within the most recent seven years of available data are required for all water quality parameters except bacteria, which requires a minimum of 20 samples. Water quality data from six monitoring stations in the San Fernando and Petronila Creek watersheds were reviewed (Figure 11; Table 4). For this WPP, stations 13033 and 13096 were identified for use generating load duration curves (LDCs). These two stations are representative of the water bodies upon which they are located and were chosen to allow for a singular load reduction goal for each waterbody.

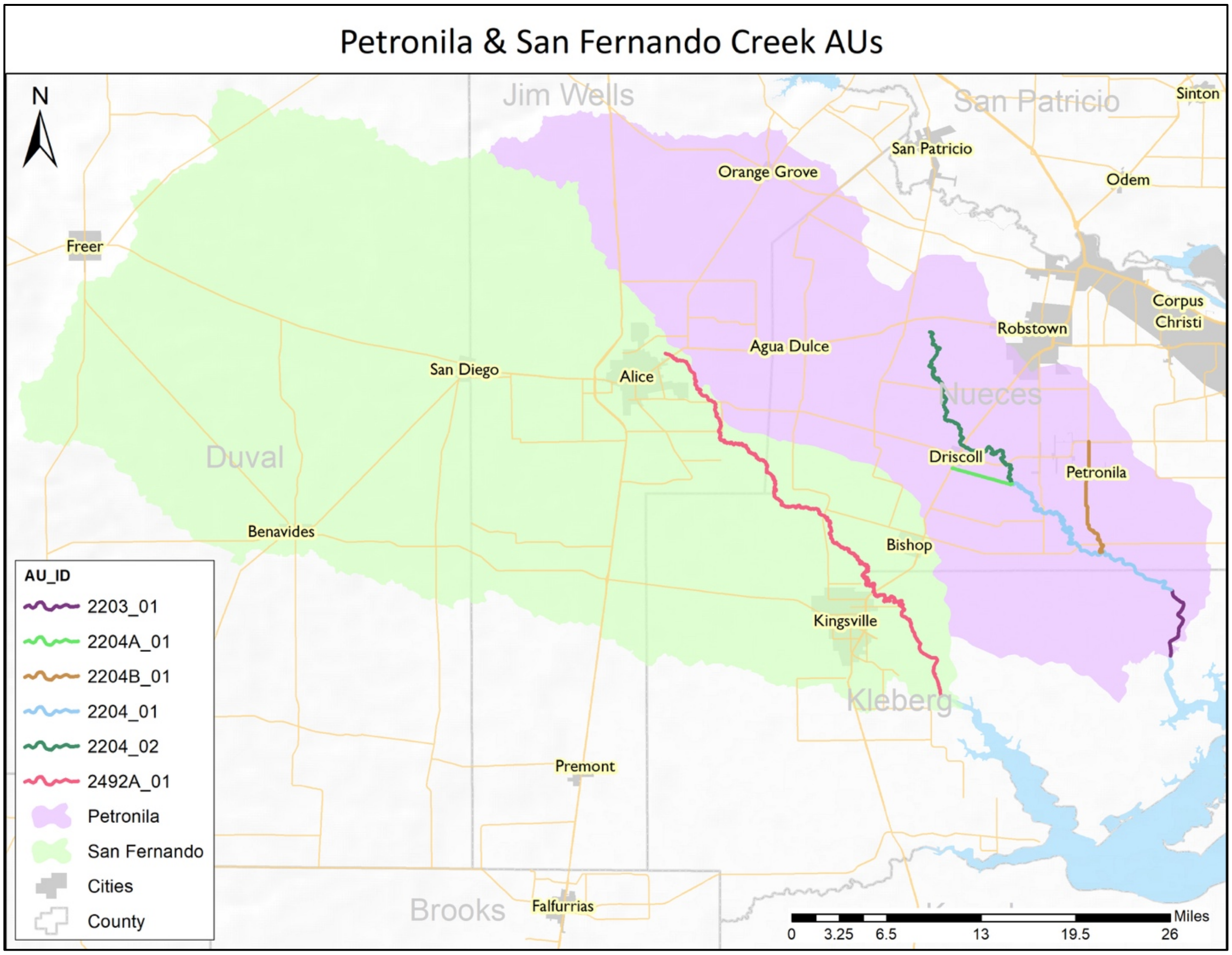


Figure 10. San Fernando and Petronila Creek AUs

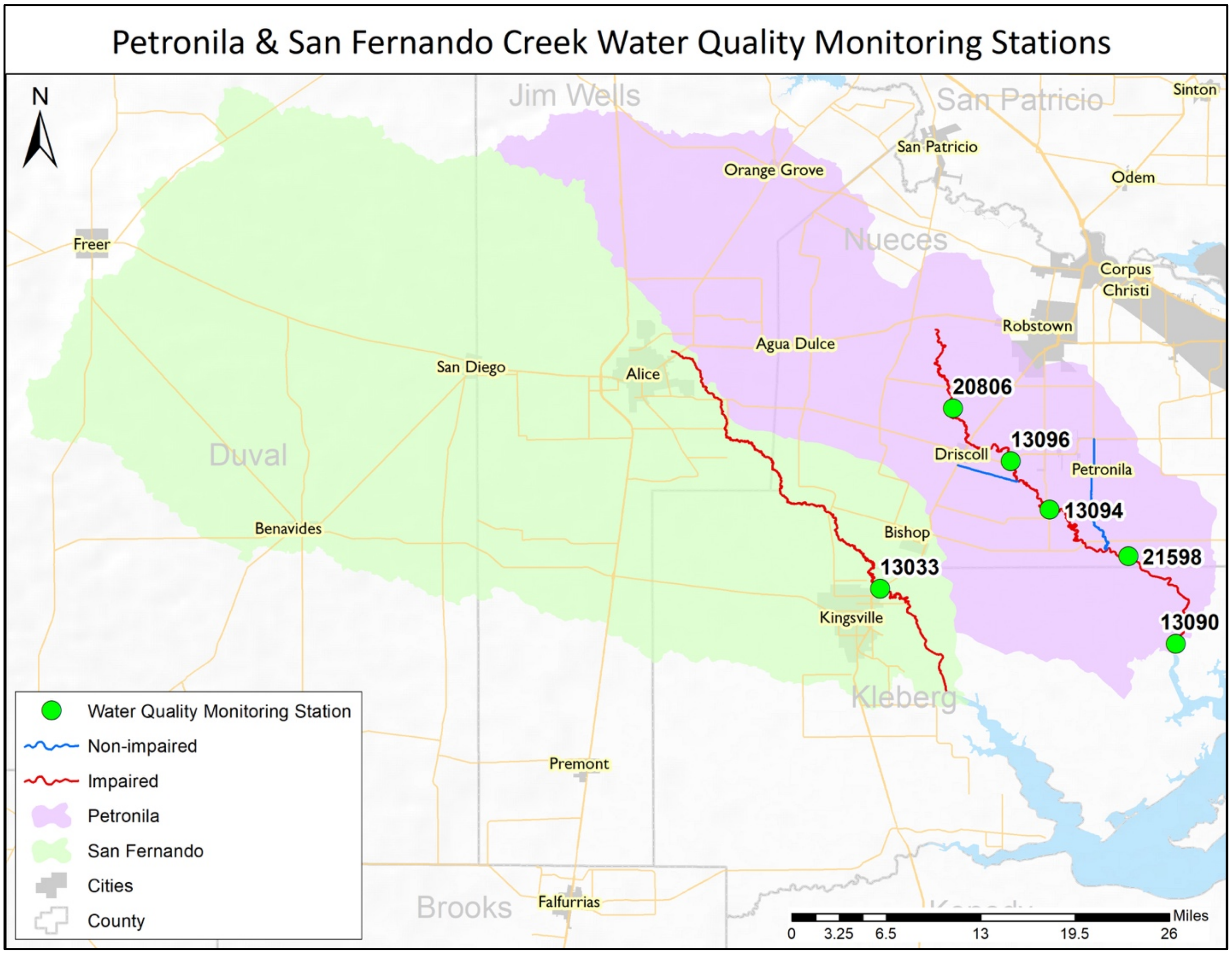


Figure 11. Water quality monitoring stations

Table 4. Water quality monitoring station summary from December 1, 2011 to November 30, 2018

Station	AUs	Samples	Location
13033	2492A_01	60	San Fernando Ck at US 77
13090	2203_01	42*	Petronila Ck above Tunas Confluence
13094	2204_01	41	Petronila Ck at FM 892
21598		1	Outfall ditch to Petronila Ck from Cefe Valenzuela Landfill
13096	2204_02	53	Petronila Ck at FM 665
20806		40	Petronila Ck southwest of Alice Rd & Lost Creek Rd

Sample numbers are based on reported *E. coli*, IDEXX-Colilert samples.

*Sample number based on enterococci, IDEXX-Enterolert samples because AU 2203_01 is a tidal segment.

According to the 2020 *Texas Integrated Report*, four AUs in the watershed are impaired due to elevated bacteria (AU 2203_01, 2204_01, 2204_02 and 2492A_01) (Table 5). The criteria used for non-tidal, fresh recreational waters is 126 colony forming units (cfu) of *E. coli* / 100 milliliter (mL); whereas, in marine (tidal) recreational water, it is 35 cfu of enterococci / 100 mL. Furthermore, several nutrient and chlorophyll-a concerns are identified in four AUs in the combined San Fernando and Petronila watershed (Table 6).

Table 5. Watershed impairments in 2020 *Texas Integrated Report*

Parameter	Category	AUs	River Reach	Criteria
Bacteria	5b*	2203_01	Petronila Creek Tidal	35 cfu/100 mL
		2204_01	Petronila Creek Above Tidal	126 cfu/100 mL
		2204_02		
	5c**	2492A_01	San Fernando Creek	

*Category 5b – A review of the standards for one or more parameters will be conducted before a management strategy is selected, including a possible revision to the Texas Surface Water Quality Standards (TSWQSs).
**Category 5c – Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

Table 6. Watershed nutrient concerns identified in the 2020 *Texas Integrated Report*

Parameter	AUs	River Reach	Criteria
Chlorophyll-a	2203_01	Petronila Creek Tidal	>20% exceedance (21 μg/L Standard Screening Level)
	2204_01	Petronila Creek Above Tidal	>20% exceedance (14.1 μg/L Standard Screening Level)
	2204_02		
	2492A_01	San Fernando Creek	
Nitrate	2492A_01	San Fernando Creek	>20% exceedance (1.95 mg/L Standard Screening Level)
Total Phosphorus	2492A_01	San Fernando Creek	>20% exceedance (0.69 mg/L Standard Screening Level)

milligrams, mg; micrograms, μg; liter, L

Texas Surface Water Quality Standards

Water quality standards are established by the state and approved by EPA to define a waterbody's ability to support its designated uses, which may include aquatic life use (fish, shellfish, and wildlife protection and propagation), primary contact recreation (swimming, wading by children, etc.), public water supply and fish consumption. Water quality indicators for these uses include DO (aquatic life use), *E. coli* (primary contact recreation), pH, temperature, total dissolved solids, sulfate and chloride (general uses), and a variety of toxins (fish consumption and public water supply) (Table 7) (TCEQ 2020).

Table 7. Designated uses, use categories, and criteria for water bodies in the San Fernando and Petronila Creek Watershed

Use	Segment Number	Use Category	Criteria	Measure
Contact Recreation	2203	Primary contact recreation 1	35 cfu / 100 mL (enterococci)	7-year geometric mean
	2204		126 cfu/100 mL (*E. coli*)	
	2492			
Aquatic Life Use	2203*	High	4.0/3.0 mg/L DO*	<10% exceedance based on the binomial method
	2204	Intermediate	4.0/3.0 mg/L DO	
	2492	High	5.0/3.0 mg/L DO	
General Use Standards	The criteria for the general use include aesthetic parameters, radiological substances, toxic substances, temperature (when surface samples are above 5°F and not attained due to permitted thermal discharges) and nutrients (screening standards or site-specific nutrient criteria)			

Dissolved oxygen, DO; Fahrenheit, F

*Segment 2203 is the tidal portion of Petronila Creek. Saline water has less capacity for DO, therefore; while 4.0/3.0 mg/L DO is only considered Intermediate in freshwater, it is considered High for tidal water.

Bacteria

Concentrations of fecal indicator bacteria are evaluated to assess a waterbody's ability to meet its contact recreation use. In freshwater environments, *E. coli* concentrations are measured to evaluate the presence of potential fecal contamination in water bodies. The presence of these fecal indicator bacteria may indicate that associated pathogens from the intestinal tracts of warm-blooded animals or other sources could be reaching water bodies and may cause illness in people that recreate in them. Water quality standards for bacteria in freshwater and tidal waters differ. In freshwater, the standard for primary contact recreation is a geometric mean of 126 cfu of *E. coli* per 100 mL of water. In tidal waters, the primary contact recreation standard is 35 cfu of enterococci per 100 mL of water. Both standards must be assessed from at least 20 samples (30 TAC § 307.7). Common sources that indicator bacteria can originate from include wildlife, domestic livestock, pets, malfunctioning on-site sewage facilities (OSSFs), urban and agricultural runoff, sewage system overflows and direct discharges from wastewater treatment facilities (WWTFs). Currently, four AUs are listed as impaired due to elevated indicator bacteria (Figure 12) (TCEQ 2020).

Figure 12. *E. coli* and enterococcus concentrations in impaired AUs

Dissolved Oxygen

Dissolved Oxygen (DO) is the main parameter used to determine a waterbody's ability to support and maintain aquatic life uses. If DO levels in a waterbody drop too low, fish and other aquatic species will not survive. Typically, DO levels fluctuate throughout the day, with the highest levels of DO occurring in mid to late afternoon, due to plant photosynthesis. DO levels are typically lowest just before dawn as both plants and animals in the water continue to consume oxygen while natural production of DO typically slows overnight. Furthermore, seasonal fluctuations in DO are common because of decreased oxygen solubility in water as temperature increases; therefore, it is common to see lower DO levels during summer than the winter.
While DO can fluctuate naturally, human activities can also cause abnormally low DO levels. Excessive organic matter (vegetative material, untreated wastewater, etc.) can result in depressed

DO levels as bacteria break down the materials and subsequently consume oxygen. Excessive nutrients from fertilizers and manures can also depress DO as aquatic plant and algae growth increase in response to nutrients. The increased respiration from plants and decay of organic matter as plants die off can also lower DO concentrations.

When evaluating DO levels in a waterbody, TCEQ considers that monitoring events need to be spaced over an index period and a critical period. The index period represents the warm-weather season of the year and spans from March 15th to October 15th. The critical period of the year is July 1st to September 30th and is the portion of the year when minimum streamflow, maximum temperatures and minimum DO levels typically occur across Texas. At least half of the samples used to assess a stream's DO levels should be collected during the critical period with one-fourth to one-third of the samples used coming from the index period. DO measurements collected during the cold months of the year are not considered because flow and DO levels are typically highest during the winter months (30 TAC § 307.7). Under the 2020 *Texas Integrated Report*, none of the AUs in the San Fernando or Petronila Creek watersheds were listed as impaired for depressed DO.

Nutrients

Nutrients, specifically nitrogen and phosphorous, are used by aquatic plants and algae. However, excessive nutrients can lead to plant and algal blooms which result in reduced DO levels. High nitrate and nitrite levels can directly affect fish respiration. Nutrient sources include effluents from WWTFs and OSSFs, direct deposition of animal fecal matter, illegal refuse dumping, groundwater return flows, and fertilizers in run off from yards and agricultural fields. Additionally, nutrients bind to soil and sediment particles; therefore, runoff and erosion events that result in heavy sediment loads can increase nutrient levels in receiving water bodies. Nutrient standards have not been set in Texas; however, nutrient screening levels developed for statewide use were established to evaluate which water bodies may be experiencing excess nutrient loadings. Screening levels are set at the 85th percentile for parameters from similar water bodies. If more than 20% of samples from a waterbody exceed the screening level, that waterbody is on average experiencing pollutant concentrations higher than 85% of the streams in Texas and is therefore considered to have an elevated nutrient concentration concern. Screening levels have been designated for ammonia, nitrate, orthophosphorus, total phosphorus and chlorophyll-a (Table 8). The nutrient levels in several AUs are analyzed and the results are shown in Figure 13 (Chlorophyll-a), Figure 14 (Nitrate), and Figure 15 (Total Phosphorus).

Table 8. Watershed nutrient screening levels and criteria

Parameter	Screening Level	Criteria
Ammonia Nitrogen (NH3-N)	0.33 mg/L	> 20% exceedance
Nitrate Nitrogen (NO3-N)	1.95 mg/L	
Chlorophyll-a	14.1 µg/L 21 µg/L (tidal)	
Total Phosphorous (TP)	0.69 mg/L	

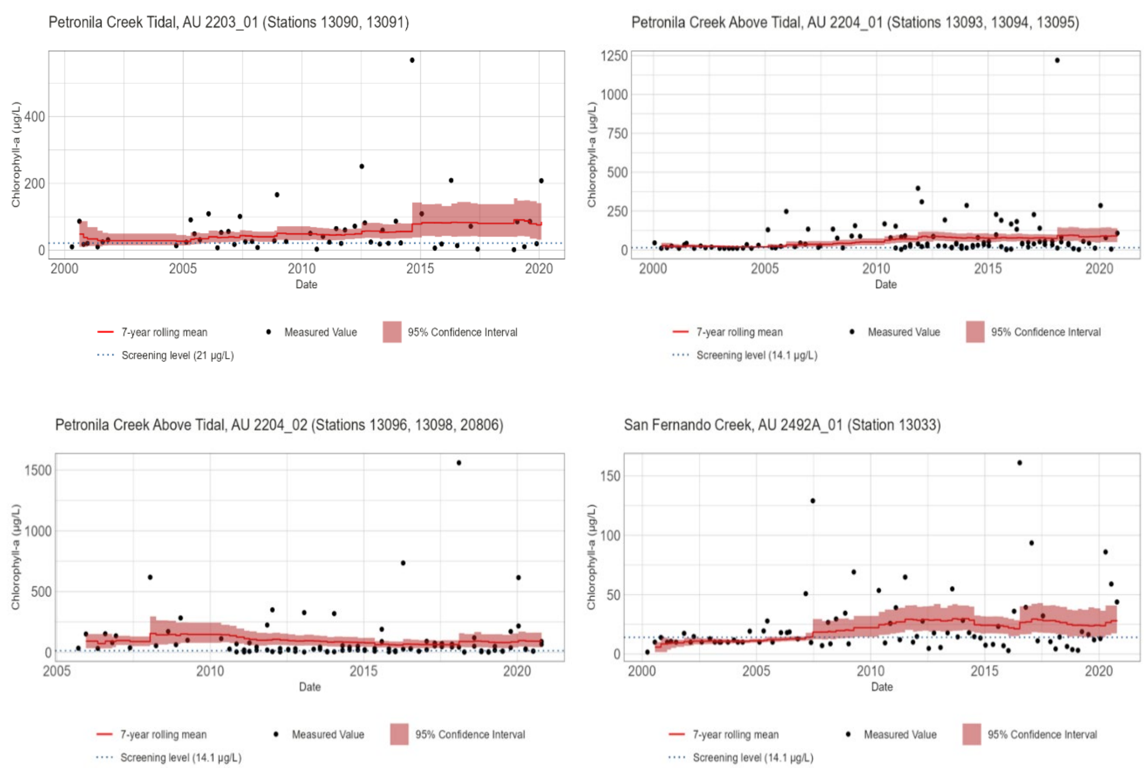


Figure 13 Chlorophyll-a concentrations

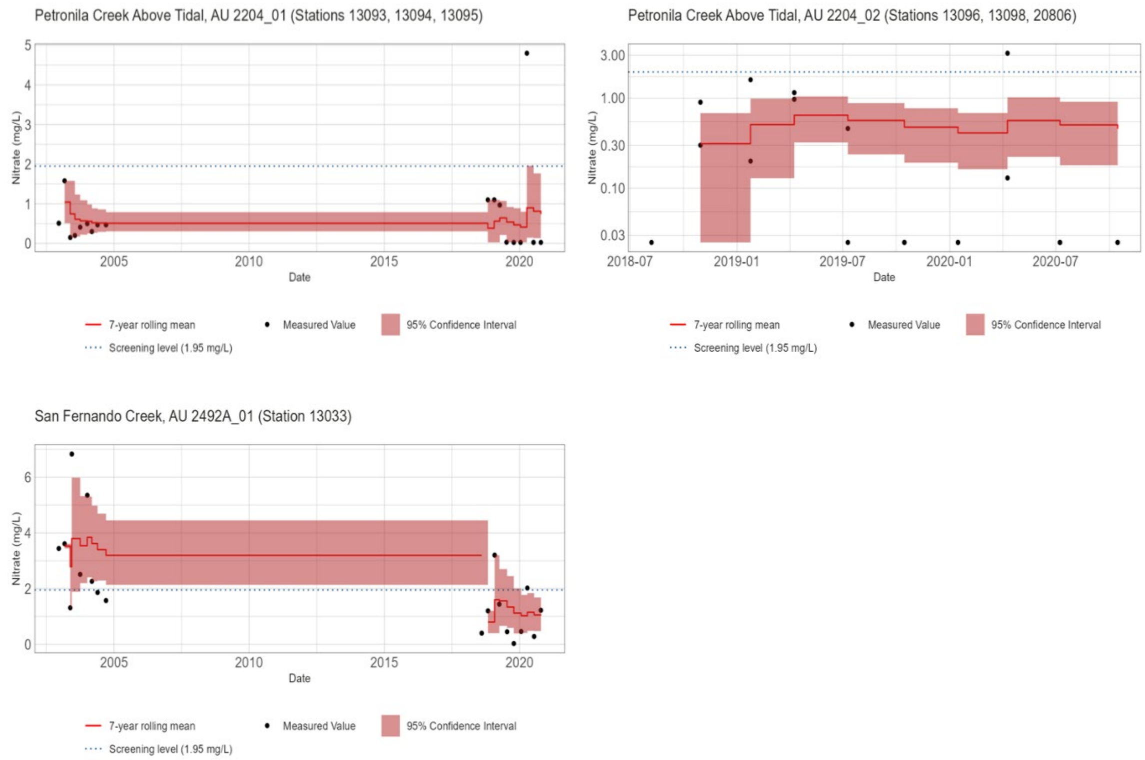


Figure 14 Nitrate concentrations

Figure 15. Total Phosphorous concentration

Flow

Generally, streamflow (the amount of water flowing in a river at a given time) is dynamic and always changing in response to both natural (e.g., precipitation events) and anthropogenic (e.g., changes in land cover or wastewater discharges) factors. From a water quality perspective, streamflow is important because it influences the ability of a waterbody to assimilate pollutants. There are four USGS streamflow gages located within the watershed (Figure 16). One gage is decommissioned (USGS-8211900), and one is not located on either San Fernando or Petronila Creek (USGS-8211800). Of the two remaining active gages, USGS-08212000 is on San Fernando Creek, and USGS-08212820 is on Petronila Creek. These two gages provide the long-term instantaneous daily streamflow information used in this report. Over the previous 10 years, mean monthly stream flows rose sharply in May, peaking in June near 32.5 cubic feet per second (cfs) and then returning to mean levels below 5 cfs until the next May. Though the monthly means are presented here (Figure 17), it must not be discounted that the watershed's proximity to the Gulf of Mexico subjects it to periods of heavy precipitation events that typically occur between May and July.

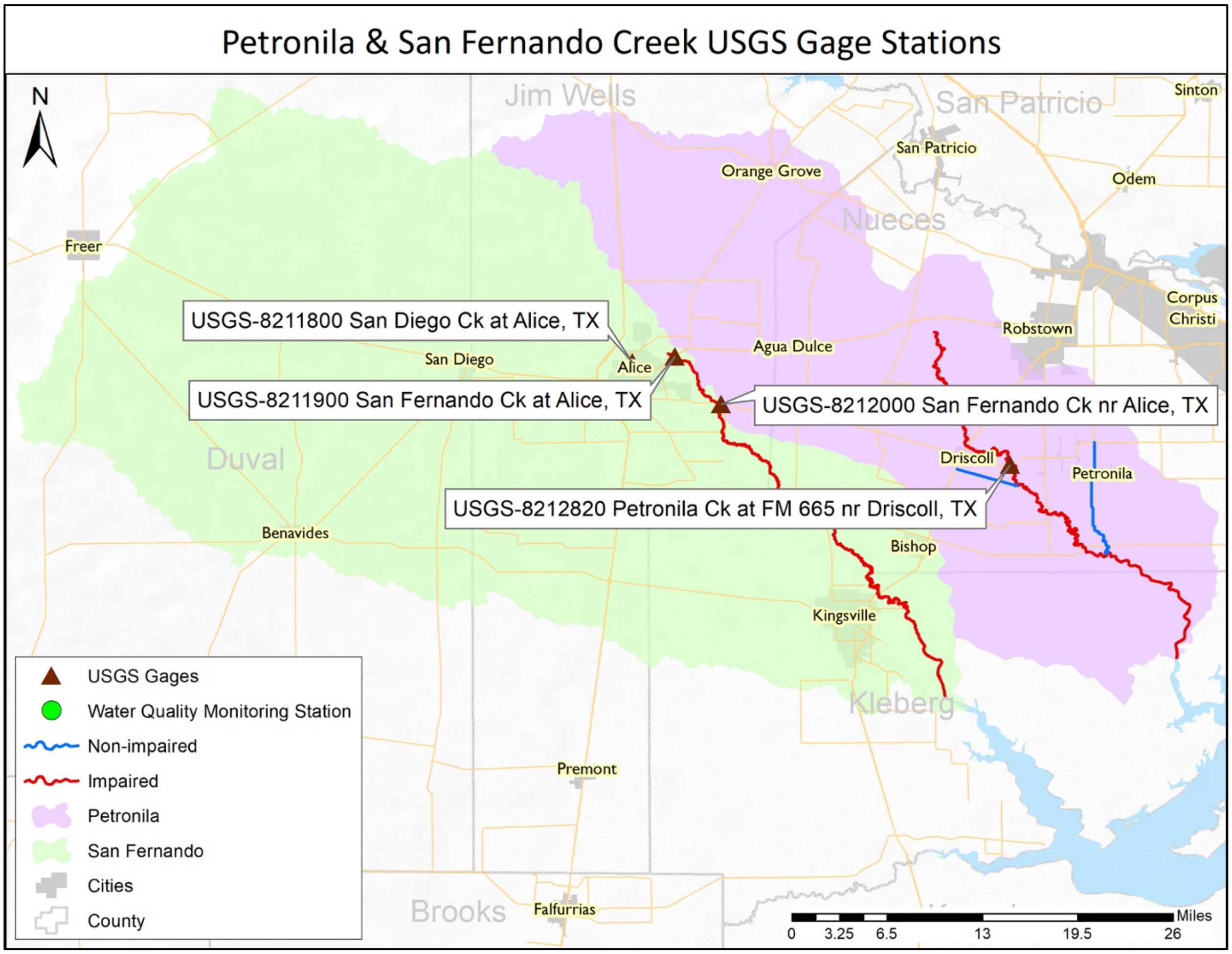


Figure 16. USGS streamflow gages

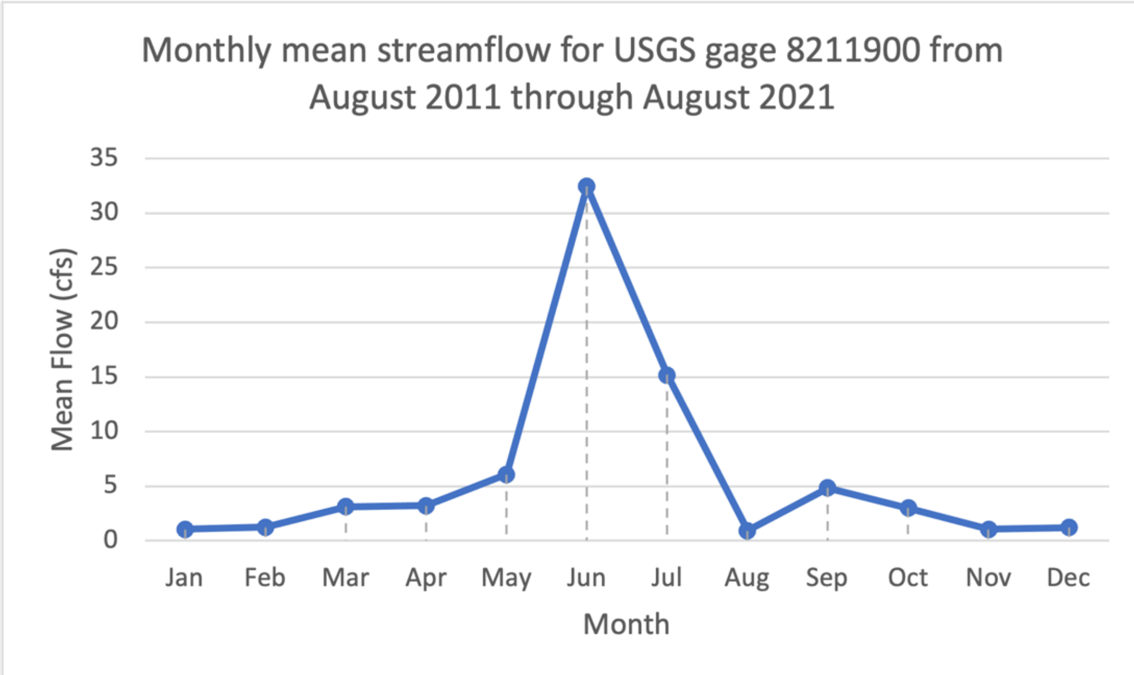


Figure 17. Mean monthly streamflow (cfs), August 2011 through August 2021

Chapter 4 Potential Sources of Pollution

Waterbody impairments in San Fernando and Petronila Creek watersheds are primarily due to excessive fecal indicator bacteria. Potential contributors of bacteria, causes and impacts of other pollutants are summarized below (Table 9). Pollutant sources are categorized as either point or nonpoint source (NPS). Point sources enter receiving waters at identifiable locations, such as a pipe. NPS includes anything that is not a point source and enters the waterbody by runoff moving over and/or through the ground. Potential pollution sources in the watershed were identified through stakeholder input, watershed surveys, project partners and watershed monitoring.

Table 9. Potential pollution source summary.

Pollutant Source	Pollutant Type	Potential Cause	Potential Impact
WWTFs/SSOs	Bacteria, nutrients	Inflows & Infiltrations - Overload from large storm events - Conveyance system failures due to age, illicit connections, blockages, etc.	Untreated wastewater may enter watershed or water bodies.
OSSFs	Bacteria, nutrients	- System not properly designed for site specific conditions - Improper function due to age or lack of maintenance / sludge removal - Illegal discharge of untreated wastewater	Improperly treated wastewater reaches soil surface; may runoff into water bodies.
Urban Runoff	Bacteria, nutrients	Stormwater runoff from lawns, parking lots, dog parks, etc. - Improper application of fertilizers - Improper disposal of pet waste	Stormwater drains quickly route water directly to creek or river
Livestock	Bacteria, nutrients	- Manure transport in runoff - Direct fecal deposition to streams - Excessive runoff from pastures due to over grazing - Riparian area disturbance and degradation	Deposited directly into waterbody or may enter during runoff events
Wildlife	Bacteria, nutrients	- Manure transport in runoff - Direct fecal deposition to streams - Riparian area disturbance and degradation	Deposited directly into waterbody or enters during runoff events
Pets	Bacteria Nutrients	- Fecal matter not properly disposed of - Lack of dog owner education regarding effects of improper disposal	Bacteria and nutrients enter waterbody through runoff
Illegal Dumping	Bacteria, nutrients, litter	Disposal of trash and animal carcasses in or near waterbody	Direct or indirect contamination of waterbody

Sanitary sewer overflow, SSOs; municipal separate stormwater sewer systems, MS4s

Point Source Pollution

Point source pollution is any type of pollution that can be traced back to a single point of origin, such as a WWTF. Generally, WWTF's discharges are permitted, which means they are regulated by permits under the Texas Pollutant Discharge Elimination System (TPDES). Other permitted discharges include industrial or construction site stormwater discharges, and discharges from Municipal Separate Storm Sewer Systems (MS4s) of regulated cities or agencies.

WWTFs

WWTFs treat municipal wastewater before discharging the treated effluent into a waterbody. WWTFs are required to test and report indicator bacteria concentrations and sometimes nutrients as a condition of their discharge permits. Plants that exceed their permitted limits may require infrastructure or process improvements to meet the permitted discharge requirements.

There are currently 15 WWTFs operating in the watershed (Figure 18). Generally, WWTF discharges are well below the permitted bacteria concentration limits. However, periodic exceedance of permitted bacteria and or flow limits as reported through the EPA Environmental Compliance History Online (ECHO) database are documented (Table 10). Annual nutrient loading reports were not available from this source.

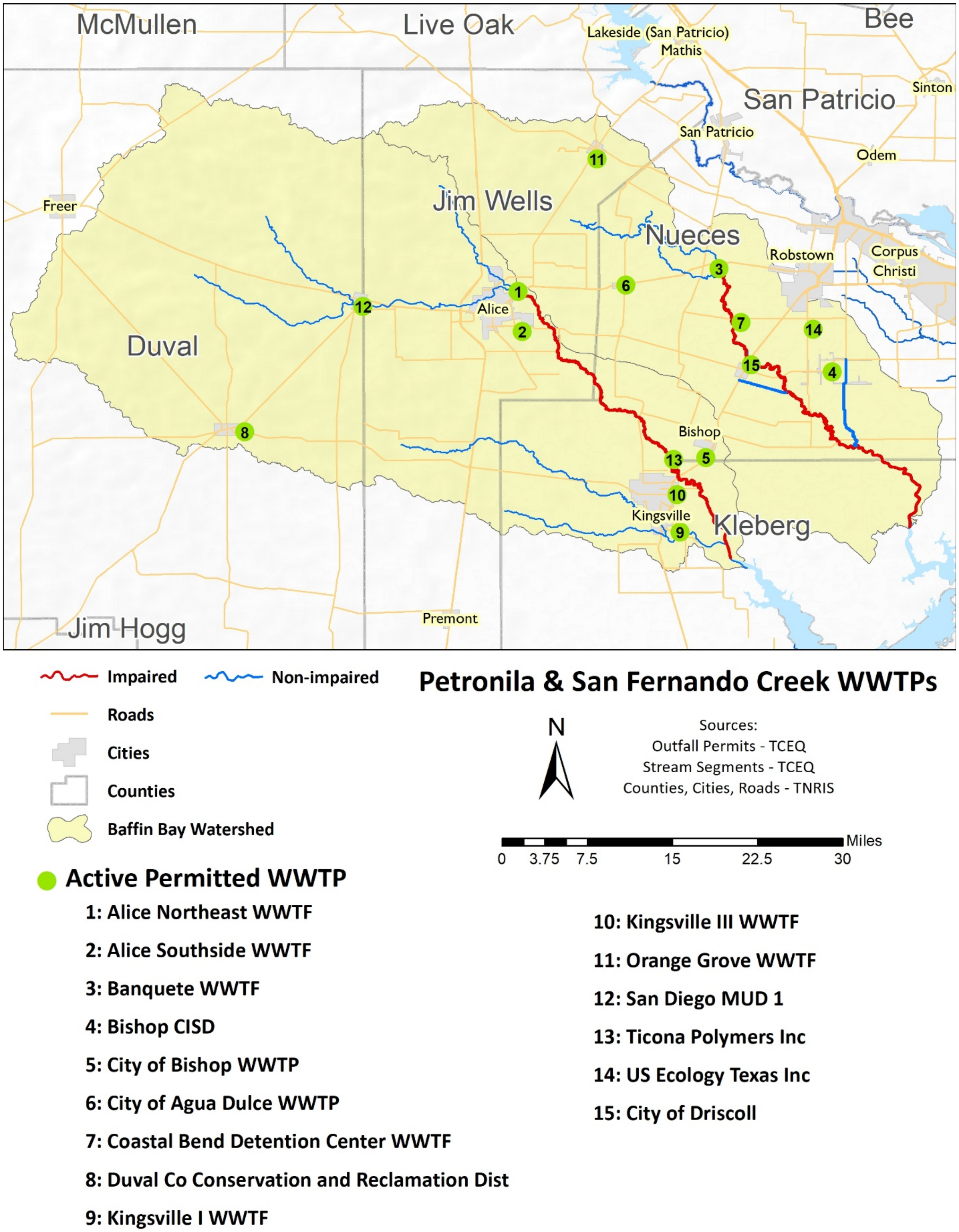


Figure 18. Permitted municipal wastewater treatment facilities

Table 10. Summary of municipal wastewater treatment facilities/plants (WWTFs/WWTPs) permitted discharges and compliance status.

Name	Receiving Waterbody	Design Flow (MGD)	Recent Average Flow (MGD)	Operation Status	Quarters in NC (5 years) (10/17 - 09/20)*
Duval County Conservation and Reclamation District (Benavides WWTP)	San Fernando Creek	0.25	0.25	Active	0 (or no data reported)
Bishop CISD	Petronila Creek	0.008	0.01	Active	0
City of Bishop WWTP	Caretta Creek	0.32	0.17	Active	12 (8 BOD, 9 *E. coli,* 1 Total Ammonia, 4 TSS)
Ticona Polymers Inc	San Fernando Creek	3.5	2.68	Active	10 (2 BOD, 1 Flow, 1 COD, 1 Selenium, 1 Nickel, 2 TSS)
San Diego MUD 1	San Diego Creek	0.75	0.30	Active	12 (Failure to report)
Agua Dulce WWTP	Agua Dulce Creek	0.16	0.11	Active	3 (Missing Measurements)
Banquete WWTF	Banquete Creek	0.1	0.81	Active	11 (1 BOD, 3 *E. coli*, 4 Flow, 5 TSS, 1 Reporting)
Orange Grove WWTF	Leon Creek	0.2	0.15	Active	1 (*E. coli)*
Kingsville III WWTF	Tranquitas Creek	3.0	2.51	Active	7 (3 Copper, 1 Flow, 4 Reporting)
Kingsville I WWTF	Santa Gertrudis Creek	1.0	0.90	Active	7 (1 E. coli, 4 Reporting)
Coastal Bend Detention Center WWTF	Petronila Creek	0.15	0.15	Active	12 (2 Chlorine, 6 Flow, 1 Arsenic, 2 Cadmium, 1 Selenium, 8 Reporting)
US Ecology Texas Inc.	Petronila Creek		0.003	Active	6 (3 Arsenic, 2 pH, 4 Reporting)
Southside WWTF (Alice)	Lattas Creek	2.6	1.75	Active	7 (3 E. coli, 4 Reporting,
Northeast WWTF (Alice)	San Fernando Creek	2.02	0.90	Active	6 (1 BOD, 5 *E. coli*)
City of Driscoll WWTF	Petronila Creek	0.1	0.04	Active	9 (2 BOD, 2 *E. coli*, 1 DO, 6 TSS)

Million gallons per day, MGD; noncompliance, NC; total suspended solids, TSS; biotechnical oxygen demand, BOD *There can be multiple violations for different parameters within a quarter violation period.

Nonpoint Source Pollution

NPS pollution occurs when precipitation flows off the land, roads, buildings and other landscape features and carries pollutants into drainage ditches, lakes, rivers, wetlands, coastal waters and underground water resources. NPS pollution includes but is not limited to water polluted from leaking chemicals or improperly functioning OSSFs, fertilizers, herbicides, pesticides, oil, grease, toxic chemicals, sediment, fecal material, nutrients, and many other substances.

Sanitary Sewer Overflows

Sanitary Sewer Overflows (SSOs) can occur when sewer lines lose or exceed capacities due to age, lack of maintenance, inappropriate connections or overload during storm events. Inflow and infiltration (I&I) are common issues to all sanitary sewer systems. Inflow most often coincides with large runoff events and can occur through uncapped cleanouts and gutter connections to the sewer system or through cross connections with storm sewers and faulty manhole covers. Infiltration happens slowly as it generally occurs through cracks and breaks in lateral lines on private property or sewer mains, bad connections between laterals and sewer mains, and in deteriorated manholes.

These overflows and spills can reach water bodies, resulting in substantial periodic bacteria loading. Permit holders are required to report known SSOs that occur in their system to TCEQ. According to the TCEQ regional office, 19 SSO events were reported in the watershed between January 1, 2016, and December 31, 2018 (Table 11, Table 12). Reported SSO causes vary, though most were the result of lift station or manhole overflows during heavy rain, power failures, or sewer line clogged by materials not recommended for flushing or pouring down drains. Other than self-reported SSO event reports, no compliance or pollutant loading data associated with SSOs are available. Pollutant loads associated with individual events are likely to vary widely depending on the amount and makeup of the discharge.

Table 11. Estimated sanitary sewer overflow receiving volumes

Water Bodies	Total Received Gallons
Santa Gertrudis Creek	7,200
Tranquitas Creek	7,500
No waterbody provided	23,910

Table 12. Reported sanitary sewer overflow events and discharged volumes (January 1, 2016 - December 31, 2018)

Facility	Number of Events	Average gallons / event
Driscoll WWTF	1	1,000
Northeast WWTF (Alice)	2	10
Southside WWTF (Alice)	1	10
City of Kingsville I WWTF	5	1,440
City of Kingsville III WWTF	7	4,214
City of Bishop	1	600
Ticona Polymers Inc	2	15

OSSFs

OSSFs are common in the watershed and may contribute *E. coli*, nutrients, and solids to water bodies if not properly functioning. The number of OSSFs, their locations, ages, types, and functional statuses in the watershed are unavailable, making it difficult to determine actual water quality impacts. To estimate OSSF numbers and approximate locations, an approach using 911 address points, 2010 Census data, and recent satellite imagery was used (Gregory et al. 2013). This method associates 911 addresses with household structures by reviewing satellite imagery then cross referencing OSSF count estimates with 2010 Census household data. Addresses located outside of WWTF service areas are presumed to use OSSFs. This method of locating potential OSSF sites was used given the lack of actual OSSF locations from regional databases. This method produced an estimate of 9,086 OSSFs within the watershed; of these, 25 OSSFs are within 100 yards (yds) of water bodies. OSSFs densities are highest in suburban areas just outside of wastewater service boundaries (Figure 19).

OSSF density can affect overall treatment performance. If the systems installed are not appropriately designed, the soil's treatment capacity may be exceeded and lead to widespread OSSF failure. Several areas, especially the central and northern areas of the watershed, have higher OSSF densities than the surrounding areas and therefore may increase OSSF failure risk and subsequent water quality effects. Proximity to streams is important for determining OSSFs' potential impact on water quality. The closer a potentially failing system is to a stream, the more likely it is to impact instream water quality.

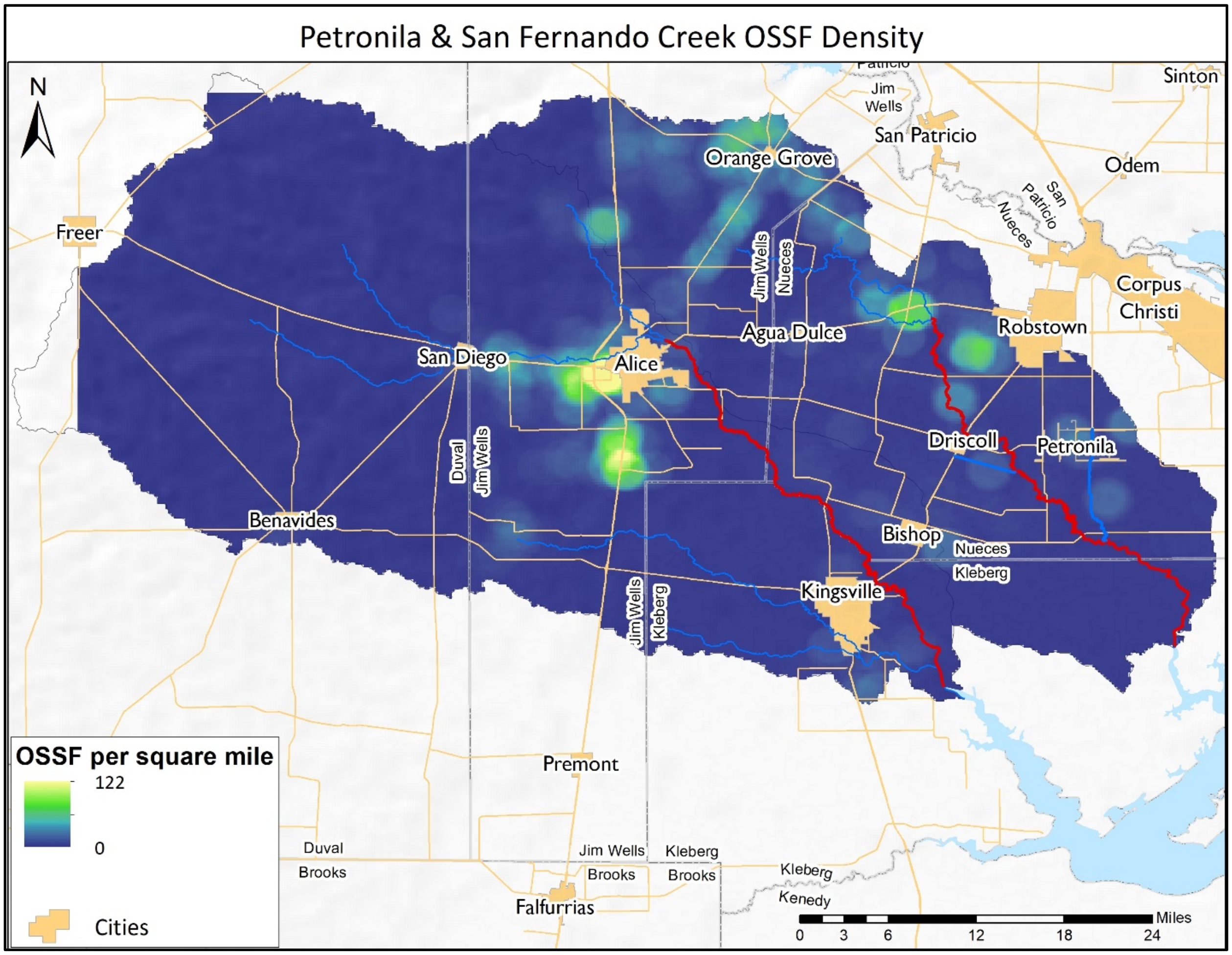


Figure 19. OSSF density

Typical OSSF designs include either (1) anaerobic systems composed of septic tank(s) and an associated drainage or distribution field, or (2) aerobic systems with aerated holding tanks and typically an above ground sprinkler system to distribute the effluent. Many factors affect OSSF performance, such as systems failure due to age, improper system design for specific site conditions, improper function from lack of maintenance / sludge removal, and illegal discharge of untreated wastewater. Adsorption field soil properties affect the final treatment effectiveness of all OSSFs. Soil suitability rankings developed by the Natural Resources Conservation Service (NRCS) to evaluate the soil's ability to treat wastewater based on soil characteristics such as topography, saturated hydraulic conductivity, depth to the water table, ponding, flooding effects and more (NRCS 2015). Soil suitability ratings are divided into three categories: not limited, somewhat limited, and very limited. Soil suitability dictates the type of OSSFs required to properly treat wastewater. If not properly designed, installed or maintained, OSSFs in somewhat or very limited soils pose an increased risk of failure. Approximately 76% of the soils are considered very limited in the San Fernando and Petronila Creek watersheds (Figure 20).

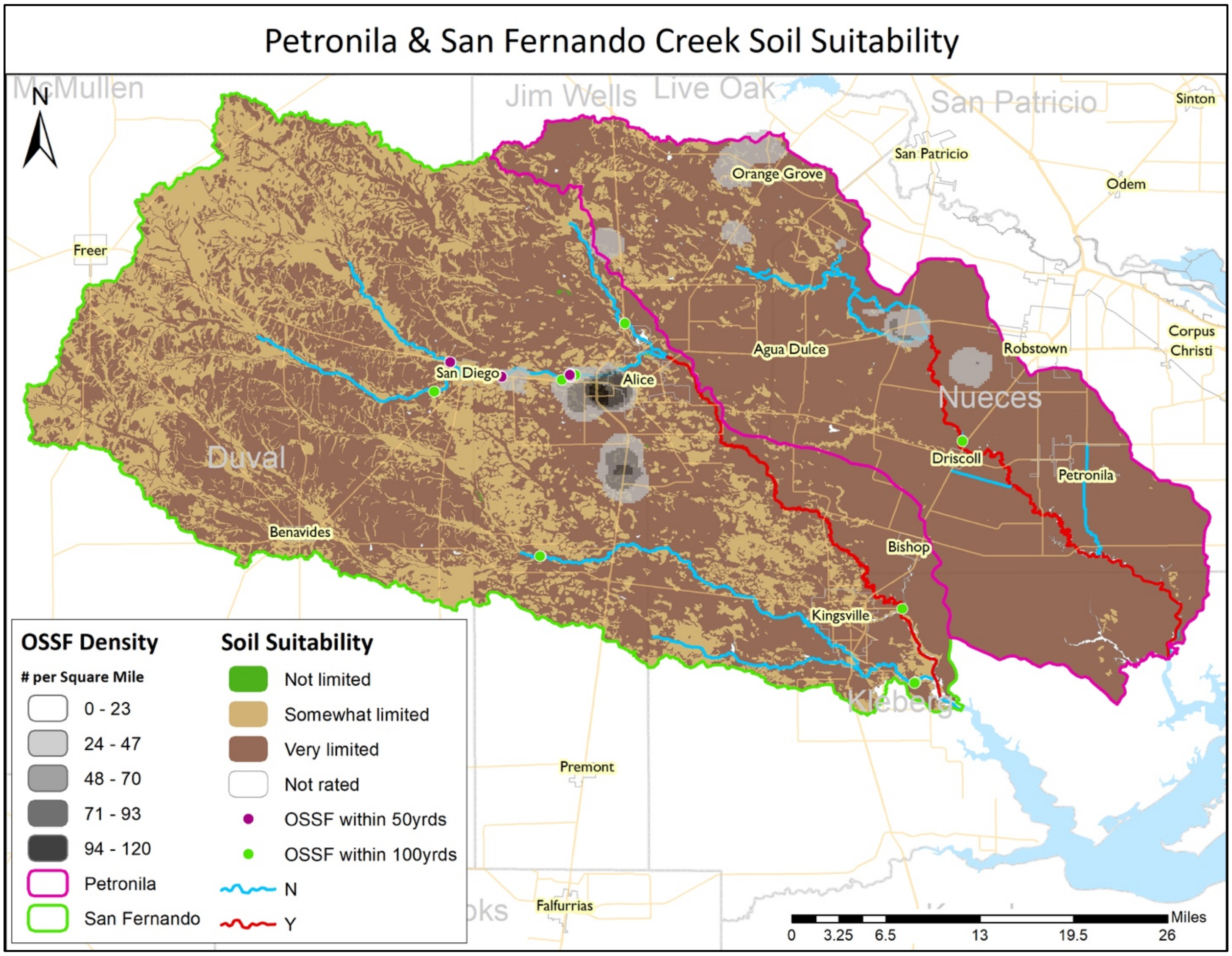


Figure 20. Soil suitability and OSSF density

Urban Runoff

Two primary pollutants in urban runoff are bacteria and nutrients which come from improper application of fertilizers and improper disposal of pet waste. Stormwater runoff from lawns, parking lots, and dog parks will wash fertilizers and waste into water bodies. Runoff from urban areas increases as population centers expand impermeable surface coverage in the watershed. Housing developments, shopping centers, and industrial and/or business parks are development examples of urban expansion that increases impermeability within the watershed. Increased runoff from unmanaged urban development can affect water quality by accelerating creek erosion and habitat loss and by carrying more NPS pollutants like bacteria, nutrients, metals and hydrocarbons into surrounding water bodies.

Livestock

Livestock grazing – predominately cattle, and to a lesser extent, goats, horses, and sheep – occurs throughout the watershed. These animals serve as a potential source of NPS pollution as they graze the landscape. Livestock deposit urine and fecal matter where they are allowed to graze and directly into accessible water bodies. Fecal matter deposited on the landscape can be transported to adjacent creeks during runoff events, which may contribute to increased bacteria loading in the waterbody.

Quantifying exact livestock populations in the watershed is impossible due to birth, death, purchase, sale and transport; however, county-level population estimates are available from the National Agricultural Statistics Service (NASS) that help estimate total livestock within the watershed. Recommended livestock stocking rates available from the USDA Farm Service Agency can also be used to generate these estimates. Comparing the results from both approaches, projected cattle populations were nearly identical when applying stakeholder confirmed average local stocking rates to improved pastures and rangeland identified in the NLCD data (Table 13). Estimates for other livestock were derived from NASS county statistics applied to pasture and rangeland land use types.

Table 13. Estimated livestock populations.

County	Livestock in Watershed				
	Cattle	Hog	Horse	Goat	Sheep
Duval	5,295	104	68	227	148
Jim Wells	22,012	130	643	1,670	338
Kleberg	6,252	63	112	295	103
Nueces	4,655	148	325	275	168
Total	38,214	445	1,148	2,467	757

Wildlife

E. coli and nutrient loads are also contributed to the watershed by wildlife. Riparian areas provide ideal habitat for wildlife which leads to their congregation in these areas. Time spent in each area is directly related to the amount of fecal deposition for each animal. Therefore, wildlife feces can be a major source of pollution in the watershed and in close proximity to the creek. Wildlife population density estimates are not available for most wildlife species making it impossible to quantify a total potential wildlife load.

White-tailed deer and feral hogs are two species that density estimates are available for, but they do not constitute the total wildlife population. The Texas Parks and Wildlife Department (TPWD) conducts annual deer population surveys at the deer management unit (DMU) level. DMUs are landscapes indexed by similar ecological characteristics within a defined area. The San Fernando and Petronila Creek watersheds are situated within two DMUs: DMU 8 East and DMU 9, both of which are considered South Texas Plains ecoregions. For this project, the most recent 5 years of density estimates were averaged and applied to appropriate land uses. The density average for DMU 8 East is 61.7 ac/deer and DMU 9 is 26.1 ac/deer. Stakeholders provided feedback regarding deer density on areas with heavy crop production in the watershed and it was agreed upon to apply only 10% of the average density in these areas due to the lack of available cover nearby. Using this combination of information, deer densities were applied to all LULC classes in the watershed except for open water, baren land, and developed land yielding an estimate of 17,593 deer in the watershed ().

Feral hogs are a non-native, invasive species rapidly expanding throughout Texas and inhabiting similar land use types as white-tailed deer. They are especially fond of places where there is dense cover with food and water readily available. Riparian corridors are prime habitat for feral hogs; therefore, they spend much of their time wallowing in or near the creek. This preference for riparian areas does not preclude their use of non-riparian areas. Reclusive by nature, feral hogs are a predominantly nocturnal species. They typically remain in thick cover during the day and venture away from cover at night into cropland, pastures, or rangeland. Feral hogs are significant contributors of pollutants to creeks and rivers across the state through direct and indirect fecal loading. Extensive rooting and wallowing in riparian areas also causes erosion and soil loss. Statewide feral hog density estimates have ranged from roughly 30 ac/hog to 72 ac/hog (Wagner and Moench, 2009; Timmons et al., 2012). Considering these estimates and stakeholder input, a feral hog density of 39 ac/hog was applied to all land uses except barren, developed, and open water. Stakeholders provided feedback regarding feral hog density in cropland dominated portions of the watershed and agreed to apply only 10% of the average density in these areas due to the lack of available cover nearby. Using this combination of information, an estimated 23,759 feral hogs are in the watershed ().

Table 14. Estimated wildlife populations

Watershed	Wildlife in Watershed	
	Feral Hogs	Deer
Petronila Creek	3,933	4,071
San Fernando Creek	17,826	13,522
Total	23,759	17,593

Other Wildlife

Many other species of wild animals call the watershed home including a variety of birds and mammals that can contribute significantly to bacteria loading in the watershed. The lack of information regarding population estimates for these animals and their fecal production rates prevent their impacts from being quantified. Additionally, reducing bacteria loading resulting from certain wild animal populations is impossible due to wildlife management and preservation laws. We acknowledge that bacteria from wildlife not specifically identified here contribute to bacteria in the creeks, but their impacts are not assessed and no management recommendations to address these sources are included.

Pets

Dogs and cats can contribute to fecal bacteria and nutrient loading in water bodies when waste is carried by runoff from lawns, parks, and other surfaces. Bacteria loading from pets can be reduced if pet owners properly dispose of waste in the garbage. According to the American Veterinary Medical Association (AVMA), the average household in the U.S. is home to 0.614 dogs and 0.457 cats (AVMA, 2018). We estimated the number of pets in the watershed by multiplying the average pets per household by the number of households represented in the U.S. Census block data. There are an estimated 20,382 dogs and 15,171 cats in the watershed (Table 15). Cats routinely bury their excrement, or it is disposed of in the trash by owners cleaning litter boxes, thus their potential influence on water quality is considered meager compared to dogs.

Table 15. Estimated household pet population

County	Households*	Cat	Dog
Petronila Creek	6,311	2,884	3,875
San Fernando Creek	26,885	12,286	16,507
Total	33,196	15,171	20,382

*Households from 2010 Census block data. Dog and cat estimations use the average number of pets owned per household provided by the American Veterinary Medical Association: *2017-2018 U.S. Pet Ownership Demographics Sourcebook.*

Illegal Dumping

Watershed stakeholders identified illegal dumping as a considerable problem across the watershed. While most items dumped are not considered major bacteria or nutrients sources, trash accumulation leads to additional dumping. Items dumped including animal carcasses and household waste do contain bacteria while, other discarded trash such as electronic or automotive waste contain harmful chemicals, metals and more. Improper waste disposal is bad for the environment and local stakeholders strongly desire to address this pollution source.

Nutrient Sources

Nutrient loading to area waterbodies has been identified as a significant water quality concern in the creeks and Baffin Bay. Nutrients come from various sources including nonpoint (animal waste, fertilizers, OSSFs, natural) and point sources (domestic and industrial wastewater). Regardless of source, nutrient loading can cause excess aquatic plant growth which may lead to waterbody eutrophication and fish kills. Chlorophyll-a is a measure of phytoplankton abundance in water and is a surrogate indicator for nutrient impacts in a waterbody.

A nonpoint nutrient source modeling exercise completed in 2019 evaluated nitrogen and phosphorus loading estimates across the watersheds (Parsons, 2019). This assessment applied the Spreadsheet Tool for Estimating Pollutant Loading (STEPL) which considers land use, soil properties, households with septic tanks, and livestock populations. STEPL estimates erosion rates and runoff generation as well in this assessment. Literature values and available population information are primary data inputs for this model. In Petronila Creek, cropland was modeled to contribute 94% and 97% of nitrogen and phosphorus, respectively, while in San Fernando Creek, cropland was estimated to contribute 56% and 78%, respectively. The report did acknowledge that modeled results should not be considered as a comprehensive assessment since wastewater, wildlife, feral hogs, and confined animal feeding operations were not considered.

Other Baffin Bay Pollutant Sources

In addition to the pollutant sources described specifically for San Fernando and Petronila Creek, Baffin Bay is also influenced by pollutant contributions on adjacent lands that drain directly to the bay and by inputs from the Los Olmos Creek watershed. Around the bay, these influences include animal contributions from livestock, pets and wildlife, and OSSFs. There are many homes on the western shore of Baffin Bay that rely on OSSFs to treat waste. If these systems fail, they can potentially have significant influences on nearby water quality. Plans for additional housing developments adjacent to the bay also pose a future threat to decline water quality and have adverse aquatic/human health impacts. Thorough consideration should be given to fostering partnerships between stakeholders and land developers to guide future development to less ecologically sensitive areas or to encourage low impact development practices.

Chapter 5 Pollutant Source Assessment

Introduction

Multiple approaches were used to assess watershed pollutant loadings and provide a more complete evaluation their sources and impacts on water quality. Each approach provides a piece of information used to define and address specific pollutant sources. No single method provides a perfect result or a definitive answer as each method analyzes data differently. Methods used included water quality data analysis, LDCs and spatial analysis of potential *E. coli* sources.

Water Quality Monitoring

The *2020 Texas Integrated Report* identified AUs 2203_01, 2204_01, 2204_02, and 2492A_01 as impaired due to elevated bacteria concentrations and reveals concerns for elevated chlorophyll-a levels. Additionally, AU 2492A_01 has elevated levels of nitrates and total phosphorous. San Fernando and Petronila Creeks are routinely monitored by the Nueces River Authority (NRA), the TCEQ Regional Office, and less frequently through special projects and studies conducted by organizations within or near the watershed. Historically, measured data from these entities have indicated the similar concerns for bacteria and nutrient concentrations across the watershed.

E. coli and Enterococcus Data Assessment

Routinely collected data from five stations in the San Fernando and Petronila Creek watershed demonstrate that the creeks are hydrologically dynamic and that *E. coli* and enterococcus loading is spatially and temporally variable. Streamflow volume strongly influences measured bacteria concentrations. Monitoring sites with sustained flow for much of the year tend to have lower geometric means under routine conditions. Monitoring stations upstream in the watershed tend to experience drier conditions more frequently. Stormwater runoff dominates flow at these stations which commonly yields higher *E. coli* concentrations than downstream stations.

Bacteria concentrations across the watershed exhibit a wide range of measured values (Figure 21, Table 16). In the freshwater portions of San Fernando and Petronila Creek, *E. coli* is commonly found above the water quality standard except for station 20806. In the tidal segment of Petronila Creek, enterococcus concentrations measured at station 13090 are also above the applicable water quality standard (Figure 21, Table 16).

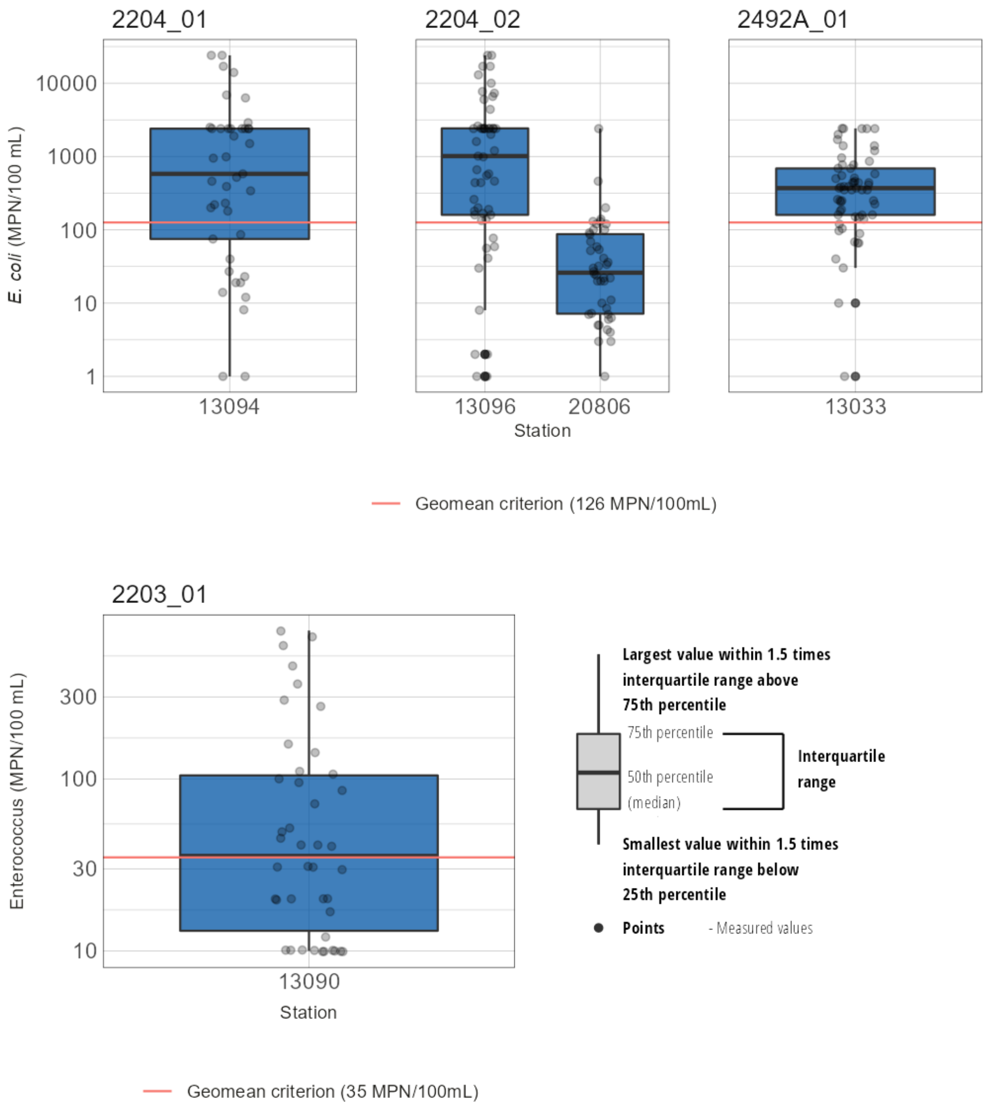


Figure 21. *E. coli* and enterococcus concentration measurements taken between 2000 and 2021

Table 16. *E. coli* and Enterococcus summary (2001 through 2021)

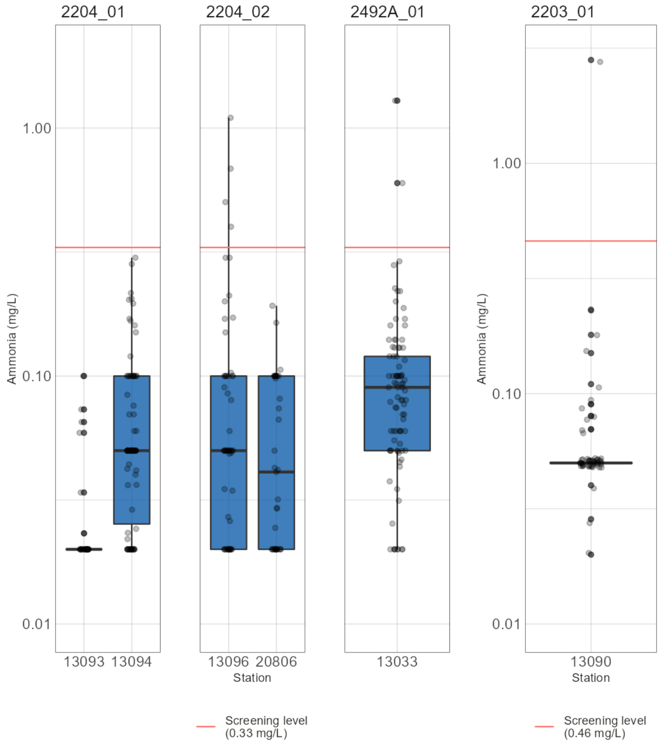
Station	AUs	Samples	Waterbody	Minimum (MPN/100 mL)	Maximum (MPN/100 mL)	Geometric Mean (MPN/100 mL)
13033	2492A_01	57	San Fernando	1	2,400	**303.6****
13090*	2203_01	42	Petronila Tidal	10	730	**44.9**
13094	2204_01	42	Petronila	1	24,000	**419.4**
21598		1	Petronila	-	-	-
13096	2204_02	53	Petronila	1	2,420	**592.5**
20806		40	Petronila	1	2,400	28.8

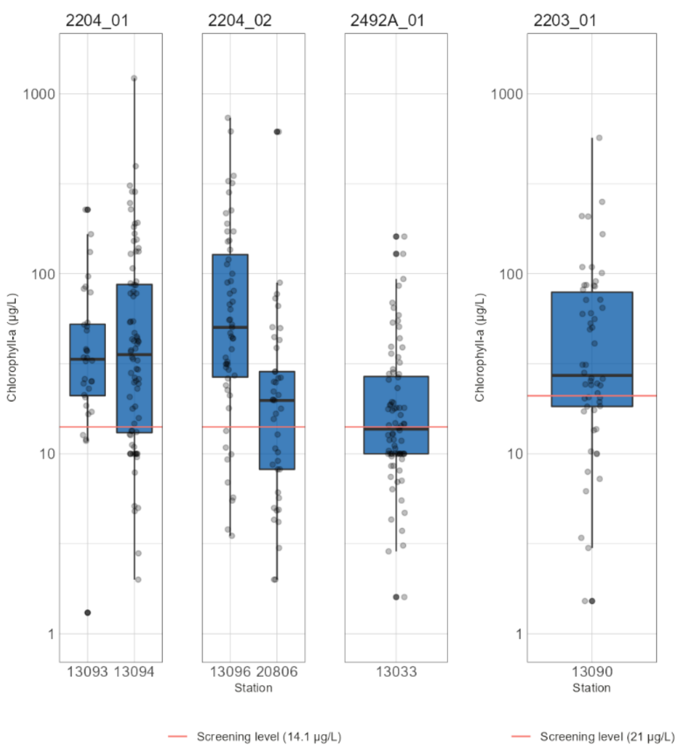
*The Enterococcus standard of 35 MPN/100 mL applies at this station

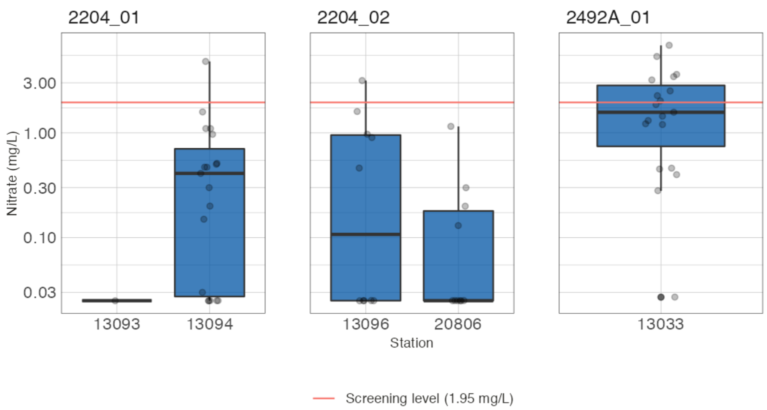
**Bolded cells indicate bacteria standard exceedances

Nutrients

Nutrient concentrations in all AUs in the watershed are typically below state screening criteria (Figure 22 and Table 17); however, all AUs have higher chlorophyll-a concentrations than the screening level. Chlorophyll-a is an indicator of excess nutrient loading in a waterbody. These data seem to contradict each other; however, organic forms of nutrients not measured in current sampling also influence Chlorophyll-a concentrations. Recent data analysis and comparison of organic and inorganic nutrient concentrations in Baffin Bay suggest that elevated organic nutrient concentrations are higher than in other Texas bay complexes and are the driver of elevated Chlorophyll-a concentrations and harmful algal blooms (Wetz et al., 2017).


2204_01
2204_02
2492A_01
2203_01
Ammonia (mg/L)
1.00
0.10
0.01
13093 13094
13096 20806
13033
13090
Station
Screening level (0.33 mg/L)
Screening level (0.46 mg/L)


2204_01
2204_02
2492A_01
2203_01
Chlorophyll-a (µg/L)
1000
100
10
1
13093 13094
13096 20806
13033
13090
Station
Screening level (14.1 µg/L)
Screening level (21 µg/L)



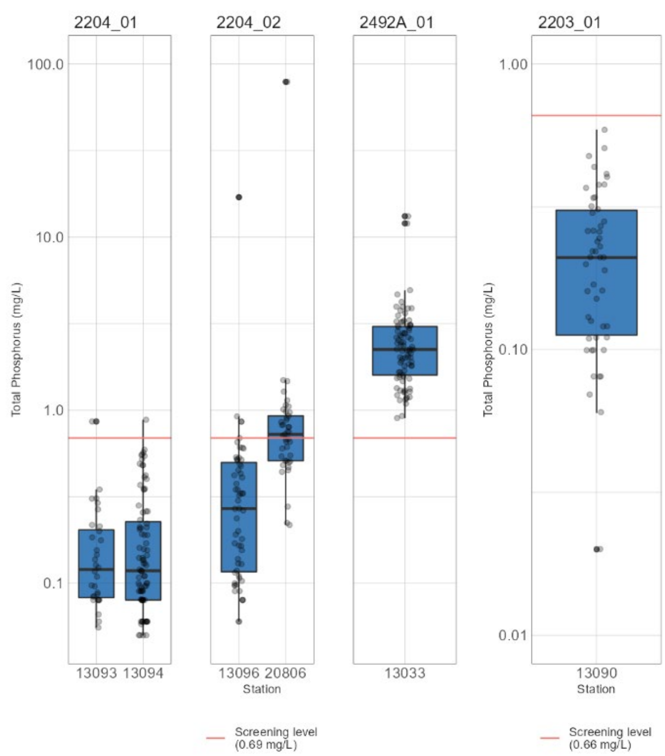


Figure 22. Boxplots of Ammonia, Chlorophyll-a, Nitrate, and Total Phosphorous at stations with more than five measurement values from 2001 - 2021

Table 17. Nutrient summary statistics

Station ID	AU	Waterbody	Mean Nitrate (mg/L)	Mean Ammonia (mg/L)	Mean Chlorophyll-a (µg/L)	Mean Total Phosphorus (mg/L)
13033	2492A_01	San Fernando Creek	**2.08***	0.11	**23.48**	**2.56**
13090	2203_01	Petronila Creek Tidal	0.5	0.11	**61.9**	0.23
13094	2204_01	Petronila Creek Above Tidal	0.67	0.07	**82.19**	0.19
21598			No data	No data	No data	No data
13096	2204_02		0.72	0.11	**131.07**	0.6
20806			0.19	0.06	**38.3**	**2.65**

*Bold values exceed respective screening levels

Load Duration Curve Analysis

The relationship between flow and pollutant concentration in the watershed was established using LDCs. This approach allows existing pollutant loads to be calculated and compared to allowable loads. It is the basis for estimating needed pollutant load reductions to achieve the established water quality goal. LDCs can also help determine whether point or nonpoint pollutant sources primarily cause stream impairments by identifying flow conditions when impairments occur. Although LDCs cannot identify specific pollutant sources (urban vs. agricultural, etc.), they can identify the likely pollutant type (point vs. nonpoint). For example, if allowable load exceedances primarily occur during high flow or mid-range flow categories, NPS is a primary contributor. If exceedances occur during low flow conditions, then point sources are the most likely source. Instream disturbances, such as those caused by increased flow velocity (release from a dam) or physical agitation (animal walks in stream), are also known to cause *E. coli* increases under all flow conditions.

For planning purposes, bacteria LDCs were completed at two monitoring sites in the San Fernando and Petronila Creek watersheds (Stations 13033 and 13096, respectively) due to the amount of available *E. coli* data collected from 1990 to 2021 (Figure 11). Load distributions across flow regimes and needed load reductions at these stations were considered representative of their respective watersheds. Although these monitoring stations are not located at the watershed outlet, each does have the most robust data record available and is representative of conditions across each watershed. Nutrient LDCs were not developed since nutrient standards have not been established for Texas. Despite the lack of nutrient water quality standards and focused efforts to address loading to the stream, the practices aimed at reducing bacteria loads will also yield nutrient load reductions when implemented in the watershed.

Flow records at both sites were limited and not representative of the full flow regime. To account for the broad range of flows in these systems, the drainage-area ratio (DAR) method (Asquith et al. 2006) was used to extend representative USGS flow gage data to the monitored locations. For both stations, the USGS gage near Alice (08211900) was used to approximate flows. Daily average streamflow from the previous 22 years were available for this assessment and were paired with *E. coli* concentrations collected at know flow rates. DAR is used to equate the ratio of streamflow of an unknown stream location to that of a nearby drainage area with enough data. This method was reviewed jointly by the USGS and TCEQ using 7.8 million values of daily streamflow data from 712 USGS streamflow gauges in Texas and was found to be a sufficient method in interpolating streamflow measurements.

Station 13033

Station 13033 is located on San Fernando Creek north of Kingsville at the US 77 road crossing. Quarterly grab sampling and instantaneous flow measurements are conducted by NRA at this location. The LDC for this station indicates that *E. coli* loads generally exceed allowable amounts under all flow conditions (Figure 23). This suggests that a combination of point and NPS *E. coli* sources are influencing instream water quality.

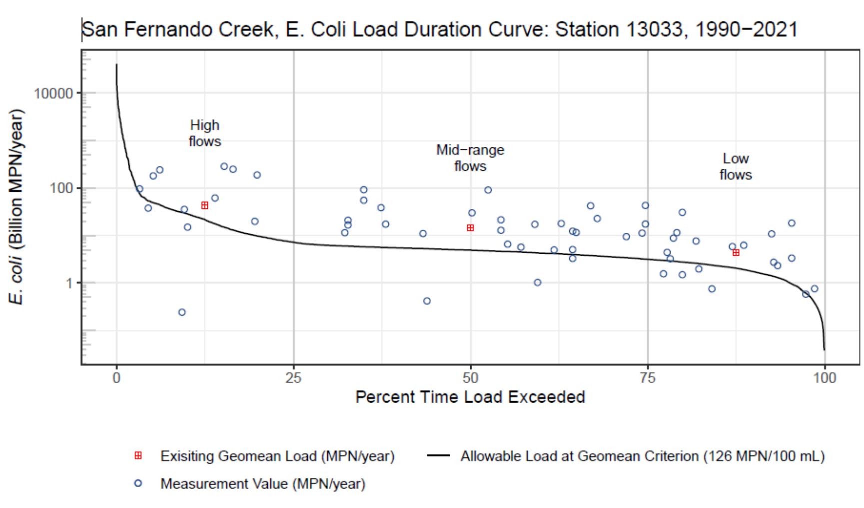


Figure 23. San Fernando Creek station 13033 *E. coli* LDC

Station 13096

Station 13096 is located on Petronila Creek at FM 665 east of Driscoll. Quarterly grab sampling and instantaneous flow measurements are conducted by NRA at this location. The LDC for this station indicates that *E. coli* loads generally exceed allowable amounts under all flow conditions (Figure 24). This suggests that a combination of point and NPS *E. coli* sources are influencing instream water quality.

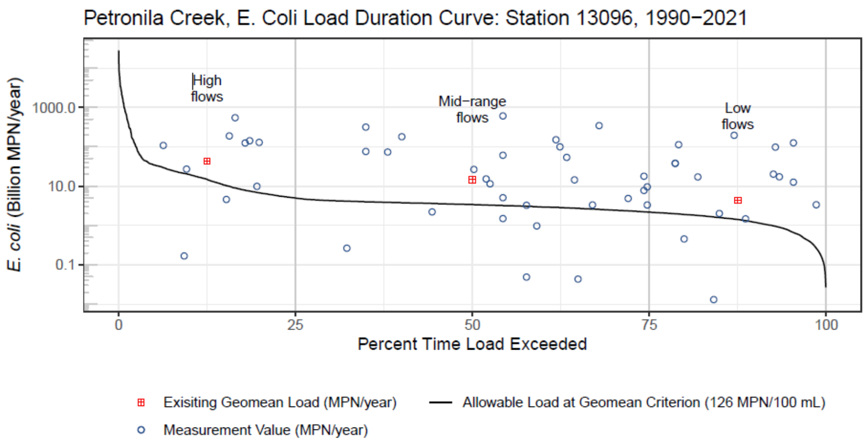


Figure 24. Petronila Creek station 13096 *E. coli* LDC

Annualized Reductions

Based on LDC analysis, both San Fernando and Petronila Creek exhibit bacteria load exceedances under all flow conditions. Estimated annual load reductions needed to meet water quality standards were developed based on LDCs for station 13033 and 13096 for San Fernando and Petronila Creeks, respectively (Tables 18 & 19). These needed load reduction estimates will serve as numeric targets for recommending management activity across the watersheds to reduce bacteria loading and improve instream water quality.

Table 18. Estimated *E. coli* load reductions needed to meet primary contact water quality criteria in San Fernando Creek (based on the 126 cfu per 100 milliliters of water standard)

San Fernando Creek	Flow Condition		
Station: 13033	Lowest Flows	Mid-Range Flows	Highest Flows
Days per year	91.25	182.5	91.25
Median Flow (cfs)	0.673	1.595	7.033
Existing Geomean Concentration (MPN/100 mL)	265.647	376.154	252.875
Allowable Daily Load (Billion MPN)	2.075	4.917	21.68
Allowable Annual Load (Billion MPN)	189.311	897.33	1,978.35
Existing Daily Load (Billion MPN)	4.374	14.678	43.511
Existing Annual Load (Billion MPN)	399.13	2,678.84	3,970.33
Annual Load Reduction Needed (Billion MPN)	209.82	1,781.51	1,992.08
Percent Reduction Needed	52.57%	66.50%	50.17%
Total Annual Load (Billion MPN)	7,048.39		
Total Annual Load Reduction (Billion MPN)	3,983.41		
Total Percent Reduction	56.52%		

Table 19. Estimated *E. coli* load reductions needed to meet primary contact water quality criteria in Petronila Creek (based on the 126 cfu per 100 milliliters of water standard)

Petronila Creek	Flow Condition		
Station: 13096	Lowest Flows	Mid-Range Flows	Highest Flows
Days per year	91.25	182.5	91.25
Median Flow (cfs)	0.463	1.097	4.838
Existing Geomean Concentration (MPN/100 mL)	1103.478	480.515	419.054
Allowable Daily Load (Billion MPN)	1.427	3.382	14.914
Allowable Annual Load (Billion MPN)	130.239	617.16	1,360.90
Existing Daily Load (Billion MPN)	12.499	12.897	49.601
Existing Annual Load (Billion MPN)	1,140.61	2,353.61	4,526.12
Annual Load Reduction Needed (Billion MPN)	1,010.37	1,736.45	3,165.22
Percent Reduction Needed	88.58%	73.78%	69.93%
Total Annual Load (Billion MPN)	8,020.34		
Total Annual Load Reduction (Billion MPN)	5,912.04		
Total Percent Reduction	73.71%		

Spatial Analysis of Potential *E. coli* Loading

The distribution of potential pollutant loadings across the watersheds were evaluated using a Geographic Information System (GIS)-based approach similar to the Spatially Explicit Load Enrichment Calculation Tool (SELECT) (Teague et al., 2009) methodology. By estimating relative potential contributions of different fecal bacteria sources across the watershed, critical source areas (CSA) can be prioritized for management measures. Publicly available information described in previous sections discussing pollutant sources, land use/land cover and soils data, combined with stakeholder feedback was used to identify probable sources of bacteria and to estimate potential loading across the watershed.

To facilitate this assessment, the watersheds were subdivided into smaller subbasins using 12-digit hydrologic unit codes (HUCs). HUCs are defined by USGS according to hydrological features, and are generally of similar size. In this WPP, the HUCs are referred to as subbasins and are given a numeric ID number. San Fernando Creek watershed includes subbasins 1 – 34 and Petronila Creek watershed includes subbasins 35 – 51 (Figure 25). Subbasin IDs are used to identify CSAs and management recommendation priorities later in the WPP.

Bacteria loading estimates are presented on color coded maps to allow easy comparison of potential loading between subbasins and to facilitate BMP implementation prioritization (Figures 25; 26; 27; 28, 29; 30; 31). Loading estimates presented are potential loading estimates that do not consider naturally occurring bacteria fate and transport processes in the environment. Therefore, this analysis presents a worst-case bacteria loading scenario in the watershed and does not represent actual bacteria loading to area waterbodies.

Deer

White-tailed deer are the only true wildlife species in the watershed with reasonable population estimates and fecal bacteria contributions available. Other wildlife and exotic species are present in the watershed, but their distribution and numbers are not known. White-tailed deer prefer habitats with ample food and cover, but they are adaptable animals known to feed on crops and vegetation around homesteads. Based on white-tailed deer density estimates, the San Fernando Creek watershed was found to contain the most deer in the area. When runoff occurs across the watershed, fecal matter deposited on the landscape can be transported to nearby waterways. Subbasins 6, 8, 21, 27, 29, 30 and 32 were identified as having the highest potential deer *E. coli* loading (Figure 25). In the Petronila Creek watershed, subbasins 35, 37, 38, and 50 have the highest potential *E. coli* load from deer (Figure 25).

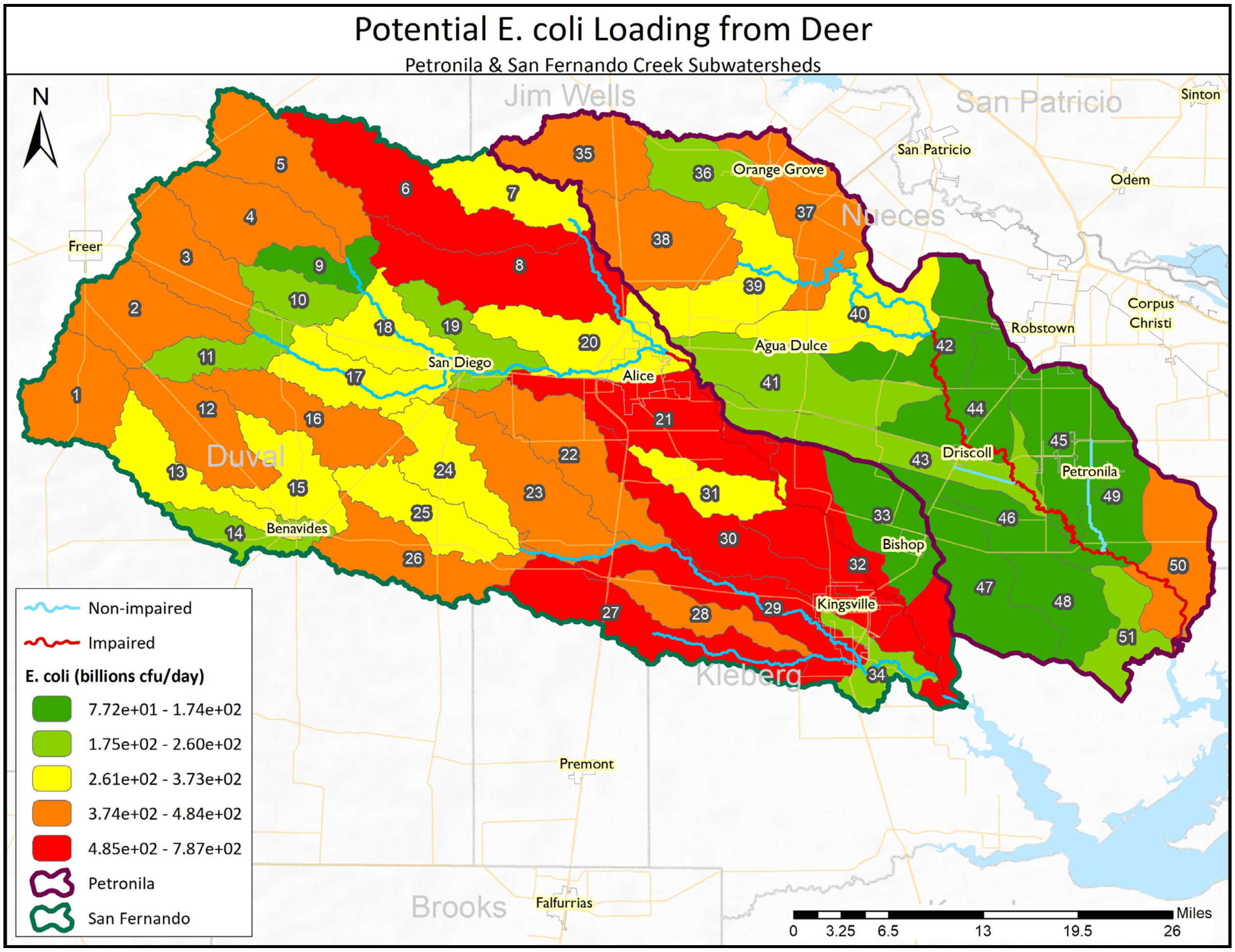


Figure 25. Estimated potential *E. coli* loads from deer

Domestic Pets

Dogs and cats can contribute significant quantities of *E. coli* to a watershed if their waste is not properly disposed of and allowed to remain on the landscape. Picking up after dogs and disposing of cat litter boxes in municipal solid waste effectively removes this source from a watershed. However, a considerable amount of pet waste, especially dogs, is left in yards or near homesteads in rural areas and can enter waterways during runoff events. Since dogs and cats are most often associated with people, the highest potential *E. coli* loading areas are near population centers in the watershed. In the San Fernando Creek watershed, subbasins with the largest potential loading from pets are 20, 21, and 30 followed closely by 19 and 34 (Figure 26). The human population in the Petronila Creek watershed is much lower, thus the number of pets is also lower. Within the watershed, subbasins 37 and 40 have the highest potential *E. coli* loading from pets (Figure 26).

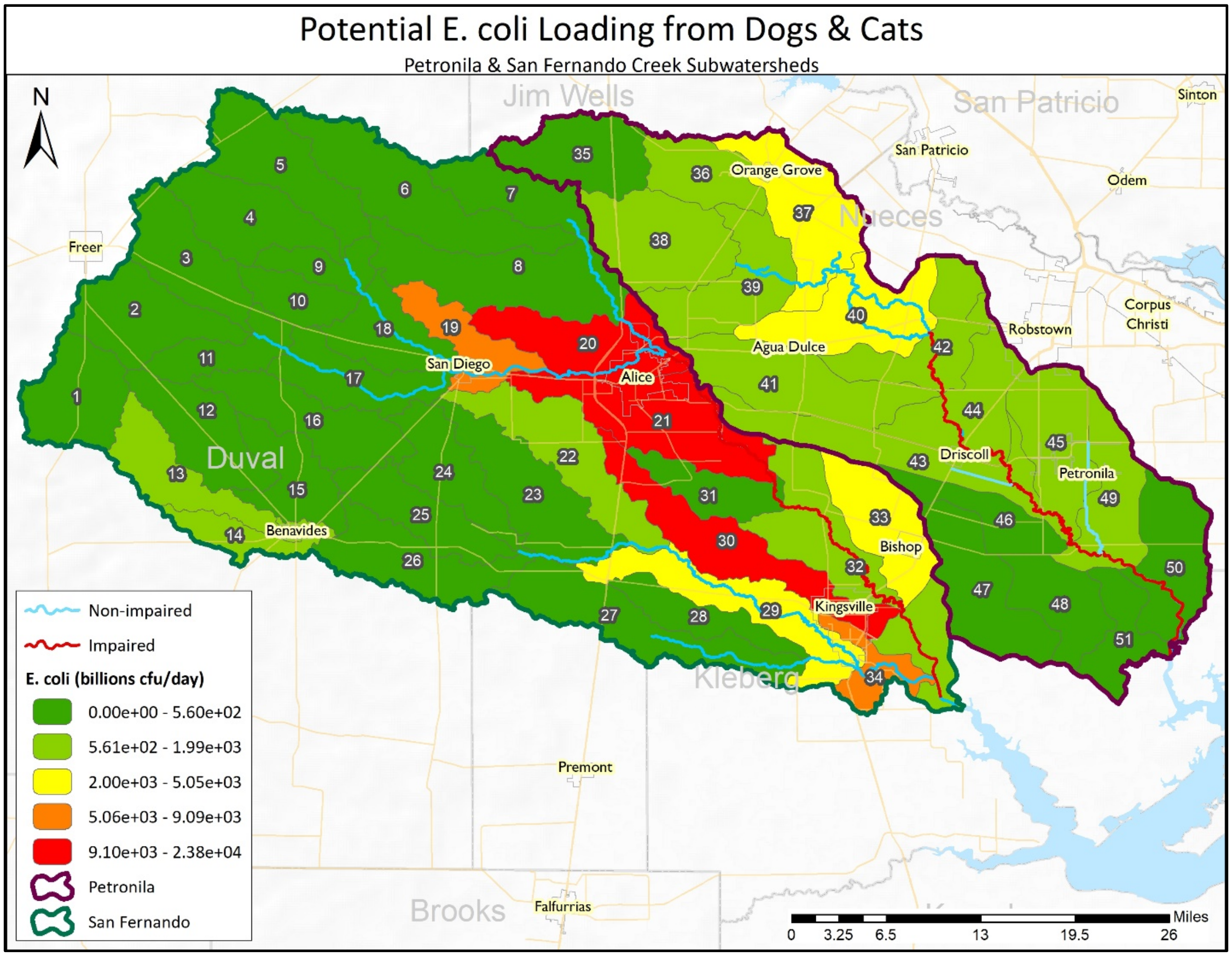


Figure 26. Estimated potential *E. coli* loads from dogs and cats

Feral Hogs

Feral hog population estimates in Texas range from 1 to 3 million individuals (Mayer 2009; Mapston 2010). Feral hogs contribute *E. coli* bacteria loading through direct deposition of fecal matter into streams while wading or wallowing in riparian areas and through fecal deposition across the landscape. Feral hogs create extensive land disturbance in riparian and upland areas which can contribute to increased soil erosion and pollutant runoff. Riparian areas provide ideal habitat and travel corridors for feral hogs as they search for food. While complete removal of feral hog populations is impossible, habitat management and trapping programs can reduce populations and associated damage. Assessment results indicate the highest feral hog loading potential occurs in subbasins 6 and 8 in San Fernando Creek and subbasins 35 and 38 in Petronila Creek watersheds (Figure 27).

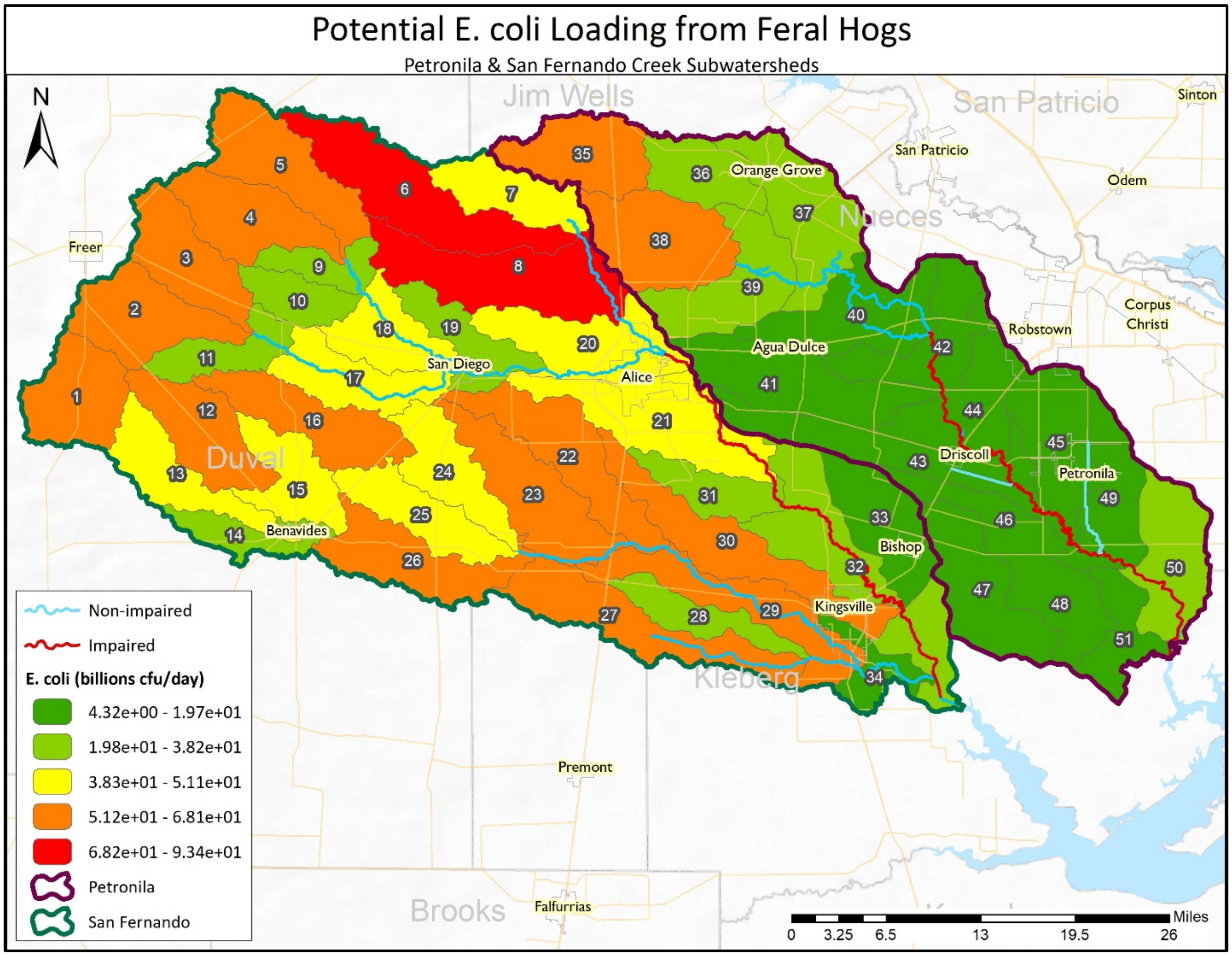


Figure 27. Estimated potential *E. coli* loads from feral hogs

Livestock

Cattle, goats, horses, and sheep are all potential *E. coli* bacteria loading contributors in the watershed. Livestock estimates derived from U.S. Department of Agriculture (USDA) Census of Agriculture (USDA 2017) county population data and stakeholder input were used to estimate potential *E. coli* loads. Spatial distribution of relative *E. coli* loading potential for each type of livestock was calculated and combined to produce the total potential livestock *E. coli* load across the watershed (Figure 28). The highest *E. coli* loading potentials exist in subbasins 6, 8, 20, 21, 22 and 23 in San Fernando Creek and in subbasins 35 and 38 in the Petronila Creek watershed.

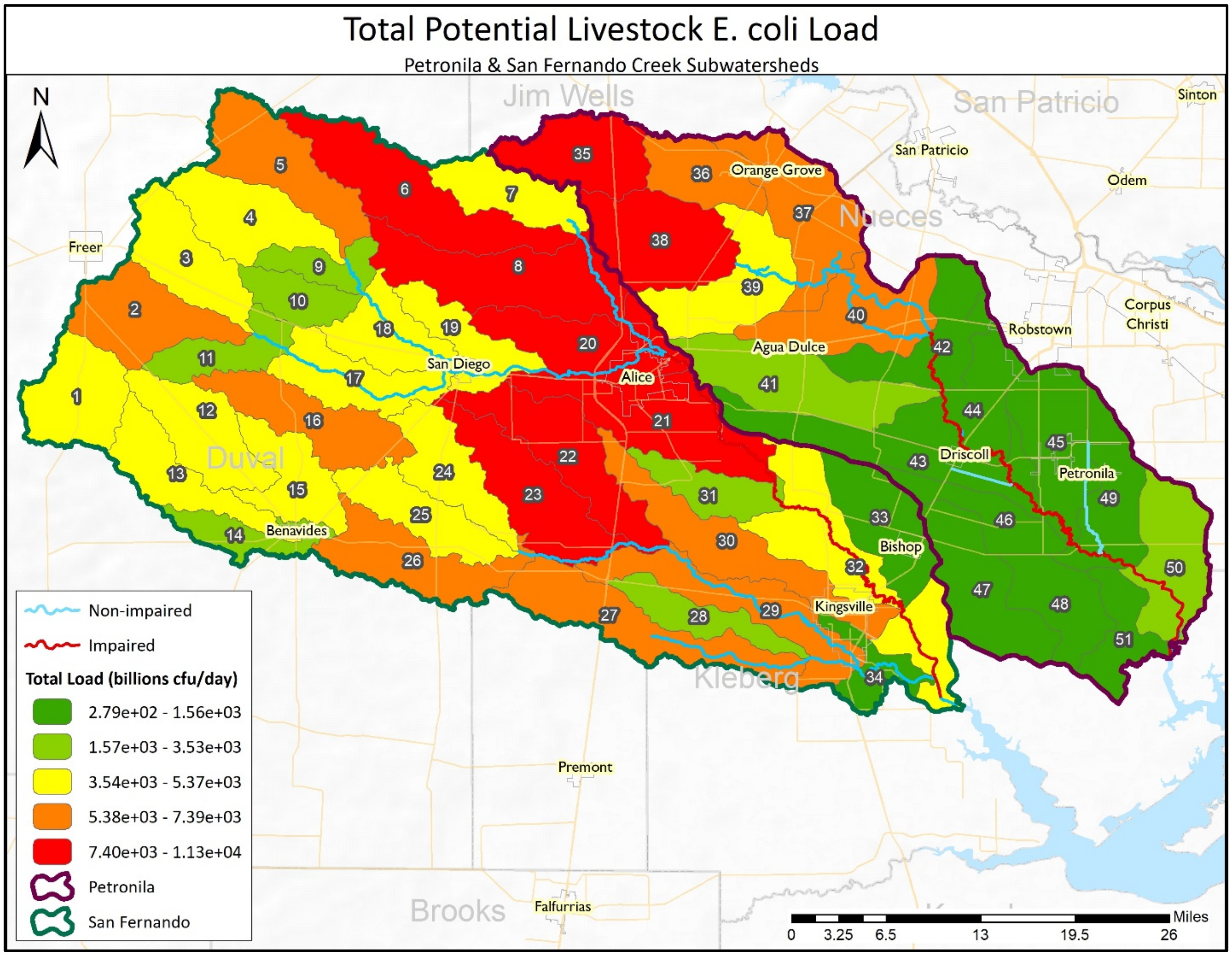


Figure 28. Estimated potential *E. coli* loads from livestock

OSSFs

Failing OSSFs can contribute bacteria loads to water bodies, especially where effluent is released near water bodies. Approximately 15% of OSSFs in the watersheds are assumed to fail according to stakeholder input. Actual failure rates are unknown and can only be determined through physical OSSF inspections. It was estimated that there are 9,086 OSSFs within the watershed based on recently available data. The highest *E. coli* loading potentials from OSSFs exist in subbasins 21, 22 and 34 in San Fernando Creek and in subbasins 36, 37, and 38 in the Petronila Creek watershed (Figure 29).

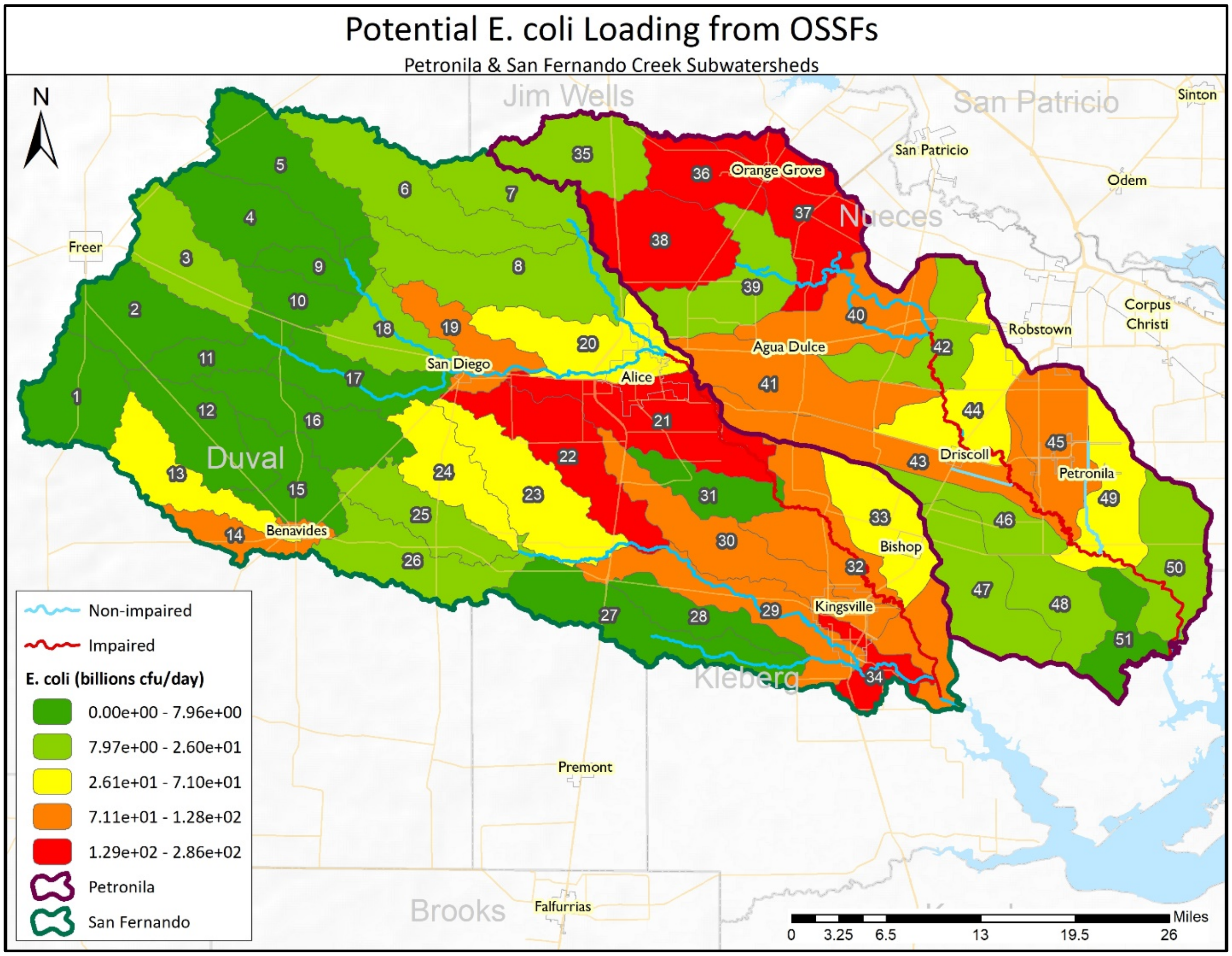


Figure 29. Estimated potential *E. coli* loads from OSSFs

WWTFs

There are 15 active permitted wastewater dischargers in the watershed. To estimate potential *E. coli* load from WWTFs, the maximum permitted discharges and concentrations were used to assess the maximum potential load. Potential *E. coli* loading from WWTFs is highest in San Fernando Creek subbasins 20, 21, and 30 (Figure 30). Comparatively, the Petronila Creek watershed does not have substantial WWTF contributions. Of those that do exist though, the highest *E. coli* loading potential is in subbasins 37 and 40 (Figure 30).

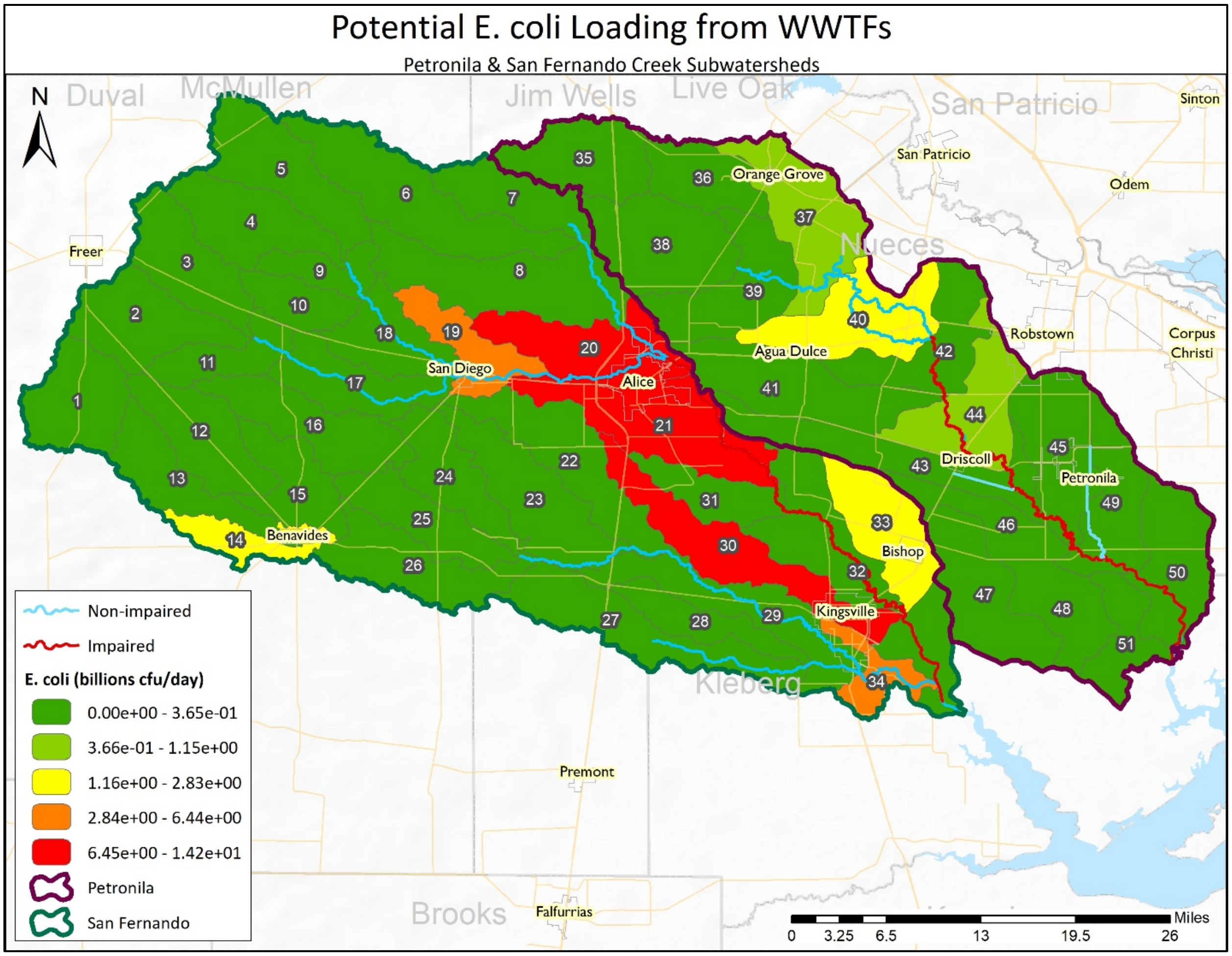


Figure 30. Estimated potential *E. coli* loads from WWTFs

Total Potential *E. coli* Load

Total potential *E. coli* loading estimates across the watershed were generated by combining potential loadings from each source evaluated. In the San Fernando Creek watershed, the highest total potential loads are estimated to occur in subbasins 20, 21, and 30. In the Petronila Creek watershed, the highest total potential loads are estimated in subbasins 35, 37, 38, and 40 (Figure 31).

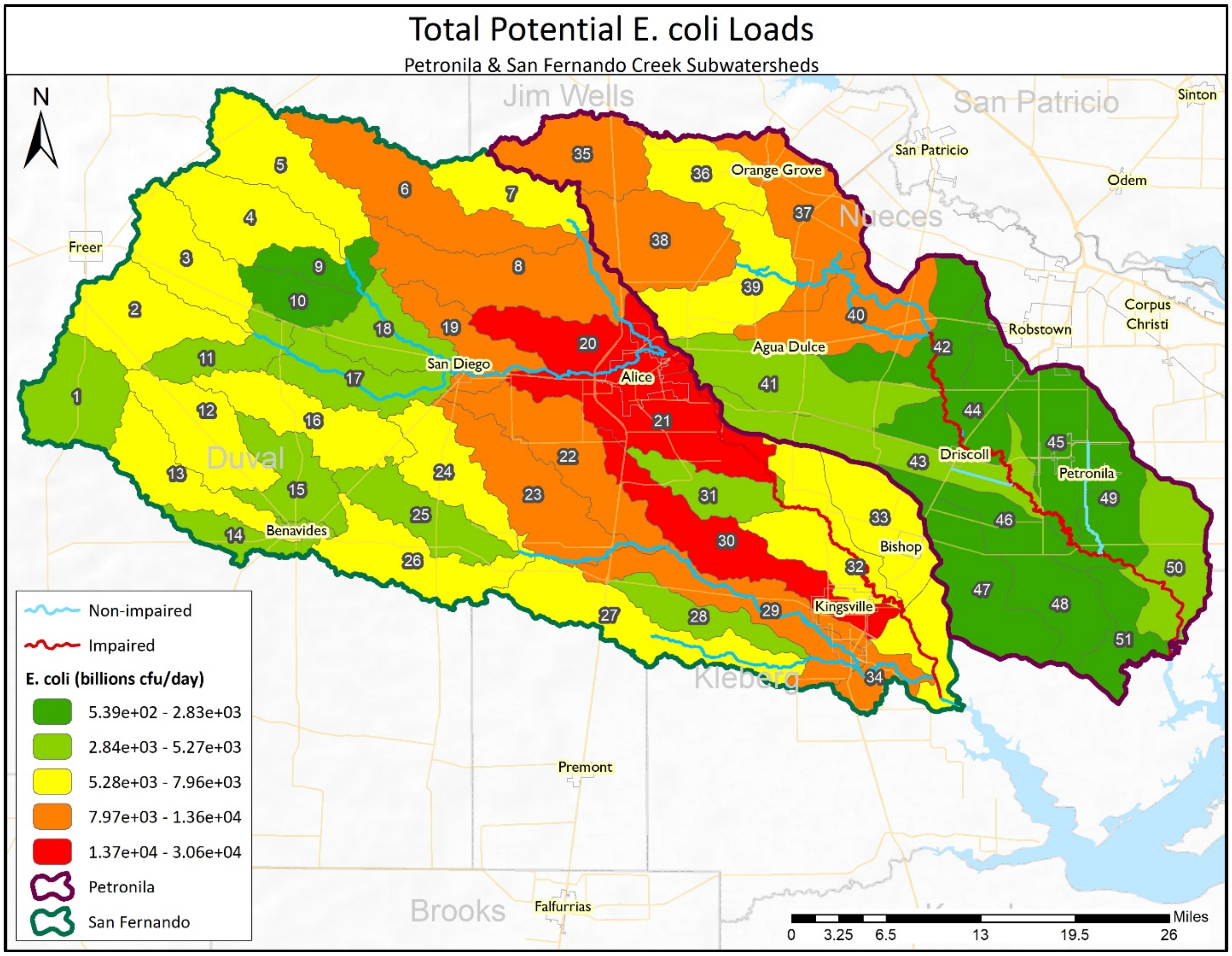


Figure 31. Estimated potential *E. coli* loads from all assessed sources

Chapter 6 Recommended WPP Implementation Strategies

Introduction

No single bacteria source is the primary cause of current waterbody impairments. According to pollutant loading estimates, cattle, pets, deer and OSSFs have the highest potential to contribute *E. coli* across the watersheds; however, all potential sources contribute to overall bacteria loading. Due to potential source diversity, various management strategies are recommended to address manageable *E. coli* sources in the watershed. Recommended management strategies were developed based on stakeholder feedback relative to pollutant removal efficiencies, likelihood of adoption and applicability to the watershed.

Estimated potential bacteria load reductions from each management measure are presented with each recommended action discussed in this chapter and further explained in Appendix A. Loading reduction estimates are based on predicted worst-case scenario loading. As a result, these estimates do not accurately predict actual loading reductions expected to occur instream. Actual reductions will depend on implementation volume and other changes across the watershed that may trigger the need for adaptive implementation. Potential annual load reductions from management measures are discussed throughout this chapter and indicate that reducing bacteria loads entering San Fernando and Petronila Creeks to levels that support primary contact recreation use is feasible.

Many management measures recommended to address bacteria loading will also yield nutrient load reductions when implemented. Where appropriate, potential nutrient reductions are presented for select management practices although nutrient load reduction targets were not established.

CSAs for each recommended management strategy were identified based on spatial analysis and stakeholder feedback. While management measures can be implemented throughout the watershed, priority locations were selected where management strategies may most effectively reduce potential loading. In all cases, management activity should be implemented as close to waterways as possible to increase potential instream water quality improvements. CSAs will help guide initial implementation in each watershed.

Stakeholder input was crucial throughout the decision-making process for these suggested management strategies. Stakeholders were engaged throughout the process through virtual and in-person meetings. Management measures suggested in this chapter are voluntary and will rely on stakeholder adoption for successful implementation. Therefore, receiving stakeholder input on willingness to adopt these practices is the first step to ensuring successful implementation of the plan. All management measures were discussed with and approved by stakeholders to ensure community support and successful implementation.

Management Measure 1 – Developing and Implementing Water Quality Management Plans or Conservation Plans

Potential bacteria loadings from cattle and other livestock are relatively high compared to other evaluated sources due to the large livestock population. Livestock waste is mostly deposited in upland areas and transported to water bodies during runoff events. Therefore, most bacteria in livestock waste dies before reaching a waterbody; however, livestock can spend significant time near or in water bodies which increases the risk of water quality degradation. Livestock distribution across the landscape is highly dependent upon food, water and shelter availability within accessible areas. This allows livestock to be managed easily compared to other species. Time that livestock spend in and near riparian areas can be reduced with fencing and by providing strategically placed water, feed, shade and forage around a property. This can reduce bacteria volume entering nearby water bodies during runoff by increasing distance between deposition locations and water bodies.

Various BMPs are available to improve forage quality, diversify water resource availability and better distribute livestock across a property (Table 20). However, the practices appropriate for implementation vary by operation due to landscape features and landowner goals. Technical assistance is available to landowners upon request to help identify appropriate practices to meet specific property goals. NRCS develops conservation plans (CPs) while the Texas State Soil and Water Conservation Board (TSSWCB) in partnership with local soil and water conservation districts (SWCDs) and NRCS develops water quality management plans (WQMPs). Currently, there are 93 WQMPs and 1,010 individual NRCS practices implemented under CPs in the Petronila Creek watershed and 43 WQMPs and 890 individual NRCS practices implemented in the San Fernando Creek watershed for cropland and grazing (Table 20). Stakeholders indicated that developing an additional 200 plans (CPs/WQMPs) for both grazing land and cropland is feasible in each watershed (400 total) over the next 10 years. Bacteria loading from cropland is predominantly from wildlife and is not considered manageable through land conservation practices. Bacteria load reductions on grazing lands achieved from these CPs/WQMPs will vary depending on specific conservation measures implemented. Based on land cover in each watershed, it is assumed that grazing land management will be the focus of 28% (56 of 200) of CPs/WQMPs developed in the Petronila watershed and 89% (178 of 200) in San Fernando. Load reduction estimates from CPs/WQMPs are based on these numbers and management practices likely to be implemented that are known to reduce livestock bacteria loading. These include fencing, grazing management and alternative water sources.

Table 20. Available cropland, pasture and rangeland practices to improve water quality.

Practice	NRCS Code	Focus Area or Benefit
Brush Management	314	Livestock, water quality, water quantity, wildlife
Conservation Cover	327	Water quality, soil moisture, wildlife
Fencing	382	Livestock, water quality
Filter Strips	393	Livestock, water quality, wildlife
Grade Stabilization Structures	410	Water quality
Grazing Land Mechanical Treatment	548	Livestock, water quality, wildlife
Heavy Use Area Protection	562	Livestock, water quantity, water quality
Livestock Pipeline	516	Livestock, water quality, wildlife
No Tillage	329	Water quality, soil moisture
Pond	378	Livestock, water quantity, water quality, wildlife
Prescribed Burning	338	Livestock, water quality, wildlife
Prescribed Grazing	528	Livestock, water quality, wildlife
Pumping Plant	533	Livestock, water quality, wildlife
Range/Pasture planting	550/512	Livestock, water quality, wildlife
Reduced Tillage	345	Water quality, soil moisture
Shade structure	N/A	Livestock, water quality, wildlife
Stream crossing	578	Livestock, water quality
Supplemental feed location	N/A	Livestock, water quality
Water well	642	Livestock, water quantity, wildlife
Watering facility	614	Livestock, water quantity, wildlife

Natural Resource Conservation Service. NRCS

Implementing CPs/WQMPs is beneficial, regardless of location in the watershed as these practices aim to keep water on the landscape by improving forage for livestock and wildlife and maintaining increased ground cover. Increasing vegetation amount and quality on a landscape aids the natural filtration process that can reduce pollutant loading to nearby water bodies. Overall CP/WQMP effectiveness can be maximized on properties with riparian habitat. Therefore, all properties with riparian areas are considered a priority. Properties without riparian habitat are also encouraged to participate in implementation activities because the cooperative effect is still consequential. Priority subwatersheds for livestock related practice implementation are 6, 8, 20, 21, 22, 23, 35 and 38 (Table 21).

Table 21. Management Measure 1. Develop and implement Water Quality Management Plans or Conservation Plans.

Source: Cattle and Other Livestock
Problem: Direct and indirect fecal bacteria loading due to livestock in streams, riparian degradation, and overgrazing which can increase pollutant loading to water bodies
Objectives: • Work with landowners to develop property-specific CPs/WQMPs that improve grazing practices, enhanced ground cover, increase pollutant retention and improved water quality. • Develop funding to hire WQMP technician. • Deliver education and outreach information, programs and workshops to landowners. • Reduce fecal loadings attributed to livestock.
Location: Entire watershed
Critical Areas: All livestock operations with riparian habitat and subwatersheds 6, 8, 20, 21, 22, 23, 35, and 38.
Goal: Develop and implement CPs/WQMPs that reduce time spent in riparian areas by livestock and improve grazing resource management across the property.
Description: CPs/WQMPs will be developed upon producer request to implement BMPs that reduce water quality impacts from grazing livestock. Practices will be identified and developed in consultation with NRCS, TSSWCB and local SWCDs as appropriate. Education information, programs and workshops will support and promote the adoption of these practices.

Implementation Strategy			
Participation	Recommendations	Period	Capital Costs
TSSWCB, SWCDs	Develop funding to hire WQMP technician	2023 – 2032	Estimated $75,000 per year
Producers, NRCS, TSSWCB, SWCDs, landowner, lessees	Develop, implement, and provide financial assistance for 400 livestock CPs and WQMPs over 10 years	2023 – 2032	$6,000,000 (est. $15,000 per plan) *
AgriLife Extension, TWRI, watershed coordinator	Deliver education and outreach information, programs and workshops to landowners	2023, 2027, 2032	N/A

Estimated Load Reduction

Prescribed management will reduce bacteria loadings associated with livestock by reducing runoff from pastures and rangeland and by reducing direct fecal deposition in water. Nutrient reductions are possible from some implemented practices. Grazing associated CP/WQMP implementation is estimated reduce loadings by:

	CP/WQMP # Planned for Grazing Operations	***E. coli*** **(cfu/year)**	**Nitrogen (lbs/year)**	**Phosphorus (lbs/year)**
Petronila Creek	56	8.15×10^{13}	16,633	8,763
San Fernando Creek	178	1.50×10^{14}	30,610	16,128

Effectiveness	High: Decreasing time livestock spend in riparian areas and reducing runoff by managing vegetative cover will reduce NPS contributions of bacteria and other pollutants to creeks.
Certainty	Moderate: Landowners acknowledge the value of good land stewardship practices; however, financial incentives are often needed to encourage CP/WQMP implementation.
Commitment	Moderate: Landowners are willing to implement stewardship practices shown to improve productivity; however, costs are often prohibitive and financial incentives are needed to increase implementation rates.
Needs	High: Financial costs are a major barrier to implementation. Education and outreach are needed to demonstrate benefits of plan development and implementation to producers.

*Unit costs for NRCS Conservation Plans vary widely depending on plan specifics

Management Measure 2 – Promote Technical and Direct Operational Assistance to Landowners for Feral Hog Control

Potential bacteria loading from feral hogs represents a considerable potential influence on instream water quality. While other sources of bacteria are potentially larger in volume, feral hogs congregate in riparian areas due to the presence of dense habitat, food sources, and water. As a result, feral hogs can have an increased potential impact on instream water quality. Common feral hog behavior, such as rooting and wallowing, affects water quality by degrading ground cover which increases erosion. Through a combination of agency technical assistance, education, and landowner implementation of feral hog management techniques, the goal of this management measure is to reduce and maintain feral hog populations 15% below current numbers in both San Fernando and Petronila Creek watersheds (Table 22). A 15% reduction in current feral hog populations would amount to removing 2,674 hogs annually from the San Fernando Creek watershed and 590 hogs annually from the Petronila Creek watershed.

Physically removing hogs is the best strategy for reducing their impact on water quality. While the complete eradication of feral hogs from the watershed is not feasible, a variety of methods are available to manage or reduce populations. Trapping is the most effective method currently available to landowners. With proper planning and diligence, trapping can successfully remove large numbers of hogs at once. Furthermore, costs of purchasing or building live traps can be split among landowners. Comparatively, shooting feral hogs removes fewer than trapping as the animals tend to quickly move away from hunting pressure, though arial gunning has been successful in other areas of Texas and should be considered as a viable option to further reduce the feral hog population within the watershed.

Excluding feral hogs from supplemental feed is also an effective management tool. Given the opportunistic feeding nature of feral hogs, minimizing available food from deer feeders is important. Constructing exclusionary fences around feeders can reduce food ability (Rattan et al., 2010). Locating feeders away from riparian areas can also reduce their impacts on water quality.

Education programs and workshops will be used to improve feral hog removal efficiency. AgriLife Extension provides various educational resources for landowners that are available online at: http://feralhogs.tamu.edu. Programs and resources are available virtually and in-person to increase outreach. Delivering up-to-date information and resources to landowners through these workshops can lead to more landowner success removing feral hog populations in the watershed. Landowner-developed wildlife management plans outlining their goals and management practices can also benefit the watershed's wildlife, habitat, and water quality.

Based on spatial analysis, subwatersheds 6 and 8 have the highest potential for feral hog loadings based on available habitat. However, given feral hogs' propensity to travel great distances along riparian corridors in search of food and habitat, priority areas will include all subwatersheds with high importance placed on properties containing or adjacent to riparian habitat.

Table 22. Management Measure 2: Promote technical and direct operational assistance to landowners for feral hog control.

Source: Feral Hogs			
Problem: Direct and indirect pollutant loading and riparian habitat destruction from feral hogs			
Objectives: • Reduce fecal contamination and land disturbance from feral hogs. • Work with landowners to reduce feral hog populations. • Reduce food availability for feral hogs. • Provide education and outreach to stakeholders.			
Critical Areas: All subwatersheds with high importance placed on riparian properties.			
Goal: Manage feral hog population through all available means to reduce populations by 15% (2,674 hogs in the San Fernando watershed and 590 in the Petronila Creek watershed) and maintain them at this level.			
Description: Voluntarily implement feral hog population management practices including trapping, reducing access to food supplies and educating landowners and others as they are available.			
Implementation Strategy			
Participation	Recommendations	Period	Capital Costs
Landowners, managers, lessees	Voluntarily construct fencing around deer feeders to prevent feral hog utilization	2023 – 2032	$300 per feeder
	Voluntarily trap/remove/shoot feral hogs to reduce numbers	2023 – 2032	N/A
Landowners, producers, TPWD	Develop and implement wildlife management plans and wildlife management practices	2023 – 2032	N/A
AgriLife Extension, Texas Wildlife Services, TPWD	Deliver Feral Hog Education Workshop	2024, 2027, 2030	$3,000 each
Estimated Load Reduction			
Removing and maintaining feral hog populations directly reduces fecal bacteria, nutrient, and sediment loading to water bodies. Reducing the population by 15% in the San Fernando and Petronila Creek watershed by:			

	Hogs to be Removed	***E. coli* (cfu/year)**	**Nitrogen (lbs/year)**	**Phosphorus (lbs/year)**
Petronila Creek	590	2.05×10^{13}	3,768	1,345
San Fernando Creek	2,674	9.28×10^{13}	17,080	6,100

Effectiveness	Moderate: Reducing feral hog populations will decrease bacteria and nutrient loading to the streams. However, substantial reduction of the population is difficult.
Certainty	Low: Feral hogs are transient, instinctful and adapt to changes in environmental conditions. Population reductions require landowner diligence. Combined, there is considerable uncertainty in the ability to remove 15% of the population annually.
Commitment	Moderate: Many landowners are actively battling feral hog populations and will continue to do so if resources remain available. Feral hogs adversely affect their livelihood.
Needs	Moderate: Landowners benefit from technical and educational resources to inform them about feral hog management options. Funds are needed to deliver these workshops and to increase removal resources available to landowners.

Management Measure 3 – Identify and Repair or Replace Failing On-Site Sewage Systems

OSSFs are used to treat wastewater where centralized WWTFs are not available. Conventional systems use a septic tank and gravity-fed drain field that separates solids from wastewater prior to its distribution into soil where treatment occurs. In the San Fernando and Petronila Creek watershed, approximately 76% of the watershed's soils are considered very limited. This indicates that conventional septic tank systems are not suitable for the proper treatment of household wastewater. In these areas, advanced treatment systems, most commonly aerobic treatment units, are suitable alternative options for wastewater treatment. While advanced treatment systems are highly effective, operation and maintenance needs for these systems are rigorous compared to conventional septic systems. Limited awareness and lack of maintenance can lead to system failures.

Failing or non-existent OSSFs can provide significant bacteria and nutrient loading into the watershed. The exact number of failing OSSFs is unknown; however, it is estimated that 15%, or 1,363, systems may be malfunctioning across the watershed. Specific locations of failing OSSF are not known and can only be determined through physical inspections. Factors contributing to OSSF failure include improper system design or selection, improper operation and maintenance and lack of financial resources for proper maintenance.

Providing educational workshops to homeowners regarding OSSF operation and maintenance will help address these issues. Repairs and replacements are also needed. Over the next 10 years, it is recommended that 100 failing septic systems in the watershed be replaced (40 in San Fernando Creek and 60 in Petronila Creek watersheds) or connected to a centralized sewer system if feasible. While OSSFs should be replaced and repaired as needed across the entire watershed, subwatersheds 21, 22, 36, 37, and 38 are considered CSAs due to OSSF densities. Additional priority should be given to OSSFs within 100 yds of perennial water bodies. Significant technical and financial resource are needed to support OSSF repairs and replacements.

Table 23. Management Measure 3: OSSF management.

Source: Failing or Non-Existent On-Site Sewage Facilities (OSSFs)
Problem: Pollutant loading reaching streams from untreated or insufficiently treated household sewage
Objectives: • Inspect failing OSSFs in the watershed and secure funding to promote OSSF repairs. • Repair or replace OSSFs by working with counties and communities. • Educate homeowners on system operations and maintenance.
Location: Entire watershed
Critical Areas: Subwatersheds 21, 22, 36, 37, 38, and systems within 100 yds of perennial waterways.
Goal: Identify, inspect, and repair or replace 100 failing OSSFs in the watershed (40 in San Fernando Creek and 60 in Petronila Creek watersheds), especially within critical areas. Where feasible, leverage resources to address failing OSSFs adjacent to Baffin Bay.
Description: Deliver education programs and workshops on proper maintenance and operation of OSSFs to homeowners. Failing or non-existent systems should be repaired or replaced as needed and as funding allows. Extend education and outreach resources to residents around Baffin Bay. Work with county to leverage additional resources to address failing OSSFs in the watersheds and near the bay.
Implementation Strategy

Participation	Recommendations	Period	Capital Costs
Counties, contractors	Identify, inspect and repair or replace OSSFs as funding allows	2023–2032	\$8,000-\$12,500 per system (estimate)
Counties, Municipalities Districts, Homeowners, NRA	Inspect and identify the possibility of connecting to existing/planned infrastructure	2023–2032	N/A
NRA, AgriLife Extension, TWRI, watershed coordinator, Voices of the Colonias	Operate an OSSF education, outreach, and training program for installers, service providers and homeowners	2024, 2028, 2032	N/A
AgriLife Extension, TWRI, watershed coordinator, Voices of the Colonias	Develop and deliver materials (postcards, websites, handouts, etc.) to educate homeowners	2023–2032	N/A

Estimated Load Reduction

As planned, 100 OSSFs will be repaired or replaced between the San Fernando and Petronila Creek watersheds. Estimated potential *E. coli* load reductions and potential nutrient reductions from these efforts are:

	OSSFs Planned for Repair or Replacement	***E. coli* (cfu/year)**	**Nitrogen (lbs/year)**	**Phosphorus (lbs/year)**
Petronila Creek	60	6.78×10^{14}	1,477	369
San Fernando Creek	40	4.52×10^{14}	985	246

Effectiveness	High: Replacing or repairing failing OSSFs yields direct *E. coli* reductions.
Certainty	Low: Funding available to identify, inspect and repair or replace OSSFs is uncertain; however, funding sources are available for assistance.
Commitment	Moderate: Watershed stakeholders acknowledge failing OSSFs as a considerable bacteria source. Addressing this source has the greatest human health benefit and is a top priority.
Needs	High: Financial resources are needed to identity, repair and replace systems as many homeowners do not have the resources to fund replacement themselves. Education is also critical because many homeowners with failing systems may not realize their system is failing or understand the associated human health or environmental implications.

Management Measure 4 – Lawn and Landscape Management and Maintenance

Bacteria and nutrient loading from improper lawn and pet waste maintenance can be a significant pollutant source. Potential pollutant loading from pet waste was identified as a large bacteria source in the watershed. If not managed properly, pet waste and *E. coli* it contains can be transported to local water bodies during runoff events. Proper pet waste disposal in the trash is a simple and effective way to reduce *E. coli* and nutrient loads in the watershed. Nutrient loading is also a concern from improper lawn fertilization. Excessive fertilization or improper application can lead to nutrient losses in sprinkler or rainfall runoff.

Management strategies to address pet waste and fertilizer emphasize reducing the transport to streams via runoff (Table 24). Potential strategies include providing waste bag dispensers and collection stations in areas of high pet density (parks, neighborhoods) and handing out waste bag carriers for pet owners at events and programs around the watershed. These strategies encourage pet owners to pick up waste before it is transported to streams. Several parks in the watershed have pet waste stations, but there are opportunities to expand their numbers. Ongoing pet waste station maintenance should be addressed as new stations are installed.

Providing education and outreach materials to pet owners about bacteria and nutrient pollution contributed by pet waste can increase the number of residents who pick up and dispose of pet waste. Recognizing that domestic pets in rural portions of the watershed likely have large areas to roam and that picking up pet waste is likely not feasible for all owners, management measures should target areas of the watershed with high housing and pet densities. Priority areas for this management measure are urbanized and public areas in subwatersheds 20, 21, and 30.

Education and outreach materials and programs regarding proper lawn maintenance will help encourage homeowners to manage fertilizer and pesticide use and irrigation on their lawn. Existing programs are available through Texas A&M AgriLife to address these needs and are discussed in Chapter 7.

Table 24. Management Measure 4: Lawn and landscape management and maintenance.

<table>
<tr><td colspan="4">Source: Dog Waste</td></tr>
<tr><td colspan="4">Problem: Direct and indirect fecal bacteria loading from household pets and nutrient loading from fertilizers</td></tr>
<tr><td colspan="4">Objectives:
Furnish education and outreach messaging on disposal of pet waste and proper fertilization.
Install and maintain pet waste stations in public areas.</td></tr>
<tr><td colspan="4">Location: Entire watershed</td></tr>
<tr><td colspan="4">Critical Areas: High pet concentration areas and urbanizing areas; subwatersheds 20, 21, and 30.</td></tr>
<tr><td colspan="4">Goal: Reduce the amount of pet waste and excess fertilizer that may wash into water bodies during rainfall and irrigation runoff events by providing educational and physical resources to increase stakeholder awareness of water quality and health issues caused by excessive pet waste and poor lawn maintenance. Effectively manage E. coli loading from 10% of the estimated dog population, or 2,037 dogs.</td></tr>
<tr><td colspan="4">Description: Expand education and outreach regarding the need to properly dispose of pet waste and properly apply fertilizers in the watershed. Install and maintain pet waste stations and signage in public areas to facilitate increased collection and proper pet waste disposal.</td></tr>
<tr><td colspan="4">Implementation Strategy</td></tr>
<tr><td>Participation</td><td>Recommendations</td><td>Period</td><td>Capital Costs</td></tr>
<tr><td>AgriLife Extension, NRA, watershed coordinator</td><td>Educational programming for homeowners</td><td>2023–2032</td><td>$9,000 ($3,000 per program)</td></tr>
<tr><td>Cities, counties, homeowners, homeowner associations</td><td>Provide needed maintenance supplies for pet waste stations: est. 25 stations</td><td>2023–2032</td><td>$500 per station: $12,500 total</td></tr>
<tr><td>Cities, Counties, AgriLife Extension, TWRI, HOAs</td><td>Develop and provide educational resources to residents</td><td>2023–2032</td><td>N/A</td></tr>
<tr><td colspan="4">Estimated Load Reduction</td></tr>
<tr><td colspan="4">Estimated E. coli load reductions and potential nutrient reductions resulting from pet waste management measure are reliant on changes in people’s behavior and are therefore uncertain. Assuming 20% of targeted individuals respond by properly disposing of pet waste, annual load reductions are:
<table>
<tr><th></th><th>Managed Dog’s Waste</th><th>E. coli (cfu/year)</th><th>Nitrogen (lbs/year)</th><th>Phosphorus (lbs/year)</th></tr>
<tr><td>Petronila Creek</td><td>387</td><td>2.23× 10^14</td><td>202</td><td>47</td></tr>
<tr><td>San Fernando Creek</td><td>1,650</td><td>9.49× 10^14</td><td>862</td><td>199</td></tr>
</table></td></tr>
<tr><td>Effectiveness</td><td colspan="3">High: Collecting and properly disposing dog waste is a direct method to immediately prevent E. coli from entering water bodies.</td></tr>
<tr><td>Certainty</td><td colspan="3">Low: Some pet owners in the watershed likely already collect and properly dispose of dog waste. Those that do not properly dispose of pet waste may be difficult to reach or convince. The number of additional people that will properly dispose of pet waste is difficult to anticipate.</td></tr>
<tr><td>Commitment</td><td colspan="3">Moderate: Some parks currently have pet waste stations installed; however, maintenance is sometimes less frequent than it needs to be. Meanwhile, little encouragement for owners to pick up after their pets occurs.</td></tr>
<tr><td>Needs</td><td colspan="3">Low: Increasing maintenance on existing pet waste stations could occur. Landscapers can easily add this to their list of items when mowing parks if resources are provided.</td></tr>
</table>

Homeowners associations, HOAs;

Management Measure 5 – Implement and Expand Surface Stormwater Runoff Management

Stormwater runoff is a potentially large *E. coli* source influencing water bodies, especially near urban centers like Alice and Kingsville, which are rapidly developing and have high percentages of impervious cover. The objective of this management measure is to work with local entities to increase green stormwater infrastructure to reduce runoff during storm events that can carry bacteria and nutrients into creeks. Runoff also increases turbidity and can carry metals and hydrocarbons to water bodies further increasing biological.

Significant local activity is underway to manage stormwater to reduce flooding potential. While water quality is not the focus of these efforts, significant opportunity exists to combine flooding and water quality management. Efforts of many parties contributing to this WPP are underway to accomplish this goal and they will continue. The WPP can and should complement these activities. Actions that can address both flooding and water quality include BMPs implemented at the demonstration, property, subdivision or regional scale. The watershed coordinator will work to encourage these activities as appropriate and as funding permits (Table 25). Urban stormwater BMPs reduce or delay runoff generated by impervious or highly compacted surfaces such as roofs, roads and parking lots. Potential BMPs include, but are not limited to, rain gardens, rain barrels/cisterns, green roofs, permeable pavement, bioretention, constructed wetlands, swales, and tree box filters. These BMPs vary in ability to reduce stormwater runoff quantity and improve runoff quality based on design and location. Furthermore, volume reductions from BMPs can reduce stormwater entering local sewage collection systems through I&I . Well-placed and well-designed stormwater BMPs can substantially decrease and delay runoff and reduce bacteria and nutrient loading. Further implementation of these practices should be encouraged through ordinance development that encourage improved practice use requirements for new development where feasible. Addressing runoff concerns during development can reduce the burden of cost for corrective actions after development.

Stakeholders expressed an interest in identifying areas for riparian restoration and constructed wetlands to help with bacteria and nutrient load reduction. Candidate implementation locations have already been identified and others will be identified as funding allows. Local interest and resource contributions should be capitalized on while available.

The second objective is to deliver education programs in the watershed that increase awareness regarding the impacts of stormwater on water quality and riparian areas. This can include installation of demonstration sites (constructed wetlands, green infrastructure practices, etc.), training for city/county/drainage district officials, flyers, and other outreach materials.

Table 25. Management Measure 5: Urban stormwater management.

<table>
<tr><td colspan="4">Source: Urban Stormwater Runoff</td></tr>
<tr><td colspan="4">Problem: Fecal bacteria loading from stormwater runoff in developed and urbanized areas</td></tr>
<tr><td colspan="4">Objectives:
• Educate residents and decision makers about stormwater BMPs.
• Identify and install stormwater BMPs at all scales feasible: demonstration, property, subdivision, region including identification of appropriate sites and costs.
• Influence future stormwater manage decisions, requirements, and implementation</td></tr>
<tr><td colspan="4">Critical Areas: In and near urbanized areas in the San Fernando and Petronila Creek watersheds</td></tr>
<tr><td colspan="4">Goal: Reduce E. coli loading associated with urban stormwater runoff through implementation of stormwater BMPs as appropriate and to increase local officials and residents' awareness of stormwater pollution and management.</td></tr>
<tr><td colspan="4">Description: Promote stormwater management BMP projects through education, demonstration and leveraging of other resources. Coordinate with decision makers and property owners.</td></tr>
<tr><td colspan="4">Implementation Strategy</td></tr>
<tr><td>Participation</td><td>Recommendations</td><td>Period</td><td>Capital Costs</td></tr>
<tr><td>Cities, property, owners, contractors</td><td>Identify and install stormwater BMPs as funding becomes available</td><td>2023-2032</td><td>$40,000 to 95,000 per acre (rough estimate)</td></tr>
<tr><td>AgriLife Extension, TWRI, watershed coordinator, CCT</td><td>Deliver education and outreach (Riparian and Stream Ecosystem Education workshop, or others as appropriate) to landowners and decision makers; encourage stormwater management requirements for future development</td><td>2023-2032</td><td>N/A</td></tr>
<tr><td colspan="4">Estimated Load Reduction</td></tr>
<tr><td colspan="4">Installation of stormwater BMPs that reduce runoff or treat bacteria will result in direct reductions in bacteria loadings in the watershed. Potential load reductions were not calculated because the location, type, and sizes of projects installed will determine the potential load reductions. Nutrient reductions are also commonly realized with many stormwater BMPs; but are not estimated as noted with bacteria.</td></tr>
<tr><td>Effectiveness</td><td colspan="3">Moderate to High: BMP effectiveness for reducing bacteria loading is dependent on design, site selection and maintenance of the BMP.</td></tr>
<tr><td>Certainty</td><td colspan="3">Moderate: BMP installation requires sustained commitment from local governments. Recent grant funding acquired will help plan and implement specific projects to reduce local flooding which can also have a positive water quality impact if properly designed.</td></tr>
<tr><td>Commitment</td><td colspan="3">Moderate: Flood reduction is a high priority for local cities/counties/drainage districts; financial needs are significant though.</td></tr>
<tr><td>Needs</td><td colspan="3">High: Stormwater management is costly and financial assistance needs are significant yet largely unknown. Information regarding stormwater management alternatives is needed to increase awareness of potential water quality management benefits.</td></tr>
</table>

Management Measure 6 – Upgrade and Repair WWTFs and Reduce SSOs and Unauthorized Discharges

Aging WWTF infrastructure is a major concern for stakeholders and significant potential contributor of bacteria and nutrients in the watershed. The NRA is working to establish management agreements for some WWTFs. Under these agreements, NRA will operate the OSSFs and perform necessary infrastructure repairs and upgrades to the treatment units and wastewater collection networks as funding allows.

The TCEQ SSO Initiative is a voluntary program that initiates efforts to address SSOs. These events are often due to aging collection systems and may be the result of I&I issues during storm events caused by line breaks and blockages. The NRA has expressed interest in generating SSO initiatives at several WWTFs as they take on facility management. Activities in SSO initiatives vary, but commonly include line inspections and testing, routine repairs and replacements, and education and outreach.

Fats, oils, grease, non-flushables, and many other substances should not be disposed of through household drains. These items can cause material build up and create blockages in collection systems which lead to system damage and repairs. Several educational programs on proper disposal of fats, oils and grease are available through AgriLife Extension and NRA. Education material distribution and providing online videos on the San Fernando & Petronila Creeks WPP website will help encourage and inform homeowners of how to properly dispose of fats, oils, grease, and non-flushables.

Table 26. Management Measure 6: Reduce sanitary sewer overflows (SSOs) and unauthorized discharges.

Source: Municipal Sanitary Sewer Overflow (SSO) or Unauthorized Discharges			
Problem: Fecal bacteria loading from SSO events and malfunctioning sewage infrastructure			
Objectives: • Reduce unauthorized discharges and SSOs. • Replace and repair sewage infrastructure as needed. • Educate residents and homeowners on the need for infrastructure maintenance and what types of waste can be put in the sewer system.			
Critical Areas: Urbanized areas in subwatersheds 20, 21, and 30			
Goal: Work with entities operating WWTFs to continue and expand inspection efforts. Identify problematic areas and repair or replace problematic infrastructure to reduce I&I issues and minimize WWTF overload occurrences.			
Description: Identify potential locations within municipal sewer systems where I&I occurs using available strategies (e.g., smoke tests, camera inspections, etc.). Prioritize system repairs or replacements based on system impacts (largest impact areas addressed first). Complete repairs or replacements to reduce future I&I issues and WWTF overloading.			
Implementation Strategy			
Participation	Recommendations	Period	Capital Costs
NRA, Responsible Entities	Repair and upgrade aging infrastructure at WWTFs within the watershed	2023-2032	$41.5 million (NRA estimate)
NRA, Cities, watershed coordinator	Identify potential resources and develop programs to aid WWTFs replacement of sewage pipes	2023–2032	N/A, TBD
Cities, AgriLife Extension, watershed coordinator	Develop and deliver education material to residents and property owners	2023–2033	N/A
Estimated Load Reduction			
Reduction of SSOs and discharges associated with I&I will result in direct reductions in bacteria loads. However, because the response to education efforts and resource acquisition to complete system repairs is uncertain, load reductions were not calculated.			
Effectiveness	Moderate to High: Although infrequent, reduction in SSOs and unauthorized discharges will result in direct reductions to bacteria loading during the highest flow events.		
Certainty	Moderate to Low: Costs associated with sewer pipe replacement and treatment plant upgrades are expensive to homeowners and municipalities.		
Commitment	Moderate: Municipal public works have incentive to resolve I&I issues to meet discharge requirements. However, limited funding hinders sewage line replacement.		
Needs	High: Financial needs are significant.		

Management Measure 7 – Reduce Illicit Dumping

Stakeholders indicate and photo evidence suggests that large-scale illicit dumping is a problem throughout the watershed. Dumping activities typically occur at or near bridge crossings and access roads near riparian habitats. Items deposited often include animal carcasses, tires, home appliances, household trash, and rubbish (Figure 32). The scope of the problem has not been fully quantified but, it is a contributor to the degradation of water and environmental quality. While much of the known trash dumped is not a direct bacteria contributor, it undoubtedly invites additional trash dumping and creates other pollution concerns for habitat, soil and water. Development and delivery of educational and outreach materials that focus on the proper disposal of carcasses and other trash should reduce the negative impacts resulting from illicit dumping (Table 27).

Hosting hazardous waste collection events (including ag-waste) annually in the watershed can reduce improper waste disposal. Stream clean-up events and outreach materials will be scheduled and distributed to help improve current dump sites and raise public awareness regarding dumping. Stakeholders are interested in providing additional trash disposal locations across the watershed; however, funding and management needs must be met to implement this activity.

Table 27. Management Measure 7: Reduce illicit dumping.

Source: Illicit and Illegal Dumping			
Problem: Illicit and illegal dumping of trash and animal carcasses in and along waterways			
Objectives: • Promote and expand education and outreach efforts in the watershed. • Provide additional disposal locations across the watershed.			
Critical Areas: Entire watershed with focus at bridge crossing and public access areas			
Goal: Increase awareness of and access to proper disposal techniques and reduce illicit dumping of waste and animal carcasses in or near water bodies throughout the watershed.			
Description: Education and outreach materials will be developed and delivered to residents throughout the watershed on the proper disposal of waste materials. Work to secure resources to provide additional waste disposal locations across the watershed.			
Implementation Strategy			
Participation	Recommendations	Period	Capital Costs
Counties, watershed coordinator	Organize hazardous waste collection events	2023 – 2032	TBD
Counties, NRA, watershed coordinator	Develop and deliver educational and outreach materials to residents	2023 – 2032	$21,000 (estimate)
Estimated Load Reduction			
Load reductions are likely minimal from this management measure and are not quantified.			
Effectiveness	Low: Preventing illicit dumping, especially animal carcasses, is likely to reduce bacteria loads by some amount, although this loading is likely limited to areas with public access.		
Certainty	Low: Anticipating changes in resident behavior due to education and outreach is difficult at best. Reaching residents that illegally dump is likely difficult.		
Commitment	Moderate: Many stakeholders indicate illicit dumping occurs; however, enforcement is difficult. Addressing the issue is not a high priority and resource availability is low.		
Needs	Moderate: Financial resources are required to develop and distribute educational materials and provide additional waste collection events/facilities.		

Figure 32. Illicit dumping site in Baffin Bay watershed.

Chapter 7 Education and Outreach

An essential element to WPP implementation is effective education and outreach. Long-term commitments from citizens and landowners are necessary to achieve comprehensive improvements in the San Fernando and Petronila Creek watersheds. The education and outreach component of implementation will focus on keeping the public, landowners and agency personnel informed of project activities, provide information about appropriate management practices, and assist in identifying and forming partnerships to implement WPP components.

Watershed Coordinator

The role of the watershed coordinator is to lead efforts to establish and maintain the working partnerships with stakeholders. Establishing a watershed coordinator role is an important step towards successful WPP implementation. The watershed coordinator will be tasked with maintaining stakeholder support for years to come, identifying and securing funds to implement the WPP, tracking success of implementation, and working to implement adaptive strategies. A full-time watershed coordinator position in or near the watershed is recommended to effectively support WPP implementation.

Public Meetings

During WPP development, stakeholder engagement was critical. Public meetings to develop the WPP began in February 2021with local stakeholders. In total, 14 meetings were held to discuss plan development, including general stakeholder meetings and specialized workgroup meetings.

Throughout the process, local stakeholders participated in public meetings, individual meetings, phone calls and video meetings associated with WPP development. Stakeholders were present from all four counties within the watersheds and represented agriculture, agency, coastal, conservation and urban groups. Groups and entities involved in the planning process include the Baffin Bay Stakeholder Group, city personnel, Coastal Bend Bay & Estuaries Program (CBBEP), county officials, Harte Research Institute for Gulf of Mexico Studies at Texas A&M Corpus Christi (HRI), King Ranch, NRA, NRCS, SWCDs, TCEQ, TSSWCB, Texas Sea Grant and the Texas Department of Transportation.

Future Stakeholder Engagement

Watershed stakeholders will continue to be engaged throughout the WPP implementation process. The watershed coordinator will facilitate engagement by continuing to coordinate, organize and host periodic public meetings and educational events and by seeking out and meeting with stakeholder groups to identify and secure implementation funds. The "Baffin Bay Stakeholder Group" is an existing group concerned with the Baffin Bay and its water quality. Many members of this group participated in meetings to develop the WPP and will remain engaged in implementation. The watershed coordinator will also provide content to maintain and update a project website, track WPP implementation progress, and participate in local events to promote watershed awareness and stewardship. News articles, newsletters, and the project website will be primary tools used to communicate with watershed stakeholders on a regular basis. It will be developed to periodically update readers on implementation progress, provide information on new implementation opportunities, inform them of available technical or financial assistance, and information relative to the WPP effort.

Education Programs

Delivering applicable and desired educational programming is a critical part of the WPP implementation process. Multiple programs providing information on potential pollutant sources and feasible management strategies will be delivered in and near the watershed and will be advertised to watershed stakeholders. These programs will be coordinated with the efforts of other entities operating in and near the watershed. An approximate program delivery schedule is provided in the management measures described in Chapter 6. As implementation and data collection continues, the adaptive management process will be used to modify this schedule and respective educational needs as appropriate. Potential programs that can meet educational needs are described in subsequent sections.

Texas Watershed Stewards

The Texas Watershed Stewards program is a free educational workshop presented by Texas A&M AgriLife Extension and the TSSWCB. It is designed to help watershed stakeholders improve and protect their water resources by getting involved in local watershed protection and management activities. The program is tailored to address the specific water quality issues within the San Fernando and Petronila Creek watersheds.

Texas Well Owners Network

Private water wells provide a source of water to many Texas residents. The Texas Well Owners Network Program provides needed education and outreach that focuses on private drinking water wells and the impacts on human health and the environment that can be mitigated by using proper management practices. This includes a brief session on proper operation and maintenance of OSSFs as they are commonly used near private drinking water wells. Well screenings are conducted through this program and provide useful water test information to well owners that aid them in better managing their water supplies.

Riparian and Stream Ecosystem Education Training

Healthy watersheds and good water quality are synonymous with well managed riparian and stream ecosystems. Delivering the Riparian and Stream Ecosystem Education Program will increase stakeholder awareness, understanding and knowledge about the nature and function of riparian zones. The program will highlight the benefits of riparian zones and BMPs that can be implemented to protect them while minimizing NPS pollution. Through this program, riparian landowners will be connected with local technical and financial resources to improve management opportunities and promote healthy watersheds and riparian areas on their land.

OSSF Operation and Maintenance Workshop

A training program that focuses on OSSF rules, regulations, operation and maintenance needs will be delivered in one or more locations in the watershed. This training consists of education and outreach practices to promote the proper OSSF management and garners support for efforts to further identify and address failing OSSFs through inspections and remedial actions. AgriLife Extension provides the needed expertise to deliver this training. Additionally, an online training module that provides an overview of septic systems, how they operate and what maintenance is required to sustain proper functionality and extend system life will be made available to anyone interested through the partnership website.

Healthy Lawns Healthy Waters Workshop

The Healthy Lawns and Healthy Waters Program aims to improve and protect surface water quality by enhancing awareness, knowledge, and implementation of residential landscape BMPs.

This program is most beneficial in urbanized portions of the watershed and can teach homeowners how to care for their lawns appropriately to reduce the risk of NPS pollution entering San Fernando and Petronila Creeks and ultimately Baffin Bay.

Urban Riparian and Stream Restoration Workshop

The Urban Riparian and Stream Restoration workshop is available for delivery in the watershed. Although the watershed is predominantly rural, urban stormwater influences on stream health and quality exist. This program discusses natural restoration techniques and the unique stressors faced by urban streams.

Lone Star Healthy Streams Workshop

The watershed coordinator will coordinate with AgriLife Extension personnel to deliver the Lone Star Healthy Streams curriculum. This program provides information regarding management practices that can be implemented to reduce potentially adverse water quality impacts resulting from cattle, feral hogs, and horses. For livestock, content focuses on improving grazing land management and presents practices that can reduce NPS pollution. The feral hog program differs in that it largely discusses population control options. This statewide program promotes BMP adoption that is proven to effectively reduce bacterial contamination of streams. This program provides educational support for developing CPs and WQMPs by illustrating the benefits of many practices included in those plans.

Wildlife Management Workshops

Periodic wildlife management workshops are warranted to provide information on management strategies and available resources to those interested. The watershed coordinator will work with AgriLife Extension wildlife specialists, TPWD and others as appropriate to plan and secure funding to deliver workshops in and near the San Fernando and Petronila Creek watersheds. Wildlife management workshops will be advertised through newsletters, news releases, the project website, and other avenues as appropriate.

Public Meetings

Periodic public stakeholder meetings will achieve several WPP implementation goals. Public meetings will provide a platform for the watershed coordinator and project personnel to provide WPP implementation information including implementation progress, near-term implementation goals and projects, information on how to sign-up or participate in active implementation programs, appropriate contact information for specific implementation programs and other information as appropriate. These meetings will keep stakeholders engaged in the WPP process and provide a platform to discuss adaptive management to keep the WPP relevant to watershed and water quality needs. This will be accomplished by reviewing implementation goals and milestones and actively discussing how watershed needs can be better served. Feedback will be incorporated into WPP addendums as appropriate.

Newsletters and News Releases

Watershed newsletters will be developed and sent directly to actively engaged stakeholders at least annually or more often if warranted. News releases will be developed and distributed through the mass media outlets in the area to highlight significant happenings related to WPP implementation and to continue raising public awareness and support for watershed protection. These means will be used to inform stakeholders of implementation programs, eligibility requirements, and when and where to sign up for specific programs. Lastly, public meetings and other WPP-related activities will be advertised through these outlets.

Events and Opportunities

Entities working in and around the watershed routinely host educational events that are relevant to the watershed and its stakeholders. These entities include the AgriLife Extension, CBBEP, HRI, King Ranch, NRA, and Texas Sea Grant.

Baffin Bay Stakeholder Group

The Baffin Bay Stakeholder Group is jointly facilitated by CBBEP and HRI to better understand the water quality issues in Baffin Bay and develop collaborative solutions to address those issues. This group meets routinely and provides a great platform to discuss WPP implementation needs and progress along with future adaptations to the plan.

Clean Rivers Program Annual Meeting

Each year, NRA hosts an annual Clean Rivers Program (CRP) stakeholder meeting. This meeting covers their entire river basin and includes San Fernando, Petronila, and Los Olmos Creeks and Baffin Bay. Discussions in these meetings focus on water quality and quantity issues across the basin and other issues of concern. These are good meetings for high level issues and concerns and an excellent location to bring up localized water resource concerns.

Nueces Delta Preserve Programs

Although outside the watershed, the Nueces Delta Preserve operated by CBBEP provides hands on learning experiences related to coastal water resources. A variety of programming opportunities are available throughout the year and upon special request. Specific information about these opportunities is available online at: https://www.nuecesdeltapreserve.org/

Chapter 8 Plan Implementation

Implementing the WPP is a multi-year commitment that will require active participation from various stakeholders and local entities for a planned 10-year period. Implementing management measures described in Chapter 6 will require significant financial and technical assistance supported by continued education and outreach. The first step to successful implementation is to create a reasonable implementation schedule with interim goals and estimated costs. All management strategies in the WPP are voluntary but have received stakeholder support which increases the likelihood that they will be implemented.

A complete list of management measures and goals, responsible parties and estimated costs are included in Table 28. Implementation goals are included incrementally to reflect anticipated implementation time frames. In specific cases, funding acquisition, personnel hiring, or program initiation may delay implementation progress. This approach provides incremental implementation targets that can be used as gauges to measure implementation progress. If sufficient progress is not made, adjustments will ensue to increase implementation and meet established goals. Adaptive management may also be used to adjust the planned approach if the original strategy is no longer feasible or other measures have proven more effective.

Table 28. Implementation Schedule

Management Measure	Responsible Party	Estimated Unit Cost	Number Implemented Time frame (year) 1–3	Number Implemented Time frame (year) 4–6	Number Implemented Time frame (year) 7–10	Estimated Total Cost
Cattle and other Livestock						
Develop funding to hire WQMP technician	TSSWCB, SWCDs, watershed coordinator	$75,000 per year	1			$750,000
Develop, implement, and provide financial assistance for CPs and WQMPs	Producers, landowners, NRCS, TSSWCB, SWCDs, watershed coordinator	$15,000 per plan	90	130	180	$6,000,000
Deliver education and outreach programs and workshops to landowners	AgriLife Extension, NRCS, TSSWCB, watershed coordinator	N/A	1	1	1	N/A
Feral Hog Management						
Voluntarily construct fencing around deer feeders to prevent feral hog access	Landowner, managers, leasees	$300 per feeder	As many as possible			N/A
Voluntarily trap/remove/shoot feral hogs to reduce numbers	Landowner, managers, leasees	N/A	3,264 hogs per year			N/A
Develop and implement wildlife management plans and practices	Landowners, producers, TPWD, watershed coordinator	N/A	As many as possible			N/A
Deliver feral hog education workshops	AgriLife Extension, TPWD, watershed coordinator	$3,000 each	1	1	1	$9,000
OSSF Management						
Identify, inspect, and repair or replace OSSFs as funding allows	Individuals, Counties, Contractors	$8,000-$12,000 per system	20	30	50	$800,000-$1,200,000

Management Measure	**Responsible Party**	**Estimated Unit Cost**	**Number Implemented Time frame (year) 1–3**	**Number Implemented Time frame (year) 4–6**	**Number Implemented Time frame (year) 7–10**	**Estimated Total Cost**
OSSF education, outreach and training program for installers, service providers and homeowners	NRA, AgriLife Extension, Counties, watershed coordinator	$3,500	1	1	1	$10,500
Develop and deliver materials (postcards, handouts, etc.) to educate homeowners	watershed coordinator, Voices of the Colonias	$2 ea.	20,000 mailouts over course of implementation			$40,000
Pet Waste Management						
Pet waste station establishment and maintenance	Cities, HOAs, counties, watershed coordinator,	$500 per station	5	10	10	$12,500
Pet waste education materials	NRA, cities, HOAs, counties, watershed coordinator	$3,000	1	1	1	$9,000
Urban Stormwater Management						
Identify and Install Stormwater BMPs	Cities, CBBEP, watershed coordinator, CCT	$4,000-$100,000 per acre	As many as possible			N/A
Deliver education and outreach programs	NRA, watershed coordinator, CCT, AgriLife Extension	N/A	1	0	1	N/A
WWTFs Infrastructure Repair and Replace						
Repair/Upgrade wastewater treatment infrastructure at smaller WWTFs	NRA, WWTFs, cities	$3,000,000 - $4,000,000 per site	As identified / needed / funding available			2021 estimate of $41,500,000 or more
Deliver education and outreach programs	NRA	N/A	1	1	1	N/A
Reduce Illicit Dumping						
Hazardous waste collection events	Cities, counties, NRA, watershed coordinator	$35,000 - $60,000 per event	3	3	3	$315,000 - $540,000

Management Measure	Responsible Party	Estimated Unit Cost	Number Implemented Time frame (year) 1–3	Number Implemented Time frame (year) 4–6	Number Implemented Time frame (year) 7–10	Estimated Total Cost
Deliver education and outreach programs	Cities, counties, NRA, AgriLife Extension	$7,000	1	1	1	$21,000

Coastal Bend Bays & Estuaries Program, CBBEP;

Chapter 9 Implementation Resources

Introduction

This chapter identifies potential technical and financial assistance sources available to implement management measures in the San Fernando and Petronila Creek watersheds. Grant funding will be a substantial source of implementation funding given the type and variety of needs identified. Funding support for a local watershed coordinator to guide WPP implementation and facilitate long-term success of the plan is also critical and will be sought through grant opportunities.

Technical Assistance

Designing, planning, and implementing many management recommendations in the plan will require technical expertise. In these cases, appropriate technical support will be sought. Funding required to secure needed expertise will be included as appropriate in requests for specific projects. Potential technical assistance sources for each management measure are listed below (Table 29).

Table 29. Summary of potential sources of technical assistance.

Technical Assistance	
Management Measure (MM)	**Potential Sources**
MM1: Develop and implement WQMPs or CPs	TSSWCB; local SWCDs; NRCS
MM2: Feral hog management	AgriLife Extension; TPWD; NRCS; TSSWCB
MM3: OSSFs	Designed technicians from counties; AgriLife Extension; CCT
MM4: Lawn and landscape maintenance	Cities; AgriLife Extension; NRA; Texas Sea Grant; CCT
MM5: Green stormwater infrastructure	CBBEP; AgriLife Extension; NRA; Texas Sea Grant; CCT
MM6: WWTFs	NRA; WWTFs
MM7: Reduce illicit dumping	AgriLife Extension; NRA; CBBEP; cities and counties

Livestock Management

Technical assistance to develop and implement practices to improve livestock management is available from TSSWCB, local SWCDs and local NRCS personnel. Interested producers must request planning assistance and these agencies will work with the producer to define operation-specific management goals and objectives and develop a management plan that prescribes effective practices that will achieve stated goals while also improving water quality.

Feral Hog Management

Watershed stakeholders can benefit from technical assistance regarding feral hog control approaches, options, best practices, and regulations. AgriLife Extension and TPWD can provide educational resources through local programs and public events. Online resources regarding feral hog trap and transport regulations, trap construction and design, and trapping techniques are also available at: http://feralhogs.tamu.edu/.

OSSF Management

Identifying failing OSSFs requires trained personnel and available time. County designated representatives or septic service providers can provide expertise and help identify systems in need of repairs or replacement. Technical support is also needed to help secure funding for large scale programs to repair or replace failing OSSFs. Education and outreach content for OSSF owners is also technical in nature and requires trained personnel. Texas A&M AgriLife Extension Service personnel can provide these educational resources.

Pet Waste

Limited technical assistance is available to directly address pet waste. City public works departments, homeowner associations and other entities as appropriate will be relied upon to identify viable sites for pet waste stations. These entities may also be able to provide operation and maintenance of collection sites. Educational materials can be provided to cities through AgriLife Extension, NRA, and Texas Sea Grant.

Urban Stormwater Infrastructure

Urban stormwater infrastructure and stormwater management efforts can benefit from technical assistance provided through education programs, BMP demonstrations, and public or privately funded projects. Practice demonstrations provide physical teaching tools and allow decision makers to see how practices look and function. This is especially useful for encouraging green stormwater infrastructure in areas where traditional practices are common. The NRA, CBBEP, and Texas Sea Grant will coordinate with city and county officials to develop and implement demonstration sites and full scale projects as needed. Technical assistance with education and outreach programming is available through AgriLife Extension, the NRA, and CBBEP. An additional resource is the *Guidance for Sustainable Stormwater Drainage on the Texas Coast,* published by the Clean Coast Texas (CCT) program in April 2021 (CCT 2021) that provides communities with information on how to implement development strategies that reduce NPS pollution resulting from land development. Structural projects may need engineering designs and should be integrated into the costs of the projects. In the city of Kingsville, a Drainage Master Plan was developed with funding from the U.S. Housing and Urban Development program for Community Development Block Grant. An engineering firm was awarded the contract in 2018 and subsequently worked with the community through public meetings to identify flood problem areas and mitigation solutions.

WWTF Infrastructure Repair or Replace

WWTFs have the potential to be large contributors of bacteria and nutrient loading in a watershed. This is especially true if facilities have antiquated or failing components needing repair or replacement. Addressing these issues in the San Fernando and Petronila Creek watersheds will take a coordinated effort by local governments and the NRA to ensure adequate funding is secured. Education and outreach assistance is available through the NRA.

Reduce Illicit Dumping

Efforts to reduce illicit dumping will focus on education and outreach in conjunction with hazardous waste collection events throughout the watershed. AgriLife Extension and the NRA will provide technical assistance with education and outreach efforts. County law enforcement and TPWD game wardens are the primary source for enforcement and monitoring activities associated with illicit dumping. NRA, CBBEP and Texas Sea Grant will continue efforts to secure funding support for cleanups and trash collection locations.

Technical Resource Descriptions

Texas A&M AgriLife Extension

AgriLife Extension is a statewide outreach education agency with offices in every county of the state. AgriLife Extension provides a network of professional educators, volunteers, and local county extension agents. AgriLife Extension will be consulted to develop and deliver education programs, workshops, and materials as needed.

Engineering Firms

Private firms provide consulting, engineering, and design services. The technical expertise provided by firms may be required for urban BMP design or wastewater infrastructure projects. Extensive work has been conducted by the General Land Office through their CCT Program to develop manuals and recommended strategies that can be incorporated into engineering designs. The CCT program can be leveraged by engineering firms to ensure future plans are aligned with the goals and regulatory guidelines of partnering organizations. Funding for services will be identified and written into project budgets as required.

County or City Designated Representatives

OSSF construction or replacement in Duval, Jim Wells, Kleberg, and Nueces counties requires a permit on file with local authorized agents. Permits must be applied for through a TCEQ licensed professional installer. The county or city's designated representative is responsible for approving or denying permits. Site evaluations must be done by a TCEQ licensed Site & Soil Evaluator, licensed maintenance provider or licensed professional installer.

Natural Resources Conservation Service

The USDA NRCS provides conservation planning and technical assistance to private landowners. For decades, private landowners have voluntarily worked with NRCS personnel to prevent erosion, improve water quality, and promote sustainable agriculture. Assistance is available to help landowners maintain and improve private lands, implement improved land management technologies, protect water quality and quantity, improve wildlife and fish habitat and enhance recreational opportunities. Local NRCS service centers are located in Benavides, Alice, Kingsville, and Robstown.

Nueces River Authority

NRA provides valuable assistance in all or parts of 22 counties located in the Nueces River Basin, the San Antonio – Nueces Coastal Basin, the Nueces Rio Grande Coastal Basin, and the adjacent Bays and Estuaries in South Texas. NRA provides routine water quality monitoring data to the state's database, conducts education outreach using custom made models, conducts riparian assessments/removal of invasive species, and provides WWTP operation expertise. NRA will be a primary source of water quality data and environmental technical assistance across the watershed.

Soil and Water Conservation Boards

A SWCD, like a county or school district, is a subdivision of the state government. SWCDs are administered by a board of five directors who are elected by their fellow landowners. There are 216 individual SWCDs organized in Texas. It is through this conservation partnership that local SWCDs can furnish technical assistance to farmers and ranchers for the preparation of a complete soil and water conservation plan to meet each land unit's specific capabilities and needs. The local SWCDs include Agua Poquita SWCD (Duval Co.), Nueces SWCD, Kleberg-Kenedy SWCD and Jim Wells County SWCD.

Texas Commission on Environmental Quality

The TCEQ offers a variety of programming and personnel resources that can provide technical support for WPP Implementation. TCEQ's Sanitary Sewer Overflow Initiative is a voluntary program for permitted WWTFs and municipalities. Through the initiative, an SSO Plan is developed outlining the causes of SSOs, mitigative and corrective actions, and a timeline for implementation. Assistance for SSO planning and participation in the SSO Initiative is available through the TCEQ Regional Office (Region 14, Corpus Christi; Region 16, Laredo) and the TCEQ Small Business and Environmental Assistance Division.

TCEQ Regional Offices also provide resources and expertise for environmental monitoring activities, investigating compliance at permitted facilities and responding to complaints, developing enforcement actions for violations, and performing environmental education and technical assistance for communities as needed. Regional offices also respond to environmental emergencies (disasters, spills, etc.) and evaluate public exposure to hazardous materials.

Texas Parks and Wildlife Department

The TPWD's Private Land Services is a program to provide landowners with practical information on ways to manage wildlife resources that are consistent with other land use goals, to ensure plant and animal diversity, to provide aesthetic and economic benefits and to conserve soil, water, and related natural resources. TPWD offers assistance in developing property-specific wildlife habitat management plans and can aid in tracking the expected water quality improvements. Additionally, TPWD offers a habitat management workshop through their regional biologists. To participate, landowners may request assistance by contacting the TPWD district serving their county.

Texas State Soil and Water Conservation Board

The TSSWCB supports the operation of local SWCDs and leads the WQMP Program by providing technical assistance for developing management and conservation plans at no charge to agricultural producers. A visit with the local SWCD offices is the first step for operators to begin the plan development process.

Clean Coast Texas

CCT is a website and technical information repository developed by the Texas General Land Office and members of the Texas Coastal Nonpoint Source Pollution Program that aims to address the negative impacts of urban development in Gulf Coast communities. Technical manuals are available on subjects such as sustainable stormwater, low-impact development, and green infrastructure. Elected officials, builders, engineers and homeowners are encouraged to utilize the free resources provided. The CCT program may be used as a reference for development and implementation of regulatory or incentivized stormwater management strategies to be adopted at the local government and organizational level.

Harte Research Institute for Gulf of Mexico Studies

The Harte Research Institute for Gulf of Mexico Studies at Texas A&M University Corpus Christi created a regional effort called the Regional Resilience Partnership. Their overall mission is to mitigate disaster risk and increase community resilience in the Texas Coastal Bend. With funding from the Economic Development Administration, the group is building an open-source GIS platform called GeoRED. The platform will integrate datasets of physical structures with layers representative of hazards so that the public may better assess risks in counties along the Texas coast.

Financial Resources Descriptions

Successful WPP implementation will require substantial fiscal resources. Diverse funding sources will be sought to meet these needs. Resources will be leveraged where possible to extend the impacts of acquired and contributed implementation funds.

Grant funds will be relied upon to initiate implementation efforts. Existing state and federal programs will also be expanded or leveraged with acquired funding to further implementation impacts. Grant funds are not a sustainable source of financial assistance but are necessary to assist in WPP implementation. Other sources of funding will be utilized, and creative funding approaches will be sought where appropriate. Sources of funding that are applicable to this WPP will be sought as appropriate and are described in this chapter.

Federal Sources

Clean Water Act §319(h) Nonpoint Source Grant Program

The EPA provides grant funding to the State of Texas to implement projects that reduce NPS pollution through the §319(h) Nonpoint Source Grant Program. These grants are administered by TCEQ and TSSWCB. WPPs that satisfy the nine key elements of successful watershed-based plans are eligible for funding though this program. To be eligible for funding, implementation measures must be included in the accepted WPP and meet other program rules. Some commonly funded items include but are not limited to:

- Development and delivery of education programs
- Water quality monitoring

- OSSF repairs and replacements
- BMP installation and demonstrations
- Waterbody cleanup events

Further information can be found at: https://www.tceq.texas.gov/waterquality/nonpoint-source/grants/grant-pgm.html and https://www.tsswcb.texas.gov/programs/texas-nonpoint-source-management-program

Conservation Stewardship Program

The Conservation Stewardship Program (CSP) is a voluntary conservation program administered by the USDA NRCS that encourages producers to address resource concerns in a comprehensive manner by undertaking additional conservation activities and improving, maintaining, and managing existing conservation activities. The program is available for private agricultural lands including cropland, grassland, prairie land, improved pasture, and rangeland. CSP encourages landowners and stewards to improve conservation activities on their land by installing and adopting additional conservation practices including, but not limited to, prescribed grazing, nutrient management planning, precision nutrient application, manure application, and integrated pest management. Program information can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/

Conservation Reserve Program

The Conservation Reserve Program is a voluntary program for agricultural landowners administered by the USDA Farm Service Agency. Individuals may receive annual rental payments to establish long-term, resource conserving covers on environmentally sensitive land. The goal of the program is to reduce runoff and sedimentation to protect and improve lakes, rivers, ponds, and streams. Financial assistance covering up to 50% of the costs to establish approved conservation practices, enrollment payments, and performance payments are available through the program. Information on the program is available at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

Environmental Quality Incentives Program (EQIP)

USDA NRCS operates the EQIP which is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of 10 years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and provides opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. Individuals engaged in livestock or agricultural production on eligible land are permitted to participate in EQIP. Practices selected address natural resource concerns and are subject to the NRCS technical standards adapted for local conditions. They also must be approved by the local SWCD. Local work groups are formed to provide recommendations to the USDA NRCS that advise the agency on allocations of EQIP county-based funds and identify local resource concerns. Watershed stakeholders are strongly encouraged to participate in their local work group to promote the objectives of this WPP with the resource concerns and conservation priorities of EQIP. Information regarding EQIP can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

National Water Quality Initiative

The National Water Quality Initiative (NWQI) is administered by the NRCS, and is a partnership between the NRCS, state water quality agencies, and the EPA to identify and address priority impaired water bodies through voluntary conservation. Conservation systems include practices to promote soil health, reduce erosion and nutrient runoff. Further information is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/?cid=stelprdb1047761

Regional Conservation Partnership Program

The Regional Conservation Partnership Program (RCPP) is a comprehensive, and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Through the RCPP and NRCS, state, local and regional partners coordinate resources to help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved. Information regarding RCPP can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/rcpp/

Rural Development Water & Environmental Programs

USDA Rural Development provides grants and low interest loans to rural communities for potable water and wastewater system construction, repair, or rehabilitation. Funding options include:

- Rural Repair and Rehabilitation Loans and Grants: provides assistance to make repairs to low-income homeowners' housing to improve or remove health and safety hazards.
- Technical Assistance and Training Grants for Rural Waste Systems: provides grants to non-profit organizations that offer technical assistance and training for water delivery and waste disposal.
- Water and Waste Disposal Direct Loans and Grants: assists in developing water and waste disposal systems in rural communities with populations less than 10,000 individuals.

More information about the Rural Development Program can be found at: https://www.rd.usda.gov/programs-services/water-environmental-programs

Urban Water Small Grants Program

The objective of the Urban Waters Small Grants Program, administered by the EPA, is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. In particular, the Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of local urban waterways.

More information about the Urban Waters Small Grants Program can be found at: https://www.epa.gov/urbanwaters/urban-waters-small-grants

Community Development Block Grants

Grants are available through the U.S. Housing and Urban Development program. The city of Kingsville has been awarded a Community Development Block Grant to address urban runoff and stormwater management. The city was able to use the funds to develop a Drainage Master Plan that will be implemented soon through contracting with an engineering firm.

More information about the Urban Waters Small Grants Program can be found at: https://www.hud.gov/program_offices/comm_planning/cdbg

State Sources

Clean Rivers Program

The TCEQ administers the Texas CRP, a state fee-funded program that provides surface water quality monitoring, assessment and public outreach. Allocations are made to 15 partner agencies (primarily river authorities) throughout the state to assist in routine monitoring efforts, special studies, and outreach efforts. NRA is the partner for the San Fernando and Petronila Creek watershed. The program supports water quality monitoring, annual water quality assessments, and engages stakeholders in addressing water quality concerns in the Baffin Bay watershed.

More information about the NRA CRP is available at: https://nracleanriversprogram.org/

Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF), authorized through the CWA and administered by the Texas Water Development Board (TWDB), provides low-interest loans to local governments and service providers for infrastructure projects that include stormwater BMPs, WWTFs and collection systems. The loans can spread project costs over a repayment period of up to 20 years. Repayments are cycled back into the fund and used to pay for additional projects. Through 2020, the program has committed approximately $10 billion for projects across Texas. More information on CWSRF is available at: http://www.twdb.texas.gov/financial/programs/CWSRF/

Landowner Incentive Program

TPWD administers the Landowner Incentive Program (LIP) for private landowners to implement conservation practices that benefit healthy aquatic and terrestrial ecosystems and create, restore, protect or enhance habitat for rare or at-risk species. The program provides financial assistance but does require the landowner to contribute through labor, materials or other means. Further information about this program is available at: https://tpwd.texas.gov/landwater/land/private/lip/

Supplemental Environmental Projects

The Supplemental Environmental Program (SEP) program, administered by TCEQ, directs fines, fees and penalties for environmental violations toward environmentally beneficial uses. Through this program, a respondent in an enforcement matter can choose to invest penalty dollars to improve the environment, rather than paying into the Texas General Revenue Fund. Program dollars may be directed to OSSF repair, trash clean up and wildlife habitat restoration or improvement, among other things. Program dollars may be directed to entities for single, one-time projects that require special approval from TCEQ or directed entities (such as Resource Conservation and Development Councils) with pre-approved "umbrella" projects. Further information about SEP is available at: https://www.tceq.texas.gov/compliance/enforcement/sep/sep-main

Texas Farm and Ranch Lands Conservation Program

The Texas Farm and Ranch Lands Conservation Program was established and is administered by TPWD to conserve high value working lands to protect water, fish, wildlife and agricultural production that are at risk of future development. The program's goal is to educate citizens on land resource stewardship and establish conservation easements to reduce land fragmentation and loss of agricultural production. Program information is available from TPWD at: https://tpwd.texas.gov/landwater/land/private/farm-and-ranch/

Other Sources

Private foundations, non-profit organizations, land trusts and individuals can potentially assist with implementing some aspects of the WPP. Funding eligibility requirements for each program should be reviewed before applying to ensure applicability. Some groups that may be able to provide funding include but are not limited to:

- Cynthia and George Mitchell Foundation: Provides grants for water and land conservation programs to support sustainable protection and conservation of Texas' land and water resources.
- Dixon Water Foundation: Provides grants to non-profit organizations to assist in improving/maintaining watershed health through sustainable land management.
- Meadows Foundation: Provides grants to non-profit organizations, agencies and universities engaged in protecting water quality and promoting land conservation practices to maintain water quality and water availability on private lands.
- Partnerships with local industry in the watershed could also provide in-kind donations or additional funding for implementation projects.

- Texas Agricultural Land Trust: Funding provided by the trust assists in establishing conservation easements for enrolled lands.

Chapter 10 Measuring Success

Implementing this WPP requires coordination with many stakeholders over the next 10 years. Implementation will focus on addressing readily manageable bacteria sources in the watershed to achieve water quality targets. This plan identified substantial financial resources, technical assistance, and education required to achieve these targets. Management measures identified in this WPP are voluntary but supported at the recommended levels by watershed stakeholders.

Measuring WPP implementation impacts on water quality is a critical process. Planned water quality monitoring at critical locations will provide data needed to document progress toward water quality goals. While improvements in water quality are the preferred measure of success, documenting implementation accomplishments can also be used. Combining water quality data and implementation accomplishments helps facilitate adaptive management by illustrating which recommended measures are working and which measures need modification.

Water Quality Targets

An established water quality goal defines the target for future water quality and allows the needed bacteria load reductions to be defined. The stakeholder selected water quality goal in San Fernando and Petronila Creek is the existing primary contact recreation standard for *E. coli* of 126 cfu/100 mL and enterococcus of 35 cfu/100 mL in the tidal segment (Table 30). If there are revisions or adoption of new water quality standards (such as nutrients), these targets may be revised or amended as appropriate.

Table 30. The water quality targets for impaired water bodies in the San Fernando and Petronila Creek watersheds.

Station(s)	Segment	Current Concentration†	5 Years After Implementation†	10 Years After Implementation†
13090	2203_01	44.9	40.0	≤35
13094	2204_01	419.4	272.5	≤126
13096	2204_02	592.5	359.3	≤126
20806	2204_02	28.8	≤126	≤126
13033	2492A_01	303.6	214.8	≤126

† Geometric mean in units of most probable numbers of *E. coli* (enterococcus in tidal segment, 2203_01) per 100 milliliters of water

Additional Data Collection Needs

Continued water quality monitoring in the San Fernando and Petronila Creek watersheds is necessary to track water quality changes resulting from WPP implementation. Currently, the NRA conducts quarterly water quality monitoring at five monitoring stations in the watersheds. This continues data collection at monitoring stations used in state water quality assessment and is critical for future evaluations and should be continued. Additionally, stations 13033 and 13096 were used in LDC analysis to determine needed load reductions to meet the water quality targets listed above. Continued data collection over time is imperative for changes in bacteria loading to be evaluated.

The current monitoring site distribution and data collection frequency across the watersheds limit potential to observe subtle changes water quality that result from WPP implementation. Defining localized water quality impacts from specific WPP implementation activities will require focused water quality monitoring efforts which can only be planned once specific WPP implementation activities and locations are known. Focused monitoring plans will require funding support and will be used to assess implementation effectiveness. Targeted water quality monitoring could include paired watershed studies, multiple watershed studies, or edge of field runoff analysis where different land use or management measures have been implemented. Data derived from this monitoring could demonstrate the applicability of different BMPs within the watershed. Targeted monitoring may also include more intensive sampling in other stream segments to identify potential pollutant sources.

Additional data collection is also warranted outside the watershed boundaries to better understand the influences of WPP implementation on water quality in Baffin Bay. Expanded Los

Olmos Creek monitoring is needed to further understand its influence on Baffin Bay water quality. Continued routine and special project monitoring should be prioritized in Baffin Bay and Los Olmos Creek.

Through the adaptive management process and WPP updates, future water quality monitoring needs will be evaluated and adjusted as necessary. This could include adding new sites to address new concerns or areas of interest in the watershed.

Data Review

Watershed stakeholders are responsible for evaluating WPP implementation impacts on instream water quality. Stakeholders will use TCEQ's statewide biennial water quality assessment approach, which uses a moving seven-year geometric mean of bacteria data collected through the state's CRP as a primary means of gauging implementation success. This assessment is published in the *Texas Integrated Report and 303(d) List* and is available online at: https://www.tceq.texas.gov/waterquality/assessment/305_303.html. It is noted that a two-year lag occurs in data reporting and assessment, therefore the 2024 or 2026 *Texas Integrated Report* will likely be the first to include water quality data collected during WPP implementation.

Identifying water quality improvements from WPP implementation is challenging if only relying on the seven-year-data window used for the *Texas Integrated Report*. Therefore, another method to evaluate water quality improvements is using the geometric mean of the most recent three years of water quality data identified within TCEQ's Surface Water Quality Monitoring Information System. To support data assessment as needed, trend analysis and other appropriate statistical analyses will be used. Regardless of method used, water quality changes resulting from WPP implementation will be difficult to determine and may be overshadowed by activity in the watershed that negatively influences water quality. As such, data review will not be relied on exclusively to evaluate WPP effectiveness. Data will be summarized and reported to watershed stakeholders at least annually through stakeholder meetings and NRA's annual CRP meeting.

The watershed coordinator will be responsible for tracking implementation targets and water quality in the watershed. Implementation progress and water quality will be evaluated to describe the success of WPP implementation to that point. Should implementation targets or water quality lag significantly, adaptive management efforts will be initiated to reevaluate management recommendations and targets included in the WPP.

Interim Measurable Milestones

WPP implementation will occur over a 10-year timeframe. Milestones can be useful in evaluating incremental implementation progress of management measures described in the WPP. Milestones outline a clear process for progression throughout implementation. Interim measurable milestones for management measures and education and outreach are addressed in Table 28. Responsible parties and estimated costs (where available) are included in the schedule. In some cases, funding acquisition, personnel hiring, or program initiation may delay the start of some items. This approach provides incremental targets to measure progress throughout WPP implementation. Adaptive management may be used where necessary to reorganize or prioritize varying implementation aspects to achieve overarching water quality goals.

Adaptive Management

Watersheds are dynamic by nature with countless variables governing landscape processes; therefore, uncertainty is expected and the WPP was developed with this in mind. As WPP implementation progresses, it is necessary to track water quality over time and make needed adjustments to the implementation strategy. Including an adaptive management approach in the WPP provides flexibility that enables such adjustments.

Adaptive management is the ongoing process of accumulating knowledge regarding impairment causes and water quality response as implementation efforts progress and adjusting management efforts as needed. As implementation activities are instituted, water quality is tracked to assess impacts. This information can be used to guide adjustments to future implementation activities. This ongoing, cyclical implementation and evaluation process can focus project efforts and optimize its impacts. Watersheds where impairments are dominated by NPS pollutants are good candidates for adaptive management. Progress toward achieving established water quality targets will also be used to evaluate the need for adaptive management. An annual implementation progress and water quality trends review will be presented to stakeholders during meetings. Due to numerous factors that can influence water quality and the time lag that often appears between implementation efforts and resulting water quality improvements, sufficient time should be allowed for implementation to occur before triggering adaptive management. In addition to water quality targets, if satisfactory progress toward achieving milestones is determined to be infeasible due to funding, implementation scope or other reasons that would prevent implementation, adaptive management provides an opportunity to revisit and revise the implementation strategy. If stakeholders determine inadequate progress toward water quality improvement or milestones is being made, efforts will be made to increase BMP adoption and adjust strategies or focus areas as appropriate.

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Appendix A: Potential Load Calculations

Estimates for potential loads are based on the best available data (local, state and federal databases; scientific research) and local stakeholder input (e.g. local livestock stocking practices, wildlife densities, etc.). Potential loading rates assume a worst-case scenario and are primarily used to calculate where management measures should be implemented first to maximize effectiveness and estimate potential load reductions.

Livestock

Calculating potential bacteria loads from livestock requires animal population estimates for the watershed. USDA provides recommended livestock stocking rates by county based on livestock census data. These estimates were used to estimate an initial livestock population as a basis to present to stakeholders in the watershed. Using stakeholder feedback, stocking rates for different counties were adjusted as shown in Table 31. Animal numbers fluctuate annually based on local conditions; however, this approach provides a baseline to estimate potential loadings. Challenges using this approach to estimate livestock numbers include the reliance on land cover maps and the difficulty in identifying pasture and rangeland. These maps do not differentiate between land that is used for hay production versus grazed pasture. Furthermore, identifying actual stocking rates used by individual landowners is impossible. Therefore, reliance on local stakeholders was critical to properly estimating cattle populations.

Cattle

Cattle are the dominant livestock species in the watersheds and were assessed separate from other livestock. Cattle estimates were compared to NASS population estimates for watershed counties to determine if generated estimates compared to USDA stocking rate-based estimates. Using these inputs, there are an estimated 29,544 cattle animal units (AnU) in the San Fernando watershed and 8,670 cattle AnU in the Petronila watershed for a combined total of 38,214 cattle AnU across both watersheds. The two methods differed by 21 animals across the watershed.

Table 31. USDA recommended cattle stocking rates by county measured in acre/animal unit (Ac/AnU).

County	pasture / grassland	light brush	medium brush	heavy brush	Med/Heavy Combined
Duval	7	18	27	34	30.5
Jim Wells	10	15	20	25	22.5
Nueces	5	15	23	28	25.5
Kleberg	17	21	n/a	32	32

Using cattle population estimates generated, potential *E. coli* loading across the watershed and for individual subwatersheds was estimated with GIS analysis. The annual load from cattle was calculated as:

$$PAL_{cattle} = AnU \times FC_{cattle} \times Conversion \times 365 \frac{days}{year}$$

Where:

PAL_{cattle} = Potential annual *E. coli* loading attributed to cattle

AnU = Animal Units of cattle (~1,000 lbs of cattle)

FC_{cattle} = Fecal coliform loading rate of cattle, 8.55×10^9 cfu fecal coliform per AnU per day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subwatersheds due to cattle is 1.58×10^{14} cfu *E. coli* per year in the San Fernando Creek watershed and 4.69×10^{13} cfu *E. coli* per year in the Petronila Creek watershed.

Other Livestock

NASS reported number for goats, sheep, and horses were used for these species and were scaled down to the watershed area in appropriate land covers using GIS. Potential *E. coli* loading for individual subwatersheds was estimated using these estimates. The annual load from other livestock was calculated as:

$$PAL_{OL} = [(AnU \times FC_{goat}) + (AnU \times FC_{horse}) + (AnU \times FC_{sheep})] \times Conversion \times 365 \frac{days}{year}$$

Where:

PAL_{OL} = Potential annual *E. coli* loading attributed to other livestock

AnU = Animal Units (~1,000 lbs of live animal weight)

FC_{goat} = Fecal coliform loading rate of cattle, 4.32×10^9 cfu fecal coliform per AnU per day (Wagner and Moench 2009)

FC_{horse} = Fecal coliform loading rate of cattle, 3.64×10^8 cfu fecal coliform per AnU per day (Wagner and Moench 2009)

FC_{sheep} = Fecal coliform loading rate of cattle, 5.8×10^{10} cfu fecal coliform per AnU per day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subwatersheds due to other livestock is 1.82×10^{14} cfu *E. coli* per year in the San Fernando Creek watershed and 5.74×10^{13} cfu *E. coli* per year in the Petronila Creek watershed.

Feral Hogs

Feral hog populations were estimated using an estimated population density of 1 feral hog per 39.4 ac of suitable habitat. The density estimate was based on statewide estimates described in Timmons et al. (2012) then adjusted based on stakeholder feedback within each watershed. GIS analysis was used to estimate watershed-wide and subwatershed feral hog populations. Based on this analysis, an estimated 17,826 feral hogs exist within the San Fernando watershed and 3,933 feral hogs within the Petronila watershed. Like other population estimates, these numbers provide general estimates that change based on actual conditions. Furthermore, feral hogs roam across large areas that might be larger than individual subwatersheds; however, these estimates provide guidance on where to focus control efforts based on suitable habitats. Using the feral hog population estimates, we estimated potential *E. coli* loading across the watershed and for individual subwatersheds. The annual load from feral hogs was calculated as:

$$PAL_{fh} = N_{fh} \times AnUC \times FC_{fh} \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_{fh} = Potential annual *E. coli* loading attributed to feral hogs

N_{fh} = Number of feral hogs

AnUC = Animal Unit Conversion; 0.125 AnU per feral hog (Wagner and Moench 2009)

FC_{fh} = Fecal coliform loading rate of feral hogs, 1.21×10^{9} cfu fecal coliform per AnU per day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

The estimated potential annual loading across all subwatersheds due to feral hogs is 1.66×10^{12} cfu *E. coli* per year in the San Fernando Creek watershed and 1.01×10^{12} cfu *E. coli* per year in the Petronila Creek watershed.

Domestic Pets

Dog estimates were generated using an estimated population density of 0.614 dogs per household applied to weighted census block household data (AVMA 2018). In the San Fernando Creek watershed, there are an estimated 16,507 dogs. In the Petronila Creek watershed, there are an estimated 3,875 dogs. It was assumed that approximately 40% of dog owners do not pick up dog waste (Swann 1999). Based on these assumptions, there are an estimated 6,603 dogs in the San Fernando Creek watershed and 1,550 dogs in the Petronila Creek watershed whose owners do not pick up after them. Using the resulting dog population estimate, the annual load due to dogs was estimated as:

$$PAL_{d} = N_{d} \times FC_{d} \times Conversion \times 365\,\frac{days}{year}$$

Where:

PAL_d = Potential annual *E. coli* loading attributed to dogs

N_d = Number of dogs that owners do not pick up after

FC_d = Fecal coliform loading rate of dogs, 5.00×10^9 cfu fecal coliform per dog per day (EPA 2001)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Therefore, the estimated potential annual loading attributed to dogs is 5.12×10^{13} cfu *E. coli* per year in the San Fernando Creek watershed and 1.07×10^{13} cfu *E. coli* per year in the Petronila Creek watershed.

OSSFs

Using the watershed OSSF estimates and distribution, potential *E. coli* loading for individual subwatersheds was estimated. Methods to estimate OSSF locations and numbers are described in Chapter 4 of this WPP. The annual load from OSSFs was calculated as:

$$PAL_{ossf} = N_{ossf} \times N_{hh} \times Production \times Failure\ Rate \times FC_s \times Conversion \times 365 \frac{days}{year}$$

Where:

PAL_{ossf} = Potential annual *E. coli* loading attributed to OSSFs

N_{ossf} = Number of OSSFs

N_{hh} = Average number of people per household (2.05)

Production = Assumed sewage discharge rate; 70 gallons per person per day (Borel et al. 2015)

Failure Rate = Assumed failure rate; 15% (Reed, Stowe & Yanke 2001)

FC_s = Fecal coliform concentration in sewage; 1.0×10^6 cfu/100 mL (EPA 2001)

Conversion = Conversion rate from fecal coliform to *E. coli*; 126/200 (Wagner and Moench 2009) and mL to gallon (3785.4 mL per gallon)

The estimated potential annual loading across all subwatersheds due to OSSFs is 1.45×10^{12} cfu *E. coli* per year in the San Fernando Creek watershed and 1.10×10^{12} cfu *E. coli* per year in the Petronila Creek watershed.

WWTFs

Potential loadings from WWTFs were calculated for all permitted dischargers with a bacteria monitoring requirement. Potential loads were calculated as the sum of the maximum permitted discharges of all WWTFs multiplied by the maximum permitted *E. coli* concentration:

$$PAL_{wwtf} = Discharge \times Concentration_{max} \times Conversion \times 365\ days/year$$

Where:

PAL_{wwtf} = Potential annual *E. coli* loading due to wastewater treatment plant discharges

Discharge = Maximum permitted daily discharge

$Concentration_{max}$ = Maximum average permitted concentration of *E. coli* in wastewater discharge (126 cfu/100 mL)

Conversion = Unit conversion (3785.4 mL/gallon)

The estimated potential annual loading across all subwatersheds due to WWTF discharges are 4.71×10^{10} cfu *E. coli* per year in the San Fernando Creek watershed and 2.65×10^{9} *E. coli* per year in the Petronila Creek watershed.

Appendix A References

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Appendix B: Load Reduction Calculations

Livestock

E. coli loading reductions resulting from implementation of CPs and WQMPs (plans) involves potential reductions from various livestock. Cattle are the dominant livestock in the watershed though and were assumed to be the species managed through livestock-focused management.

According to USDA NASS data and stakeholder input, there are an estimated 29,544 AnU of cattle in the San Fernando watershed and 8,670 AnU of cattle in the Petronila watershed for a combined total of 38,214 AnU of cattle across both watersheds (see Appendix A). This information was used to estimate the number of cattle per operation. In the Petronila Creek watershed, 53 AnU per operation were assumed and 30 AnU per operation were estimated in the San Fernando Creek watershed. These are the presumed number of cattle managed by each plan.

The Agriculture work group estimated that 200 producers per watershed will be willing to implement management plans if assistance is provided. However, not all of these will primarily address livestock. USDA NASS also reports average farm/ranch size and the number of farms/ranches by county. Averaged across the four counties that make up the watershed, average farm/ranch size is 686.5 ac. Using this size and the percentage of suitable grazing acres compared to total agricultural acres across the watersheds (Table 2), the anticipated number of plans that will primarily address livestock loading in each watershed was estimated (Table 32).

Table 32. Data for estimating grazing focused plans

Watershed	Suitable Grazing Acres[1]	Total Grazing plus Cropped Acres[1]	Percent of Acres for Grazing	Presumed # of Plans with Grazing Focus (out of 200 total)
Petronila	112,237	399,783	28%	56
San Fernando	660,557	743,396	89%	178

[1] Acres reported in Table 2 from the 2017 NLCD land cover layer

In reality, each plan will vary in size and number of actual AnU addressed based on the specifics of the managed property and the current climatic conditions.

To estimate expected *E. coli* reductions, median BMP efficacy values reported in literature were used (Table 33). BMPs were selected based on agriculture work group member feedback.

Because actual BMPs implemented in each plan are unknown, an overall median efficacy value of 0.62 (62%) was used to estimate load reductions. The proximity of implemented BMPs to water bodies also influences the effectiveness at reducing loads reaching the creek. A proximity factor of 0.05 (5%) is used for BMPs in upland areas and 0.25 used in riparian areas. Since there is uncertainty in specific BMPs and the locations where plans are implemented, an average proximity factor of 0.15 was used.

Table 33. Best management practice load reduction median effectiveness values

Management Practice	*E. coli*	Nitrogen	Phosphorus
Exclusionary Fencing[1]	62%[1]	33%[4]	49%[7]
Prescribed Grazing[2]	54%[2]	55%[5]	41%[8]
Watering Facility[3]	73%[3]	5%[6]	57%[9]

[1] Brenner et al. 1996; Cook 1998; Hagedorn et al. 1999; Line 2002; Line 2003; Lombardo et al. 2000; Meals 2001; Meals 2004; Peterson et al. 2011
[2] Tate et al. 2004; EPA 2010.
[3] Byers et al. 2005; Hagedorn et al. 1999; Sheffield et al. 1997
[4] Line et al. 2000
[5] Chesapeake Bay Program, 2017; Olness et al., 1980; Tuppad et al., 2010
[6] Byers et al. 2005; Chesapeake Bay Program, 2017
[7] Flores-Lopez et al., 2010; Kay et al., 2009; Line et al., 2000, 2016; Sharpley et al., 2009
[8] Chesapeake Bay Program, 2017; Olness et al., 1980; Sharpley et al., 2009; Tuppad et al., 2010
[9] Byers et al., 2005, Kay et al., 2009; Sheffield et al. 1997

Total potential *E. coli* load reductions from plans were calculated with the following equation:

$$LR_{cattle} = N_{plans} \times \frac{AnU}{Plan} \times FC_{cattle} \times Conversion \times 365\frac{days}{year} \times BMP\ Efficacy \times Proximity\ Factor$$

Where:

LR_{cattle} = Potential annual load reduction of *E. coli*

N_{plans} = Number of WQMPs and CPs, 200 are proposed in each watershed for this WPP

AnU/Plan = Animal Units of cattle (~1,000 lbs of cattle) per management plan

FC_{cattle} = Fecal coliform loading rate of cattle, 8.55×10^9 cfu fecal coliform per AnU per day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Efficacy = Median BMP efficacy value, 0.62

Proximity Factor = percentage-based factor based on the assumed proximity of the management measure to the waterbody, 0.15

Using the above described inputs, estimated annual potential *E. coli* load reductions by managing cattle through plans (San Fernando (178) and Petronila (56) Creek watersheds) total 8.15×10^{13} cfu in Petronila Creek and 1.50×10^{14} cfu in San Fernando Creek. Additionally, nutrient reductions can also be anticipated with each plan through some of the same practices used to reduce bacteria loading (Table 33). Using the same assumptions as above, potential nutrient load reductions expected from cattle management practices were estimated with:

Number of plans × cattle per plan × pounds of nutrient per animal per day × median effectiveness × proximity factor

Based on the above assumptions and equations, the total potential nitrogen load reduction from implementation of CPs is estimated at 16,633 lbs of nitrogen and 8,763 lbs of phosphorus per year in the Petronila Creek watershed. In the San Fernando Creek watershed, total potential load reductions are estimated at 30,610 lbs of nitrogen per year and 16,128 lbs of phosphorus per year.

Feral Hogs

Loading reductions for feral hogs assume that existing feral hog populations can be reduced and maintained by a certain amount on an annual basis. Removal of a feral hog from the watershed is assumed to completely remove the potential bacteria load generated by that feral hog. Therefore, the total potential load reduction is calculated as the population reduction in feral hogs achieved in the watershed. Based on GIS analysis, 3,933 feral hogs were estimated to exist across the San Fernando Creek watershed and 17,826 across the Petronila Creek watershed (see Appendix A for details). The established goal is to reduce and maintain the feral hog population 15% below current population estimates, thus resulting in a 15% reduction in potential loading that is attributable to feral hogs. Load reductions were calculated based on the following:

$$LR_{fh} = N_{fh} \times FC_{fh} \times Conversion \times Proximity\ Factor\ \times 365 \frac{days}{year}$$

Where:

LR_{fh} = Potential annual load reduction of *E. coli* attributed to feral hog removal

N_{fh} = Number of feral hogs removed

FC_{fh} = Fecal coliform loading rate of feral hogs, 1.00×10^{10} cfu fecal coliform per AnU per day (Wagner and Moench 2009)

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench 2009)

Proximity Factor = 0.25

The estimated potential annual loading across the San Fernando and Petronila Creek watershed based on reducing and maintaining the population by 15% (2,674 feral hogs in San Fernando Creek watershed and 590 in Petronila Creek watershed) is 9.28×10^{13} and 2.05×10^{13} cfu *E. coli* annually, respectively. Nutrient reductions are also anticipated for each feral hog removed. USDA NRCS (2009) estimates nitrogen and phosphorus production from swine at 0.14 and 0.05 lbs per day respectively. Using these values and the equation below, annual load reductions 3,769 lbs of nitrogen and 1,346 lbs of phosphorus per year can be removed from the Petronila Creek watershed. In the San Fernando Creek watershed, these annual reductions are 17,080 and 6,100 lbs of nitrogen and phosphorus respectively.

Removed feral hogs × pounds of nutrient per animal per day × 0.125 (AnU per feral hog) × 365 days

Domestic Pets

The San Fernando Creek watershed contains approximately 16,507 dogs and the Petronila Creek watershed contains approximately 3,875 dogs. Load reductions assume that approximately 10% of pet owners that do not currently dispose of pet waste will respond to the management measure efforts (Swann, 1999). Therefore, the goal is to increase the number of pet owners that dispose of pet waste by 660 and 155 pet owners in each of the San Fernando and Petronila Creek watersheds, respectively. The resulting reductions are calculated by:

$$LR_d = N_d \times FC_d \times Conversion \times Effectiveness\ Factor \times 365\frac{days}{year}$$

Where:

LR_d = Potential annual load reduction of *E. coli* attributed to proper dog waste disposal

N_d = Number of additional dog owners disposing of pet waste (10% of total dogs)

FC_d = Fecal coliform loading rate of dogs, 5.0×10^9 cfu fecal coliform per dog per day (EPA, 2001)

$Effectiveness\ Factor$ = 0.5

Conversion = Estimated fecal coliform to *E. coli* conversion rate; 126/200 (Wagner and Moench, 2009)

The estimated potential load reduction attributed to dog waste management in San Fernando Creek is 9.49×10^{14} cfu *E. coli* annually and 2.23×10^{14} cfu *E. coli* annually in Petronila Creek. Additionally, nutrient reductions are anticipated from proper dog waste management. Schuster and Grismer (2004) report daily nitrogen and phosphorus production of 1.3 g and 0.3 g per dog respectively. Using this information and the equation below, in the Petronila Creek watershed an estimated 202.3 lbs of nitrogen and 46.7 lbs of phosphorus per year are expected to be removed. In the San Fernando Creek watershed, expected reductions for nitrogen and phosphorus are 861.6 and 198.8 lbs per year respectively.

Dogs in watershed × percent of dogs managed × grams of nitrogen per day × pounds per gram × practice efficiency

Where:

Pounds per gram = 0.0022

OSSFs

OSSFs are common in the San Fernando and Petronila Creek watersheds with an estimated 9,087 systems across both watersheds. OSSF failures are factors of system age, soil suitability, system design and maintenance. For this area of the state, a 15% failure rate is assumed (Reed, Stowe & Yanke 2001). Load reductions from repairing or replacing failing OSSFs are calculated based on the number of assumed failing OSSFs replaced. The following equation was used to calculate potential load reductions:

$$LR_{ossf} = N_{ossf} \times N_{hh} \times Production \times FC_s \times Conversions \times 365 \frac{days}{year}$$

Where:

LR_{ossf} = Potential annual load reduction of *E. coli* attributed to OSSF repair/replacement

N_{ossf} = Number of OSSFs repaired/replaced

N_{hh} = 2.89 = Average number of people per household (four county average; US Census Bureau 2021)

Production = Assumed sewage discharge rate; 70 gallon per person per day (Borel et al. 2012)

FC_s = Fecal coliform concentration in sewage; 1.0×10^7 cfu/100 mL (EPA 2001)

Conversions = Conversion rate of 126/200 from fecal coliform to *E. coli* (Wagner and Moench 2009) and mL to gallon (3785.4 mL per gallon)

Proximity Factor = 0.5 for very limited; 0.1 for not limited soil suitability (76% of OSSFs presumed in very limited soils; 24% presume in not limited soils)

In the San Fernando Creek and Petronila Creek watersheds, it is assumed that 40 and 60 OSSFs, respectively, will be repaired or replaced. This results in a potential reduction of 4.52×10^{14} cfu *E. coli* annually in the San Fernando Creek watershed and 6.78×10^{14} cfu *E. coli* annually in the Petronila Creek watershed. Additionally, nutrient reductions are anticipated for every OSSF replaced.

Table 34. OSSF septage constituent assumptions

Assumptions	
Persons per household	2.89 (US Census Bureau 2021)
Milligrams of nitrogen per liter of septage	40 mg/L (Davis & Cornwell, 1991)
Milligrams of phosphorus per liter of septage	10 mg/L (Davis & Cornwell, 1991)
Gallons of septage per person per day	70
Pounds per milligram	2.2×10^{-6}
Liters per Gallon	3.79

Number of OSSFs replaced × average people per household × milligrams of nutrient per liter × gallons of sewage produced per person per day × pounds per milligram × liters per gallon × 365 days/year

Using the assumption (Table 34) and equation above, annual nutrient reductions for the watersheds are estimated at 1,477.6 lbs of nitrogen and 369.4 lbs of phosphorus reduced in Petronila Creek and 985.1 lbs of nitrogen and 246.3 lbs of phosphorus reduced from San Fernando Creek.

Appendix B. References

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Appendix C. Watershed Protection Plan Review Checklist

EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA 2008) describes the nine elements critical for achieving improvements in water quality that must by sufficiently included in a WPP for it to be eligible for implementation funding through the CWA Section 319(h) funds. These elements do not preclude additional information from being included in the WPP. This Appendix briefly describes the nine elements and references the chapters and sections that fulfill each element.

Name of Waterbody	San Fernando and Petronila Creek Watersheds
Assessment Units	2203_01, 2204A_01, 2204B_01, 2204_01, 2204_02, 2492A_01
Impairments Addressed	Bacteria and nutrient concerns
Concerns Addressed	Impaired fish community, nitrate, total phosphorus

Element	**Report Section(s) and Page Number(s)**
Element A: Identification of Causes and Sources	
1. Sources identified, described and mapped	Ch. 3, Ch. 4, Ch.5, Appendix A
2. Subwatershed sources	Ch. 5
3. Data sources are accurate and verifiable	Ch. 5, Appendix A
4. Data gaps identified	Appendix A
Element B: Expected Load Reductions	
1. Load reductions achieve environmental goal	Ch. 5, Appendix B
2. Load reductions linked to sources	Ch. 5
3. Model complexity is appropriate	Appendix B
4. Basis of effectiveness estimates explained	Ch. 6 Table 20-27, Appendix B
5. Methods and data cited and verifiable	Appendix B
Element C: Management Measures Identified	
1. Specific management measures are identified	Ch. 6
2. Priority areas	Ch. 6

Element	Report Section(s) and Page Number(s)
3. Measure selection rationale documented	Ch. 6
4. Technically sound	Ch. 6
Element D: Technical and Financial Assistance	
1. Estimate of technical assistance	Ch. 9
2. Estimate of financial assistance	Ch. 9
Element E: Education/Outreach	
1. Public education/information	Ch. 7
2. All relevant stakeholders are identified in outreach process	Ch. 7
3. Stakeholder outreach	Ch. 7
4. Public participation in plan development	Ch. 7
5. Emphasis on achieving water quality standards	Ch. 7
6. Operation and maintenance of BMPs	Ch. 8 Table 28

Element	Report Section(s) and Page Number(s)
Element F: Implementation Schedule	
1. Includes completion dates	Ch. 8 Table 28
2. Schedule is appropriate	Ch. 8 Table 28
Element G: Milestones	
1. Milestones are measurable and attainable	Ch. 8 Table 28, Ch. 10
2. Milestones include completion dates	Ch. 8 Table 28, Ch. 10
3. Progress evaluation and course correction	Ch. 8 Table 28, Ch. 10
4. Milestones linked to schedule	Ch. 8 Table 28, Ch. 10
Element H: Load Reduction Criteria	
1. Criteria are measurable and quantifiable	Ch. 6 Table 20-27
2. Criteria measure progress toward load reduction goal	Ch. 6 Table 20-27
3. Data and models identified	Ch. 6 Table 20-27, Appendix B

Element	Report Section(s) and Page Number(s)
4. Target achievement dates for reduction	Ch. 10
5. Review of progress toward goals	Ch. 10
6. Criteria for revision	Ch. 10
7. Adaptive management	Ch. 10
Element I: Monitoring	
1. Description of how monitoring is used to evaluate implementation	Ch. 10
2. Monitoring measures evaluation criteria	Ch. 10
3. Routine reporting of progress and methods	Ch. 10
4. Parameters are appropriate	Ch. 10
5. Number of sites is adequate	Ch. 10
6. Frequency of sampling is adequate	Ch. 10
7. Monitoring tied to QAPP	Ch. 10
8. Can link implementation to improved water quality	Ch. 10