Chapter 1 Introduction to Watershed Management

1.1: 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 backed 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, organizations or agencies. The continuous involvement of stakeholders throughout the watershed approach is critical for effectively selecting, designing and implementing management measures that address water quality throughout the watershed.

1.2: Watershed Protection Plan

Watershed protection plans (WPPs) are locally driven mechanisms for voluntarily addressing complex water quality problems that cross political boundaries. A WPP serves as a framework to better leverage and coordinate resources of local, state and federal agencies, in addition to non-governmental organizations.

The Petronila and San Fernando Creek WPP follows the EPA’s nine key elements, which are designed to provide guidance for the development of an effective WPP (EPA 2008). WPPs will 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

1.3: 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 the WPP, water quality and other measures of success will be monitored, and adjustments will be made as needed to the implementation strategy.

1.4: Education and Outreach

The development and implementation of a WPP depends on effective education, outreach and engagement efforts to inform stakeholders, landowners and residents of the activities and practices associated with the WPP. Education and outreach events provide the platform for the delivery of new and/or improved information to stakeholders through the WPP implementation process. Education and outreach efforts are integrated into many of the management measures that are detailed in this WPP.

Chapter 2 Watershed Characterization

2.1: Introduction

This chapter provides geographic, demographic, and water quality overviews of the Petronila and San Fernando Creek watershed. Development of the information within this chapter relied heavily on state and federal data resources as well as local stakeholder knowledge. The collection of this information was a critical component to the reliable assessment of potential sources of water quality impairment and the recommendation of beneficial management measures.

2.2: Watershed Description

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. There, the creek flows into Cayo Del Mazón. San Fernando Creek begins at the confluence of the San Diego and Chiltipin creeks in Jim Wells County northeast of Alice. From there, it continues approximately 44 miles downstream to Cayo Del Grullo southeast of Kingsville. San Fernando, Petronila creek and their tributaries flow throughout portions of Duval, Jim Wells, Kleberg and Nueces counties (Table 1) and ultimately flow into Baffin Bay. The two creeks are two of three major tributaries to Baffin Bay, Los Olmos Creek being the third tributary.

The watershed of San Fernando Creek is 1,270 square miles and Petronila Creek is 675 square miles for a total combined watershed area of 1,945 square miles (Figure 1). Both San Fernando and Petronila creeks are perennial freshwater streams until their last few miles which tend to be tidal. The watershed is predominately rural but does include several urban areas including the cities of Kingsville, Benavides, San Diego, Alice, Bishop, Driscoll, Aqua Dulce, Orange Grove, and a portion of Robstown. As these cities and their surrounding rural areas increase expansion of their residential and suburban landscapes, the ecological health of the water bodies within this region are facing rising potential threats. It is increasingly important to develop a plan to protect the watershed’s creeks and streams.

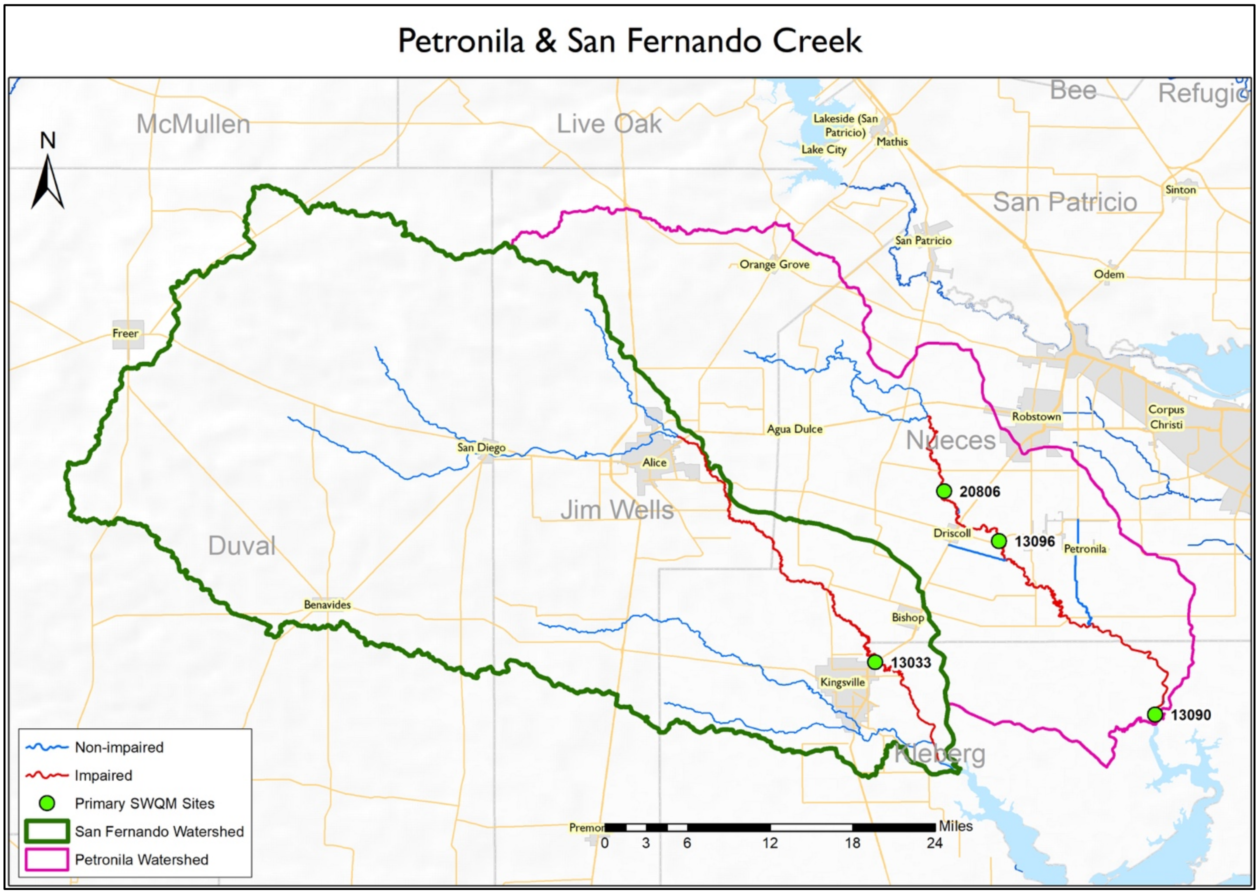


Figure 1. San Fernando and Petronila Creek watershed map

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

2.3: Physical Characteristics

Soils and Topography

The soils and topography of a watershed are important components of watershed hydrology. Slope and elevation define where water will flow, while elevation and soil properties influence the quantity and speed at which water will infiltrate into the soil, as well as how much water will flow over or through the soil into a water body. Soil properties may also limit the types of development and activities that can occur in certain areas.

Elevation across the watershed 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, USGS 2019). Topography of the San Fernando and Petronila Creek watershed is comprised of mildly hilly terrain on the northwestern edge quickly giving way to a gradual smoothing of topography until the watershed meets the coast to the southeast.

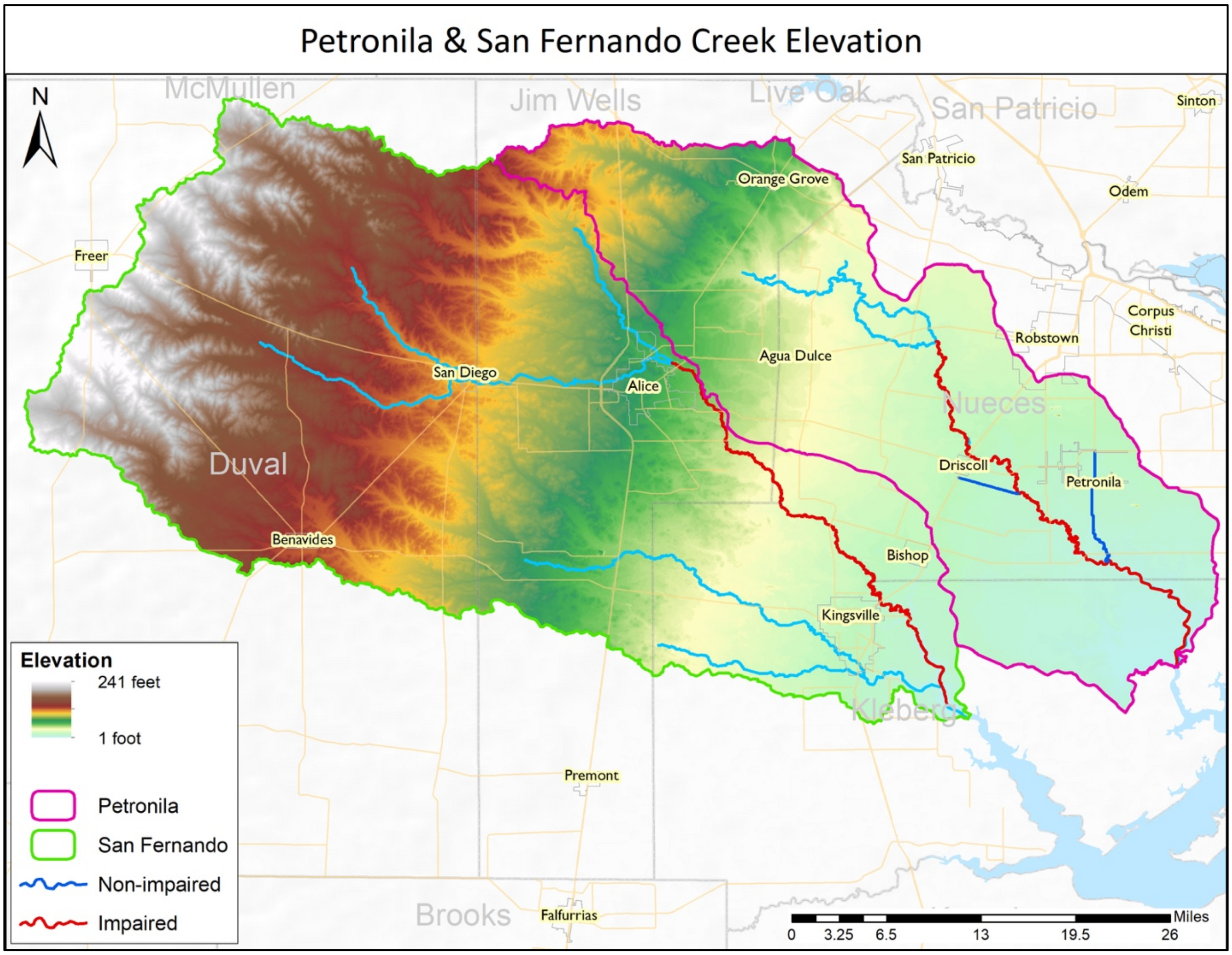


Figure 2. Watershed elevation

The dominant soils in the San Fernando and Petronila Creek watersheds are Alfisols, Inceptisols, Mollisols and Vertisols (Figure 3). Mollisoils (47%; 744,625 acres (ac)) are characterized by a dark surface layer indicative of high amounts of organic material and are 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 even during moderately dry conditions. Inceptisols (2.2%; 108,404 ac) are common in humid and subhumid regions and are sprinkled throughout the central watershed.

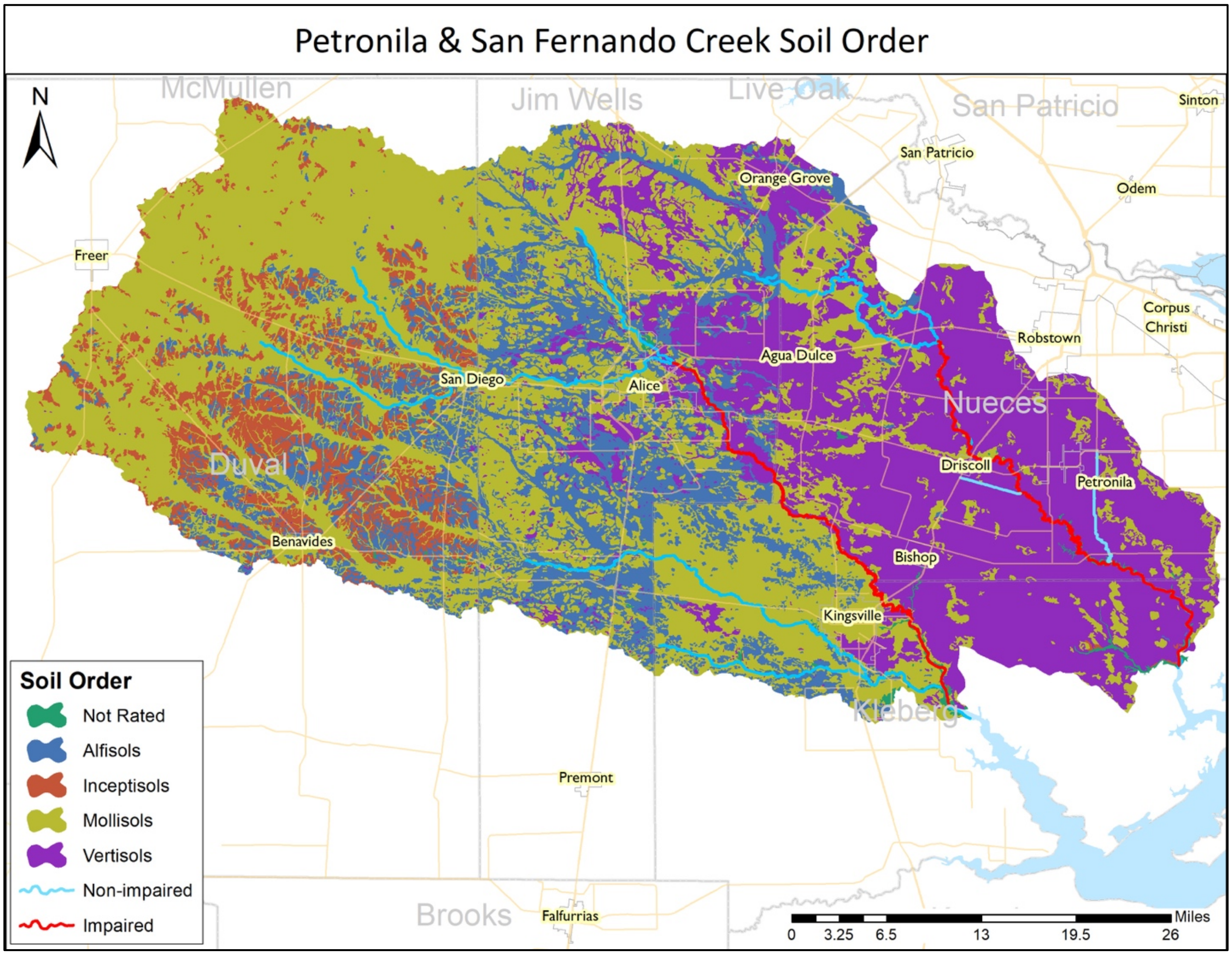


Figure 3. Watershed soil orders

Hydrologic soil groups are groups of soil that 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. The predominate soil types in the watershed are

Group C (45% of watershed soils) and Group B (29% of watershed soils). Group D soils comprise 25% of the watershed soils followed by Groups A and C/D, both at 1% of soils. The distinct difference in soil classifications along the Jim Wells, Nueces and Kleberg county lines is 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. The soils of Baffin Bay 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 the use new mapping concepts that follow the natural landscape rather than political boundaries.

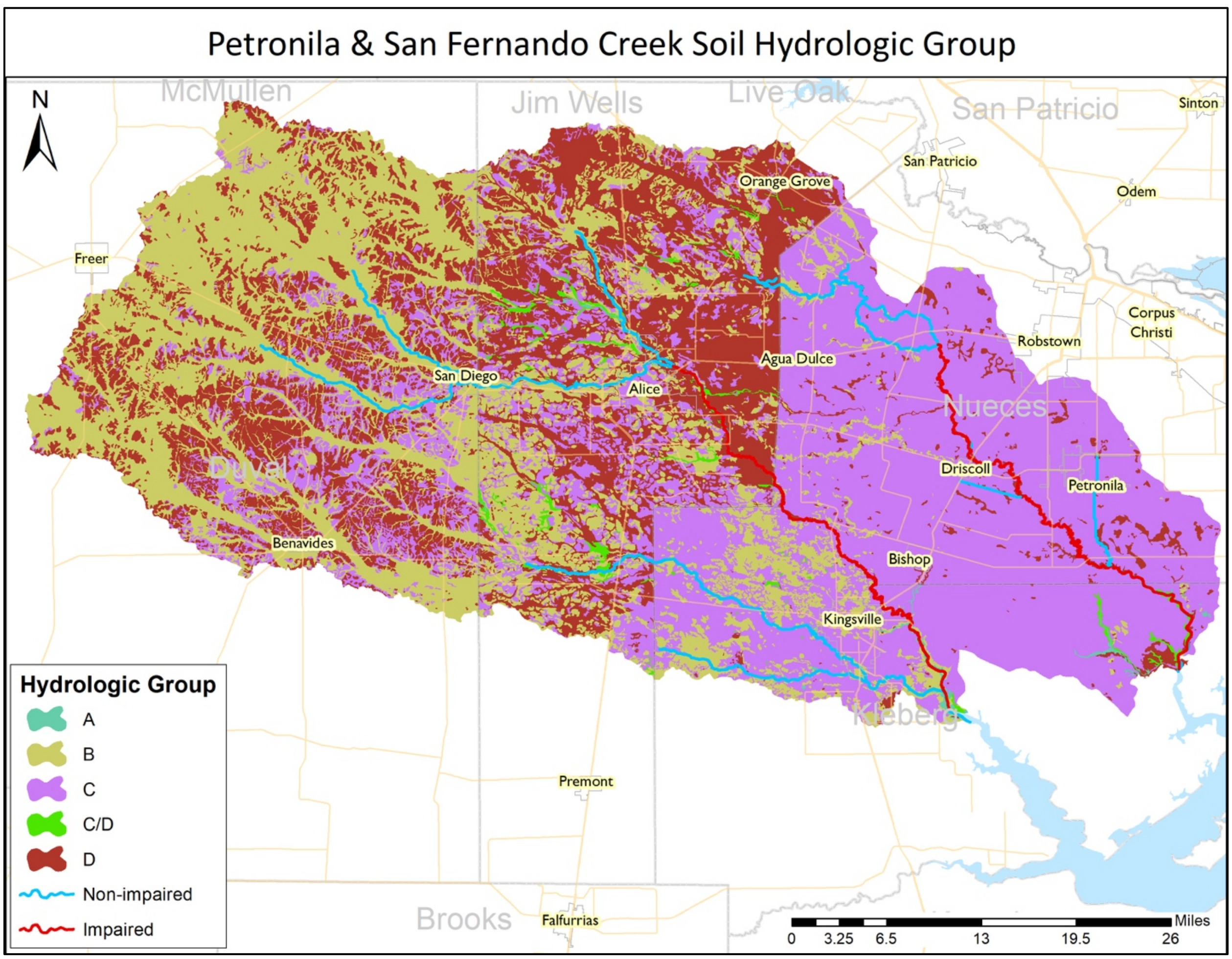


Figure 4. Hydrologic soil groups

2.4: Land Use and Land Cover

According to 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, urban areas are present in the watershed, but only comprise 4.1% (51,414 ac) of the total land use.

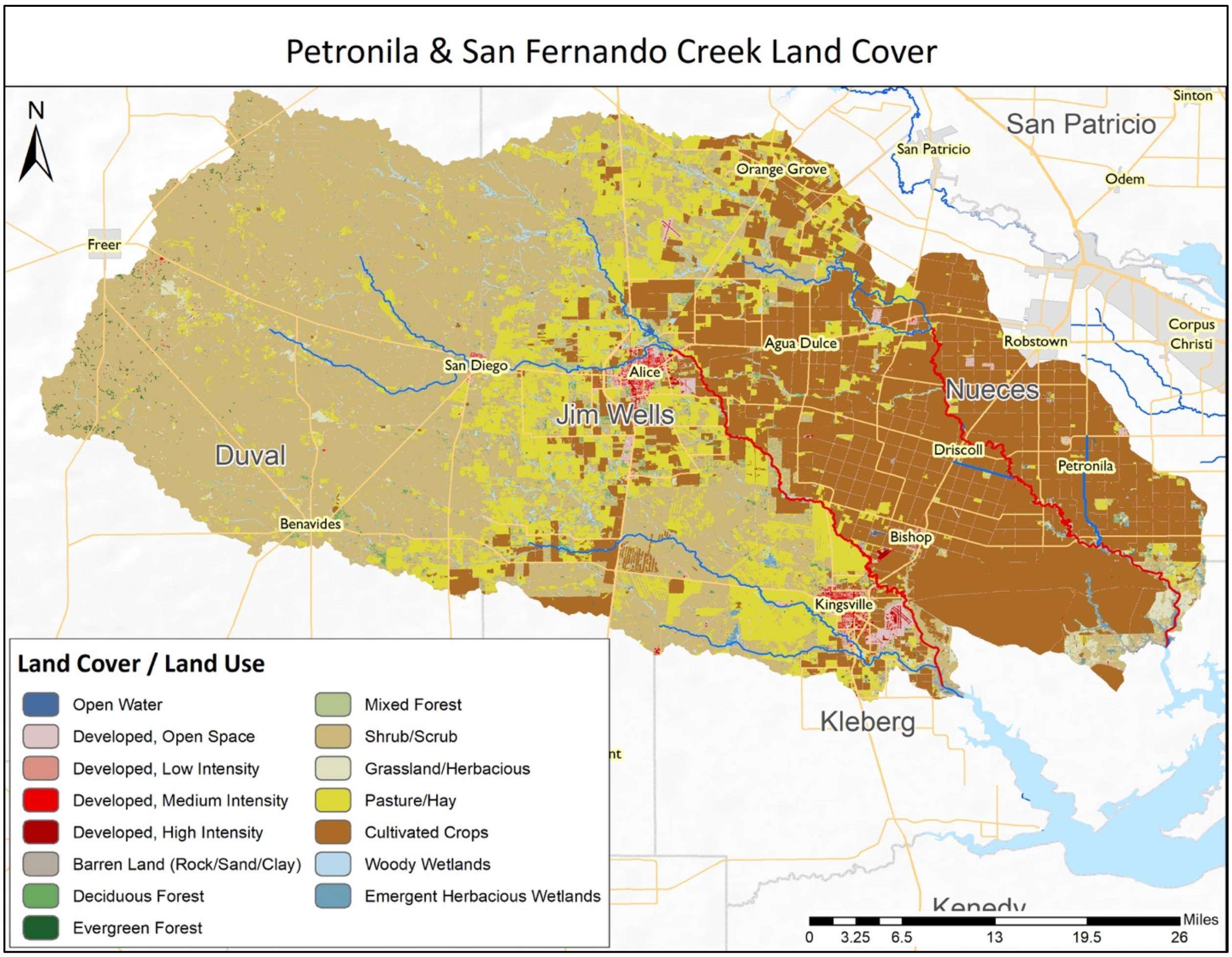


Figure 5. Watershed land use and land cover

Table 2. LULC summary

Land Use Class	Acreage	Percentage of Watershed
Developed Area	51,414	4.1%
Barren Land	3,694	0.3%
Forest	17,640	1.4%
Shrub/Scrub	562,941	45.1%
Grassland/Herbaceous	14,956	1.2%
Pasture/Hay	194,917	15.6%
Cultivated Crop	370,329	29.7%
Wetland	29,717	2.4%
Open Water	1,494	0.1%
Total Acreage	1,247,102	100.0%

2.5: 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), including the Texas-Tamaulipan Thornscrub (31c) throughout the western portion of the watershed in Duval and Jim Wells counties (Figure 6). From there, Southern Subhumid Gulf Coast Prairies (34b) begin and continue east through Kleberg and Nueces counties to the bay. 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.

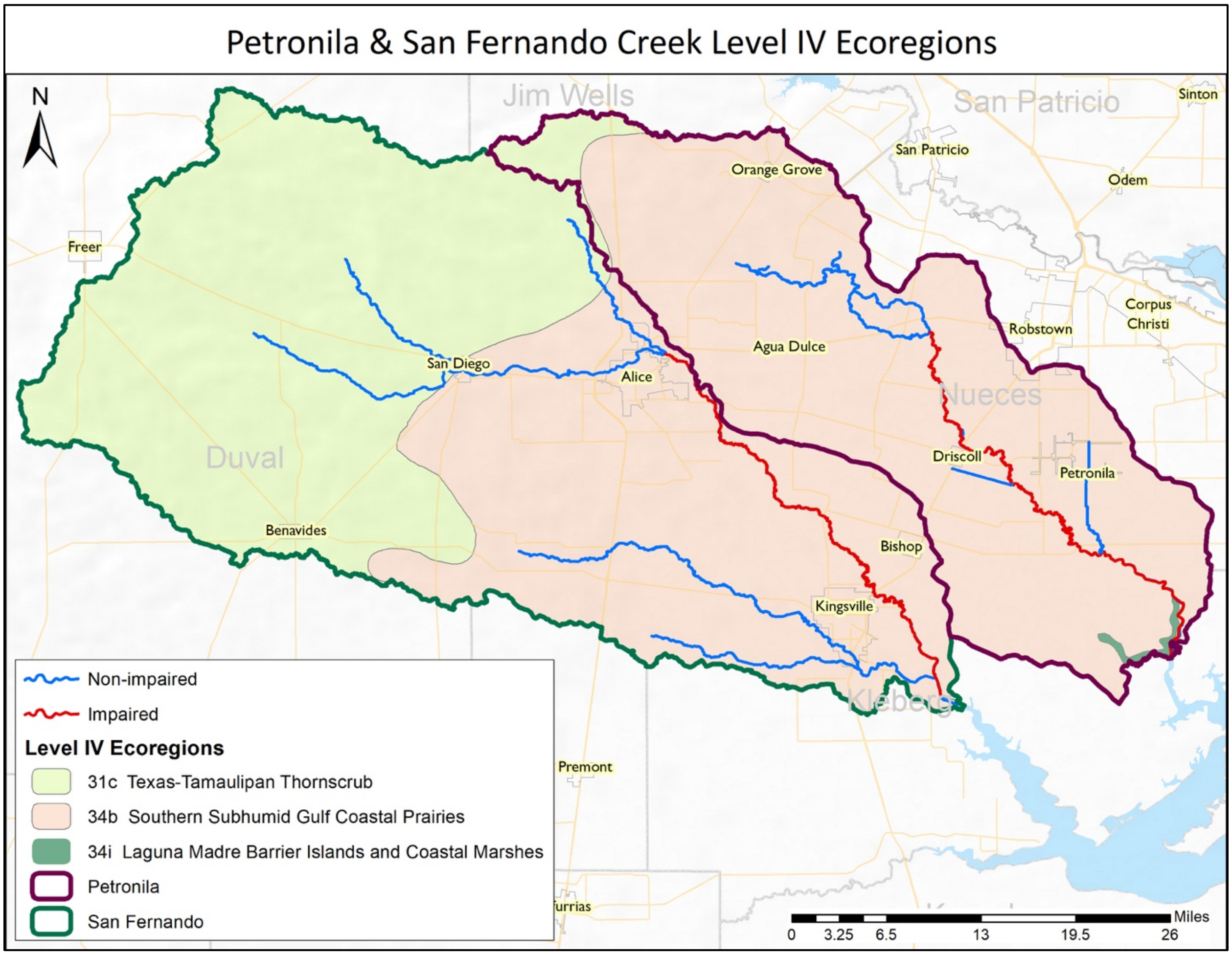


Figure 6. Level IV ecoregions

2.6: Climate

The San Fernando and Petronila Creek watershed is characterized as a humid subtropical climate zone, with hot summers and warm or mild winters. The average annual precipitation in the watershed from 2011 to 2021 ranged between 21 inches (in) to 30 in (Figure 7). 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).

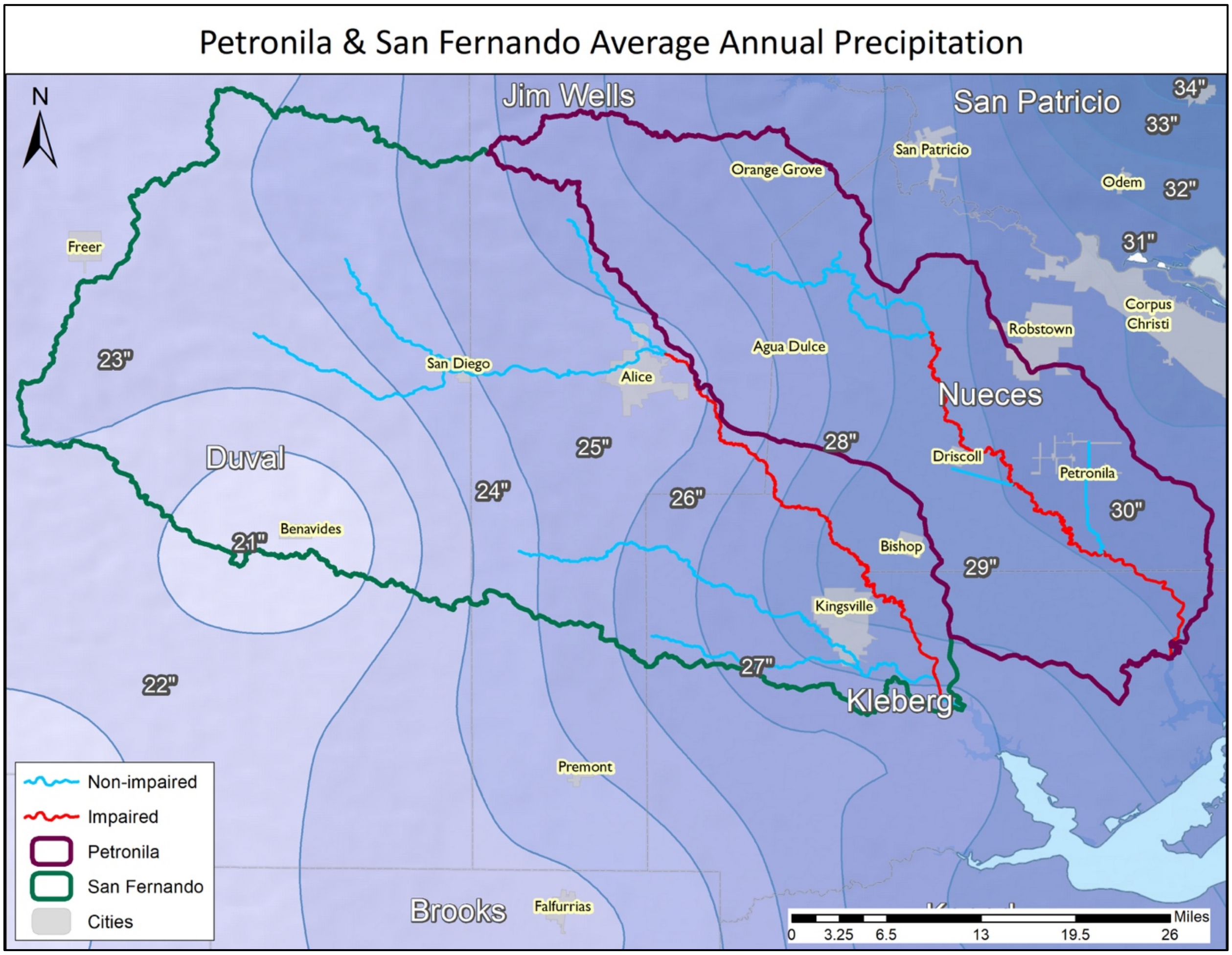


Figure 7. Annual normal precipitation in inches

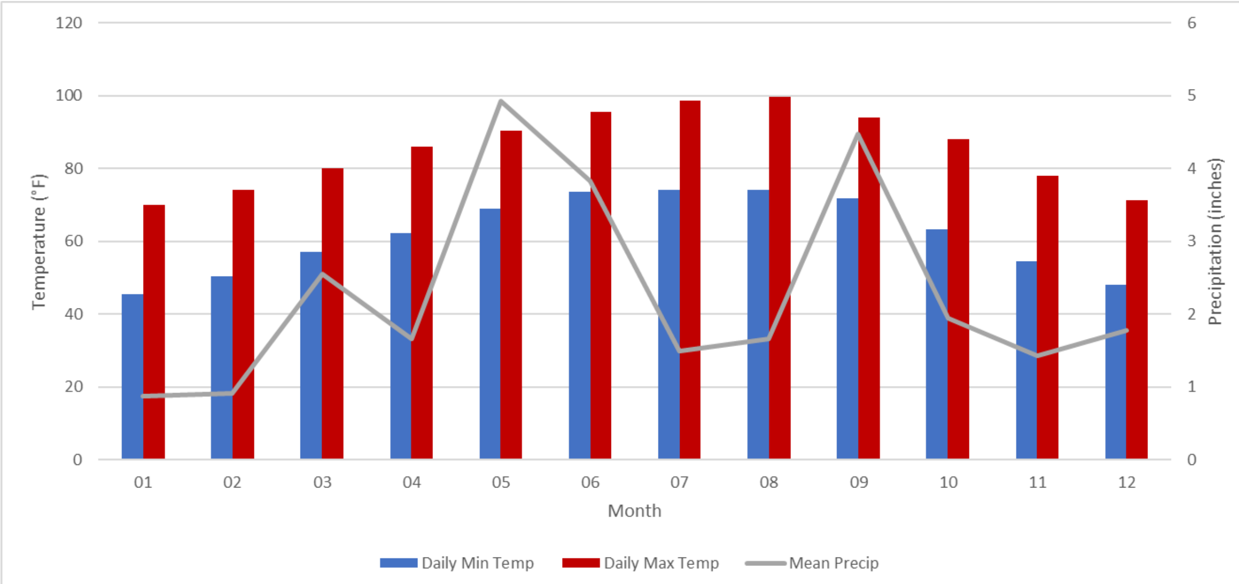


Figure 8. Monthly mean maximum and minimum air temperatures (°F) and monthly mean rainfall (inches) measured at Alice International Airport, TX (NOAA, 2021)

2.7: 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), with all watershed counties projecting population increase over the next 50 years, provided by the Office of the State Demographer and the Texas Water Development Board (TWDB).

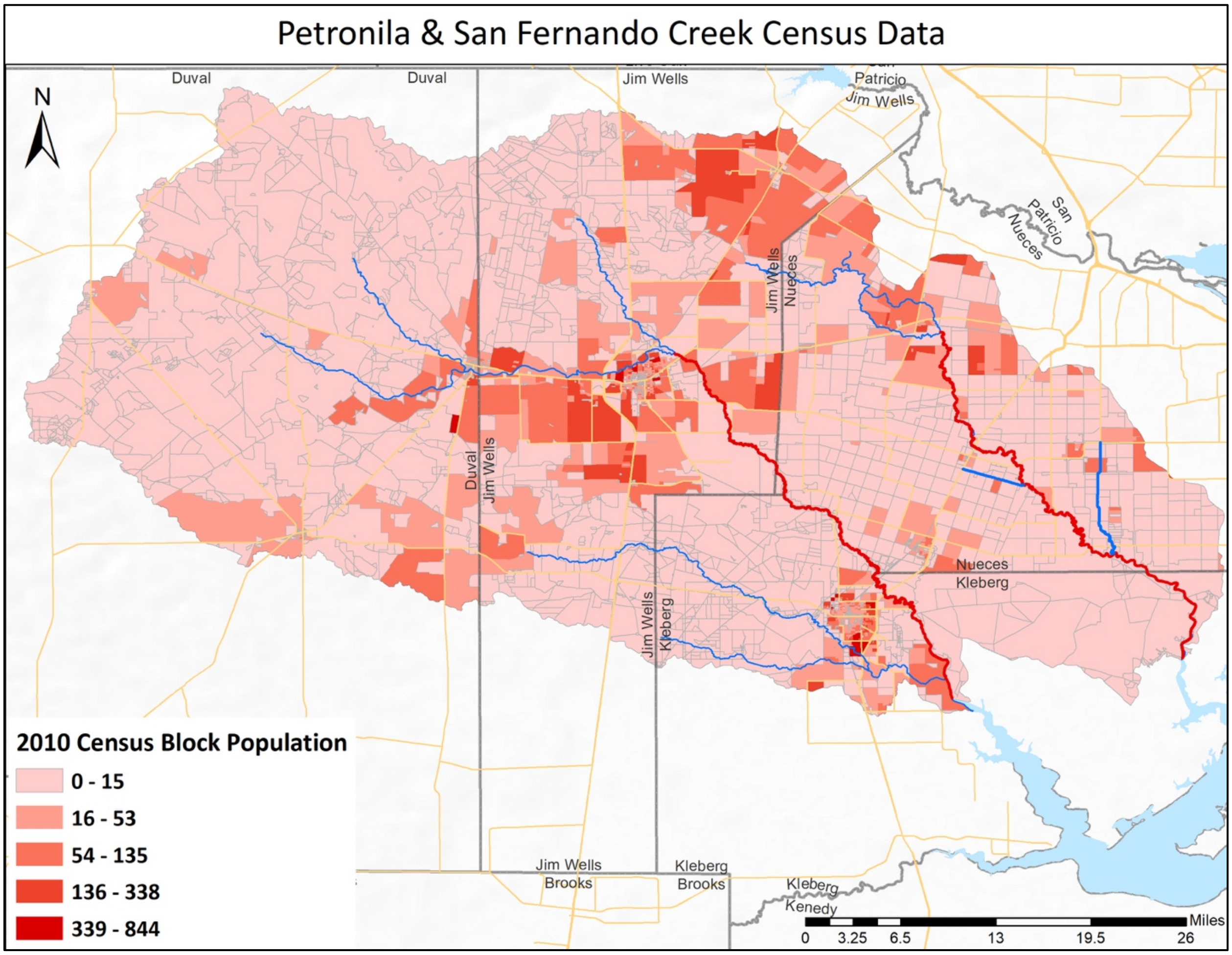


Figure 9 2010 U.S. Census population estimates

Between 2020 and 2070, significant population growth is expected in Duval, Jim Wells, Kleberg, and Nueces counties (Table 3). With this growth, we can expect increased residential and commercial development and further pressures on existing wastewater infrastructure.

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%

2.8: Aquifers

Texas has 9 major and 22 minor aquifers, but only one lies beneath 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 of dissolved solids. As distance from the coast increases, the aquifer, less impacted by saltwater-intrusion, has a low enough salinity that it is used in groundwater irrigation systems.

Chapter 3 Water Quality

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.

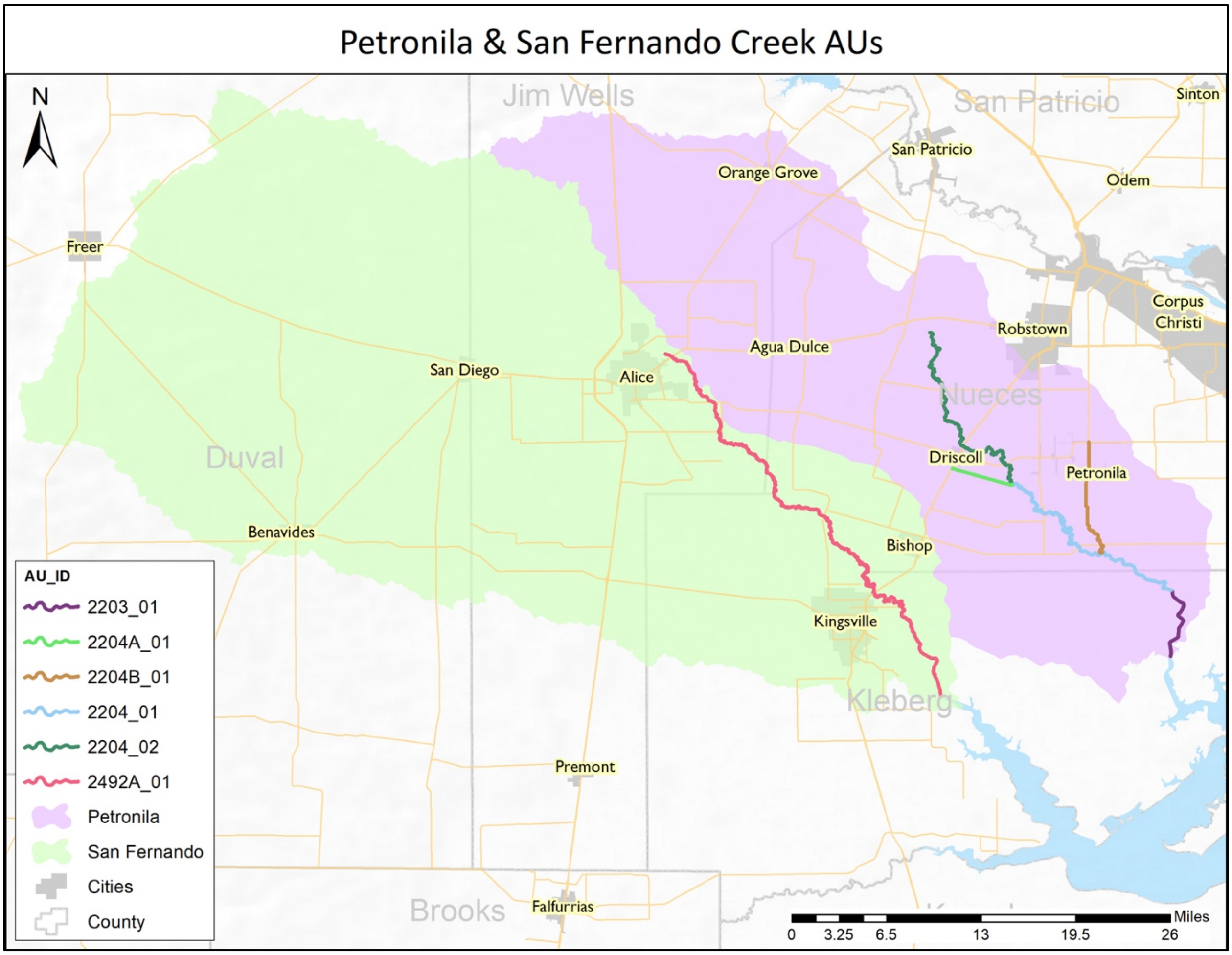
The CWA (33 USC § 1251.303), administered by the EPA (40 CFR § 130.7), requires states to develop a list that describes all water bodies that are impaired and are not within established water quality standards (commonly called "303(d) list" in reference to Texas Water Quality Inventory and 303(d) List). In addition, states are required to develop total maximum daily loads (TMDLs) or other acceptable strategies to restore water quality of impaired water bodies. A TMDL is a budget that sets the maximum pollutant loading capacity of a water body and the reduction needed for a water body to meet applicable standards. The development of a stakeholder-driven WPP is another potential strategy. By encouraging stakeholders to address possible causes and threats of impairments and giving them decision-making powers to set WPP goals, WPPs can provide a comprehensive, long-term restoration plan with water body assessments and protection strategies.

3.1: Water Body Assessments

TCEQ conducts a water body assessment on a biennial basis to satisfy requirements of federal Clean Water Act Sections 305(b) and 303(d). The resulting *Texas Integrated Report of Surface Water Quality (Texas Integrated Report)* describes the status of water bodies throughout the state of Texas. The most recent finalized 2020 *Texas Integrated Report* 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 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 water body 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 6 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 6 monitoring stations within the San Fernando and Petronila Creek watersheds were reviewed (Figure 11; Table 4). For the development of this WPP, two stations have been identified for use generating load duration curves; stations 13033 and 13096. These two stations are representative of the water bodies upon which they are located.


Petronila & San Fernando Creek AUs
N
Jim Wells
San Patricio
Sinton
San Patricio
Orange Grove
Odem
Freer
Corpus Christi
Robstown
Agua Dulce
San Diego
Alice
Nueces
Duval
Driscoll
Petronila
Benavides
Bishop
Kingsville
Kleberg
Premont
Brooks
Falfurrias
AU_ID
2203_01
2204A_01
2204B_01
2204_01
2204_02
2492A_01
Petronila
San Fernando
Cities
County
0
3.25
6.5
13
19.5
26
Miles

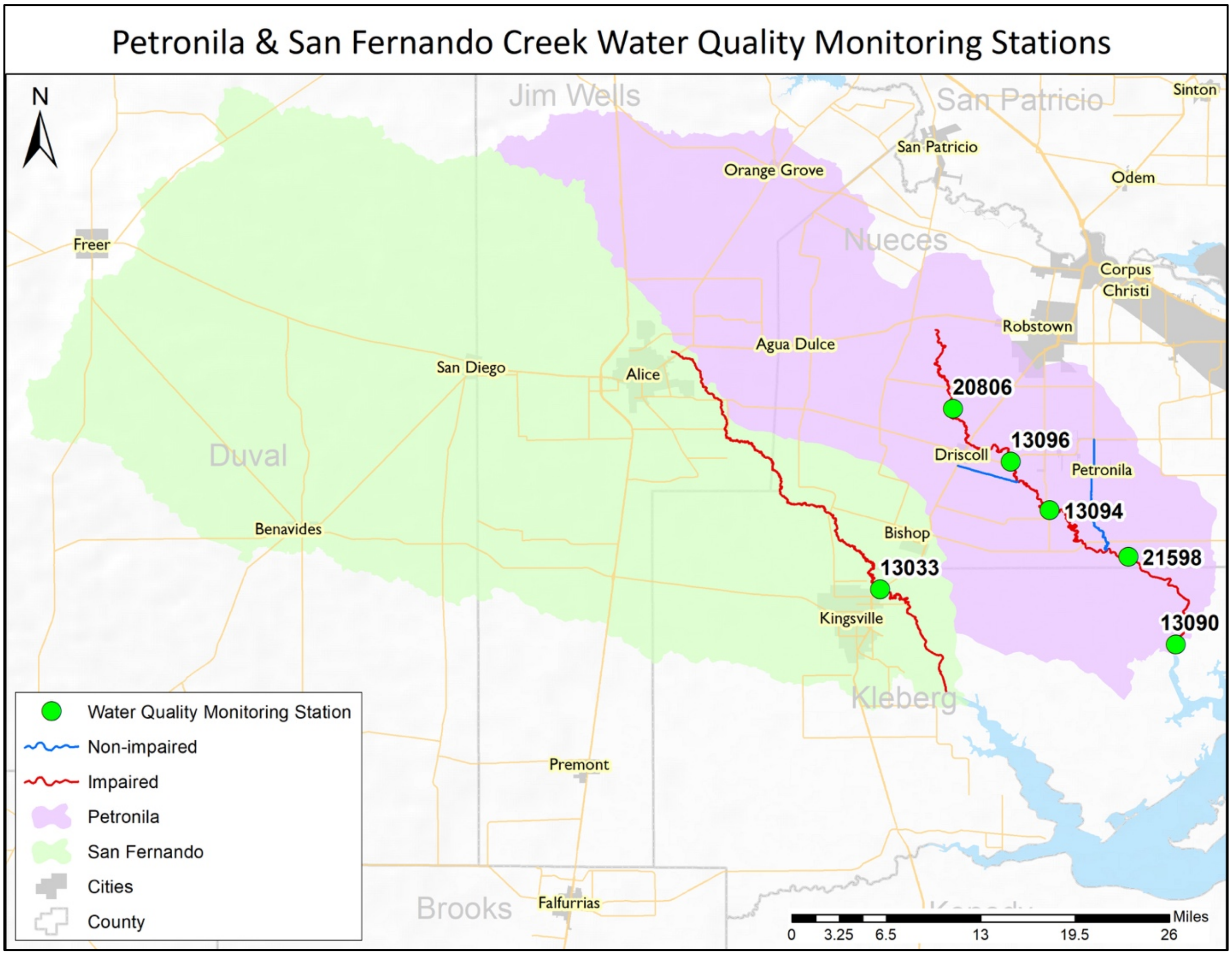


Figure 11. Water quality monitoring stations

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 on Surface Water Quality*, 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 E. coli cfu / 100 mL. The criteria for marine (tidal) recreational waters is 35 enterococci cfu / 100 mL. Furthermore, a number of concerns are identified including nutrient and bacteria concerns 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	

Assessment unit, AU; colony forming unit, cfu; milliliter, mL
*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 concerns identified in the 2014 *Texas Integrated Report*

Parameter	AUs	River Reach	Criteria
Bacteria	2203_01	Petronila Creek Tidal	35 cfu / 100 ml
	2204_01	Petronila Creek Above Tidal	126 cfu/100 ml
	2204_02		
	2492A_01	San Fernando Creek	
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)

Assessment unit, AU; colony forming unit, cfu; milliliter, mL; milligrams, mg; micrograms, µg; *liter, L*

3.2: Texas Surface Water Quality Standards

Water quality standards are established by the state and approved by EPA to define a water body's ability to support its designated uses, which may include: aquatic life use (fish, shellfish, and wildlife protection and propagation), primary contact recreation (swimming), 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)			

Colony forming unit, cfu; milliliter, mL; milligrams, mg; liter, L; dissolved oxygen, DO; Fahrenheit, F

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

3.3: Bacteria

Concentrations of fecal indicator bacteria are evaluated to assess a waterbody's ability to meet its contact recreation use. In freshwater environments, concentrations of E. coli bacteria 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 can cause illness in people that recreate in them. The 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 colony forming units (cfu) of E. coli per 100 milliliters (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 measured 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 assessment units (AUs)

3.4: Dissolved Oxygen

DO is the main parameter used to determine a water body's ability to support and maintain aquatic life uses. If DO levels in a water body 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 consume oxygen through respiration. 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. 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 drive down DO concentrations.

When evaluating DO levels in a water body, 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 (TAC §307 2014). 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 though it will be monitored in this WPP as one indicator of the overall health of each segment.

3.5: Nutrients

Nutrients, specifically nitrogen and phosphorous, are used by aquatic plants and algae. However, as previously mentioned, excessive nutrients can lead to plant and algal blooms, which will result in reduced DO levels. High levels of nitrates and nitrites can directly affect respiration in fish. Sources of nutrients include effluents from WWTFs and OSSFs, direct deposition of animal fecal matter, illegal dumping of refuse, groundwater return flows, and fertilizers that runoff from yards and agricultural fields. Additionally, nutrients bind to soil and sediment particles; therefore, runoff and erosion events that result in heavy loads of sediment can increase nutrient levels in water bodies.

Nutrient standards have not been set in Texas. However, nutrient screening levels developed for statewide use were established to protect water bodies from excessive nutrient loadings. Screening levels are set at the 85th percentile for parameters from similar water bodies. If more than 20% of samples from a water body exceed the screening level, that water body 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. The current screening level in freshwater streams for chlorophyll-a is 14.1 µg/L; nitrate is 1.95 mg/L; and total phosphorous is 0.69 mg/L (Table 8). For tidal streams, the chlorophyll-a screening level is 21 µg/L. 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	**Standard 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	

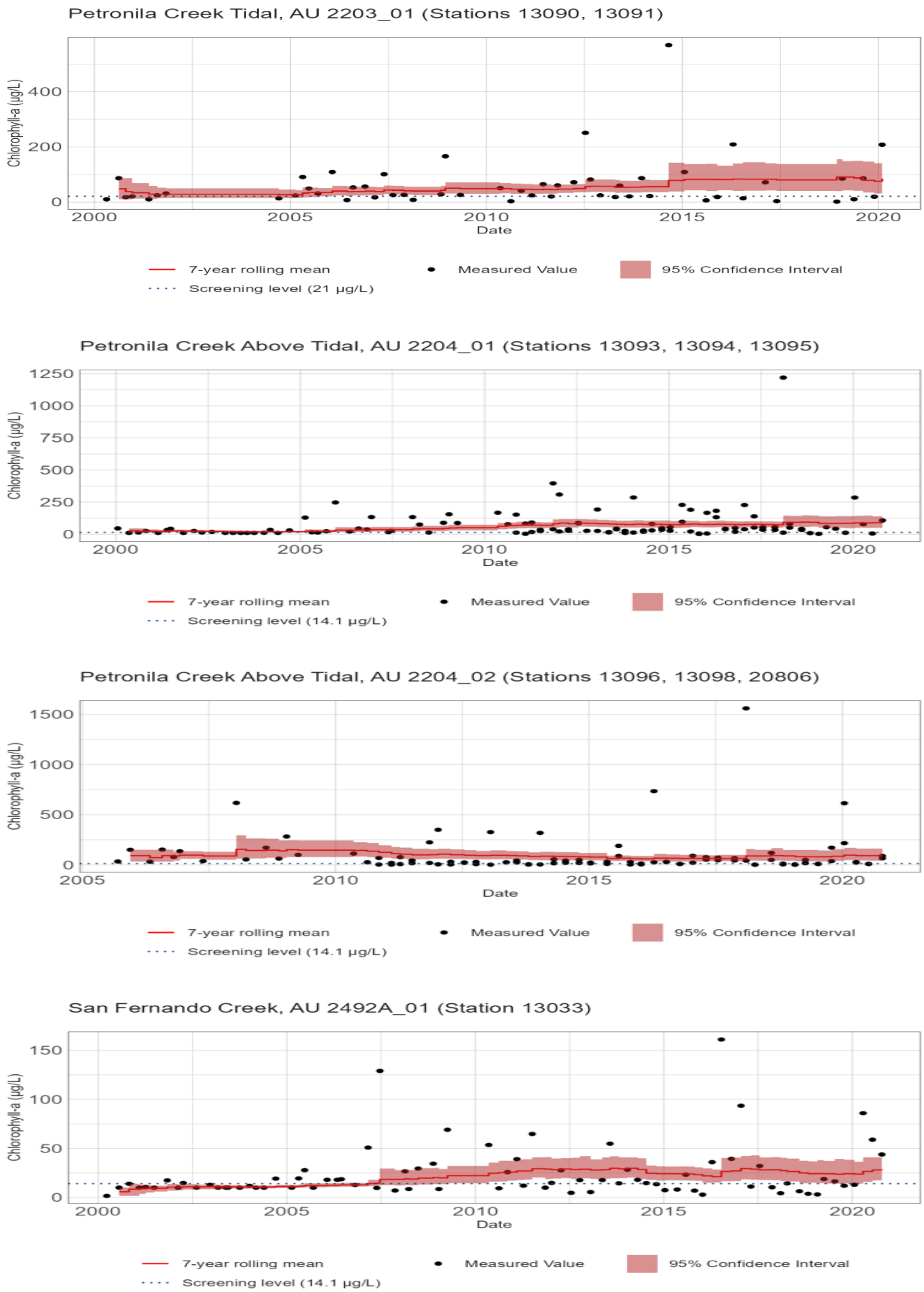


Figure 13 Chlorophyll-a concentrations

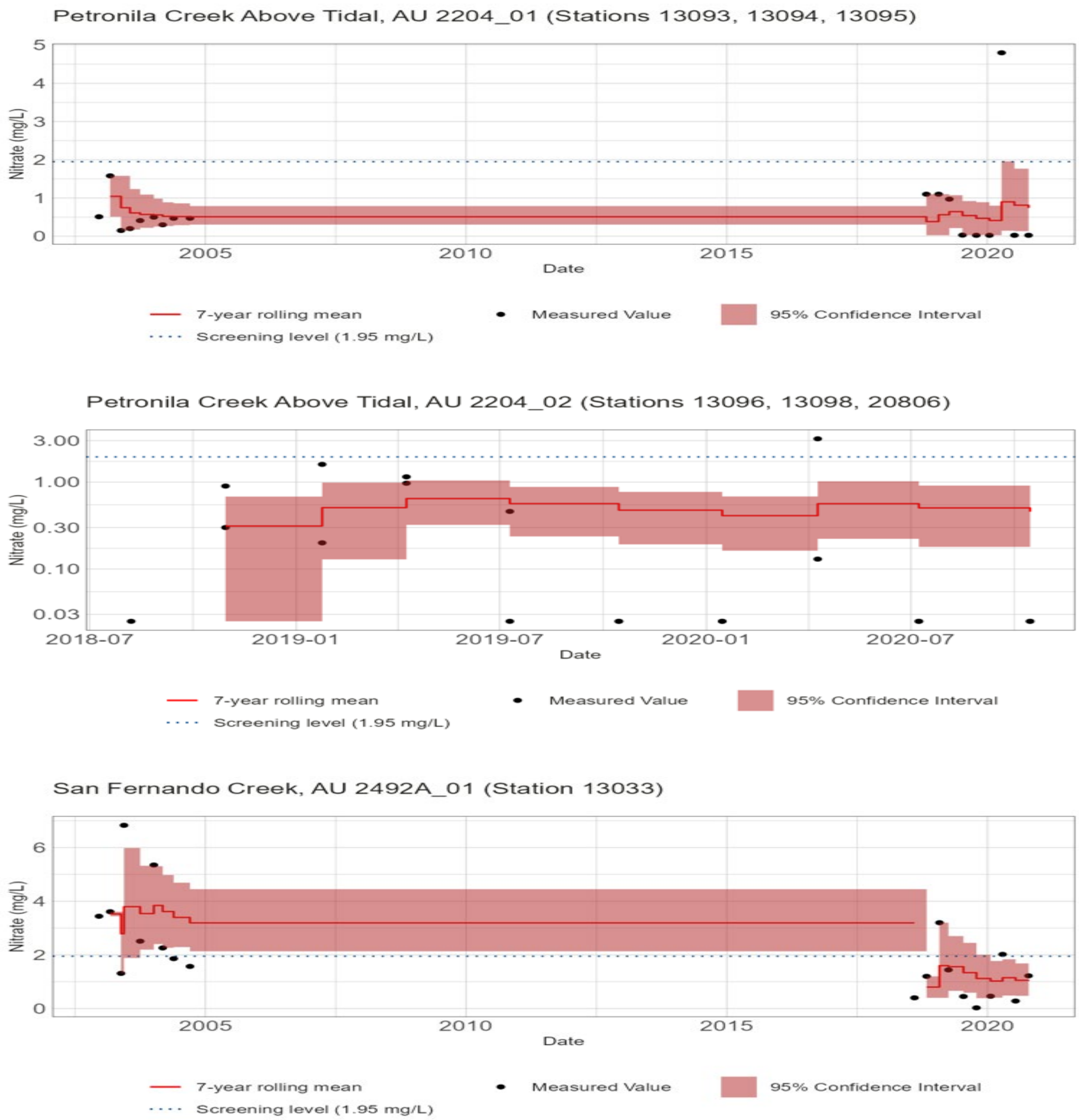


Figure 14 Nitrate concentrations

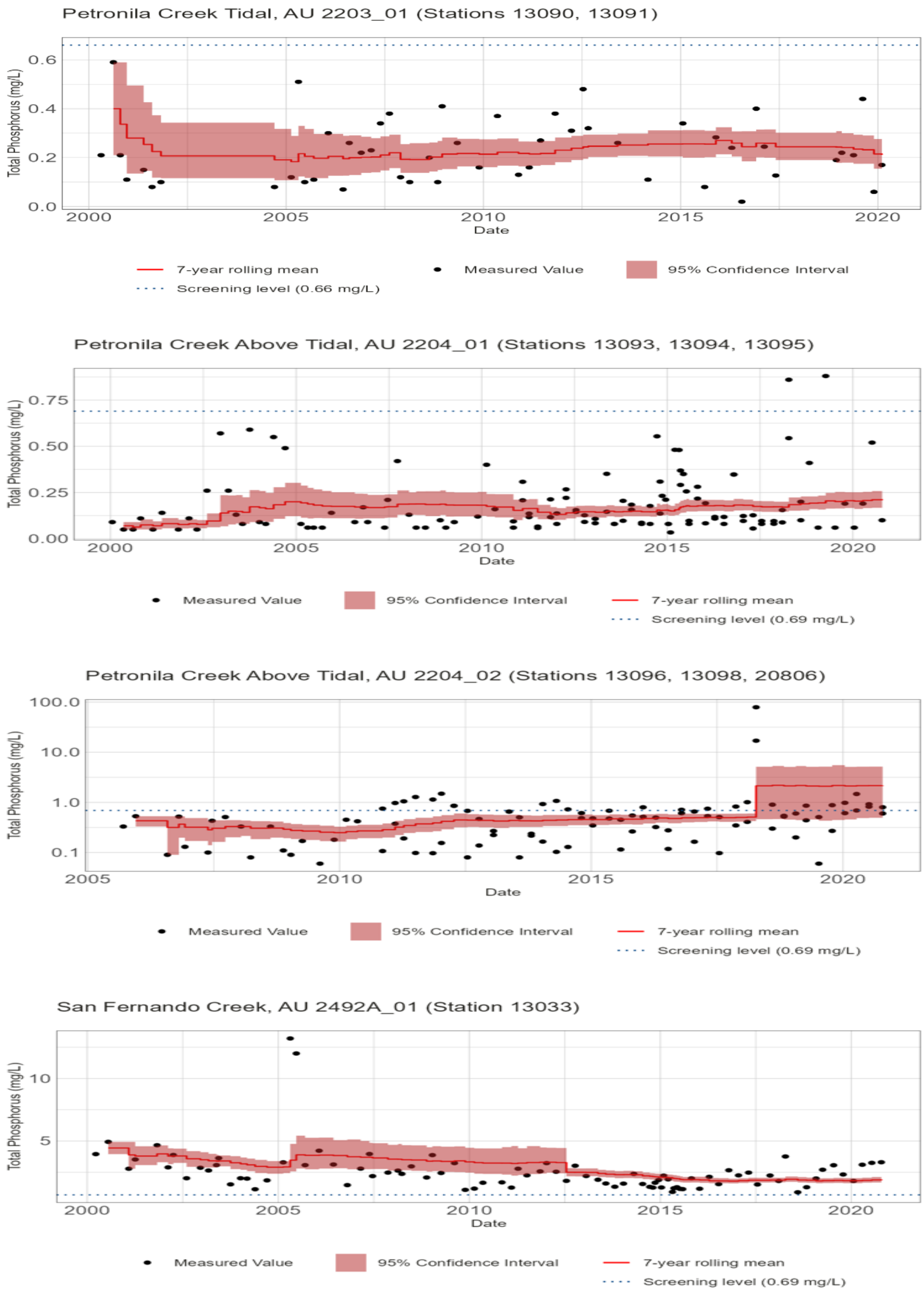


Figure 15. Total Phosphorous concentration

3.6: 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 water body 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 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.

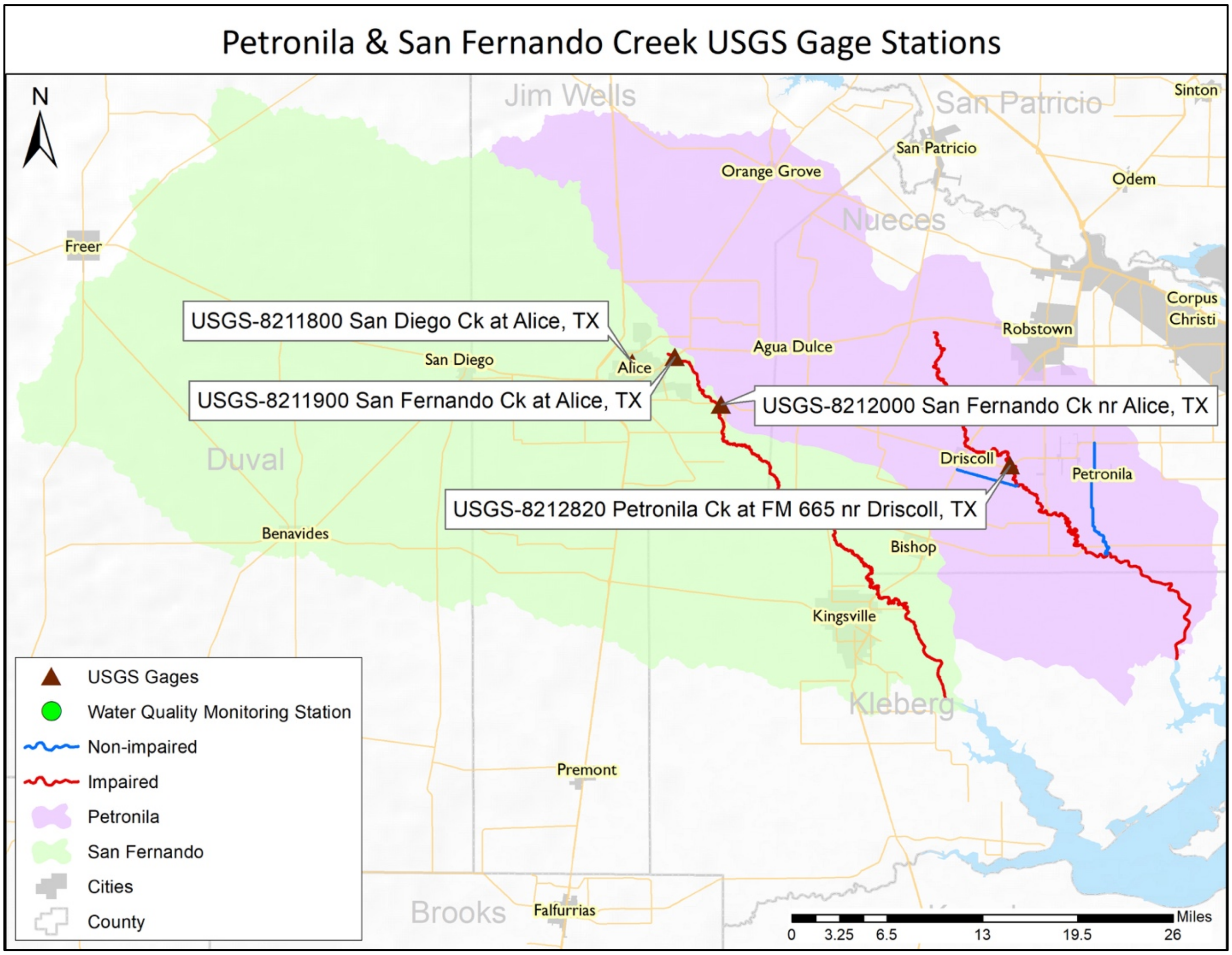


Figure 16. USGS streamflow gages

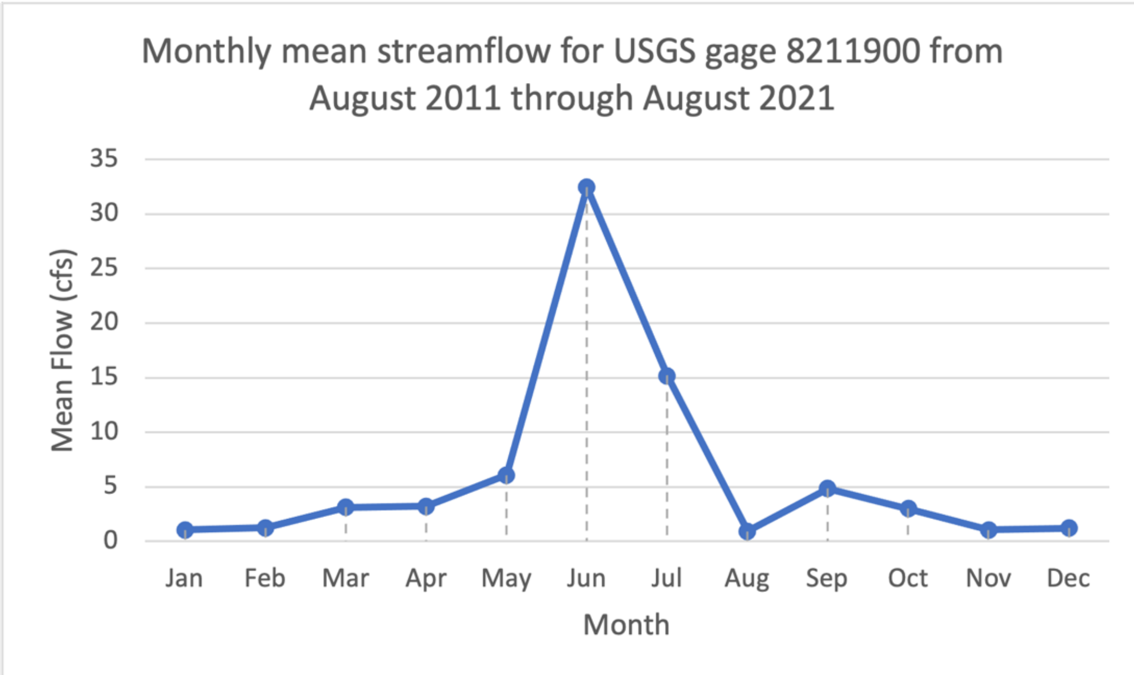


Figure 17. Mean monthly streamflows (cfs), August 2011 through August 2021

Chapter 4 Potential Sources of Pollution

As described in chapter 3, most water body impairments in San Fernando and Petronila Creek watersheds are primarily due to the excessive fecal indicator bacteria. Table 9 includes a summary of potential pollutant sources, causes, and impacts.

Pollutant sources are categorized as either a point or nonpoint source. Point sources enter receiving waters at identifiable locations, such as a pipe. Nonpoint sources include anything that is not a point source and enters the water body 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/MS 4s	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 water body 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 water body 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 water body through runoff
Illegal Dumping	Bacteria, nutrients, litter	Disposal of trash and animal carcasses in or near water body	Direct or indirect contamination of water body

Wastewater treatment facility, WWFTs; sanitary sewer overflow, SSOs; municipal separate stormwater sewer systems, MS4s; on-site sewage facility, OSSFs

4.1: 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, WWTFs 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 MS4s of regulated cities or agencies.

WWTFs

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

There are currently 15 facilities operating in the watershed (Figure 18). Generally, WWTF discharges are well below the permitted bacteria concentration limits. However, periodic exceedance in 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.

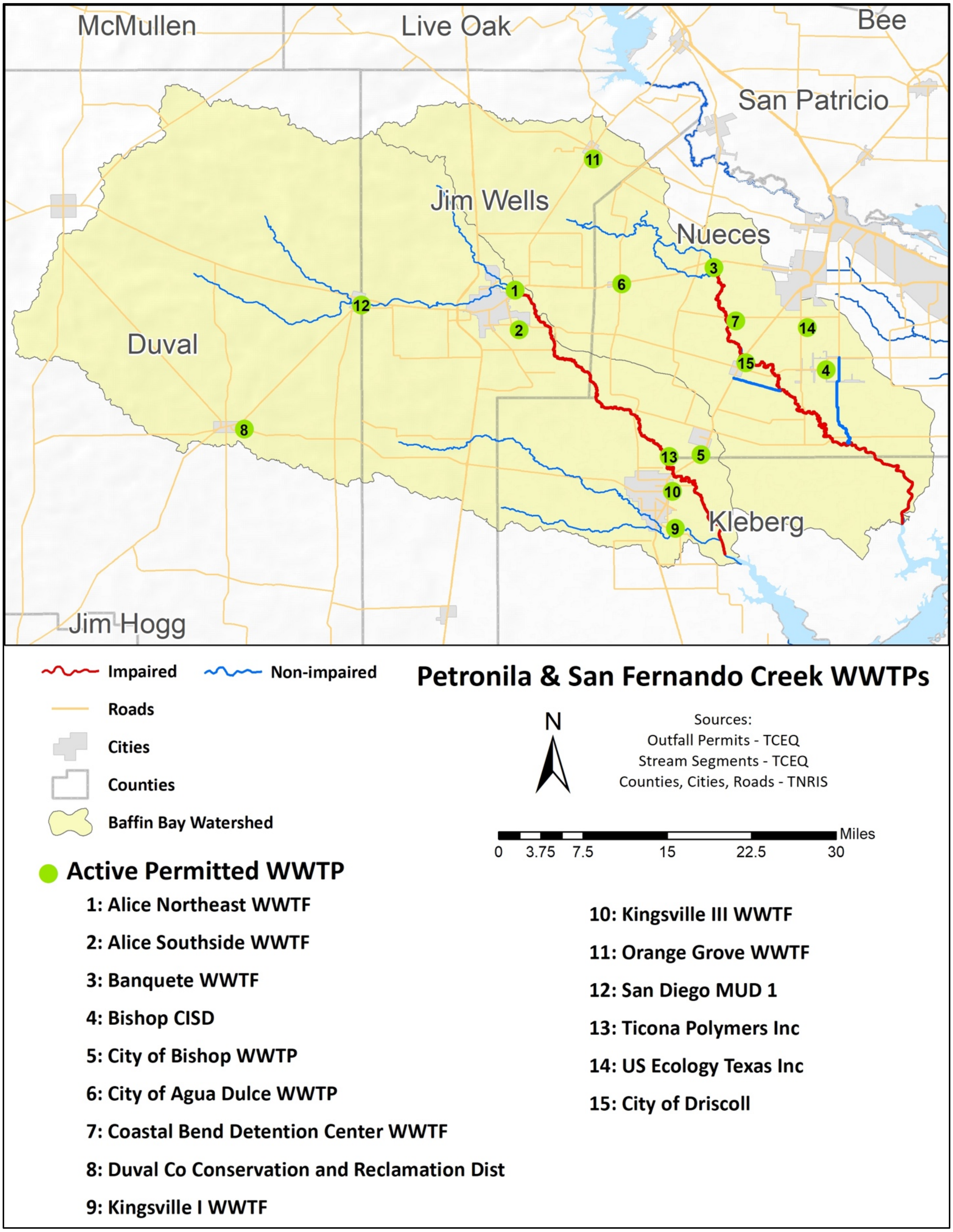


Figure 18. Permitted municipal wastewater treatment facilities

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

Name	Receiving Water Body	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 Amonia, 4 TSS)
Ticona Polymers Inc	San Fernando Creek	3.5	2.68	Active	10 (2 BOD, 1 Flow, 1 COD, 1 Selinium, 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 Selinium, 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.

Sanitary Sewer Overflows (SSOs)

SSOs can occur when sewer lines lose capacities due to age, lack of maintenance, inappropriate connections or overload during storm events. Inflow and infiltration are common issues to all sanitary sewer systems. Inflow occurs primarily during 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 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). The reported causes of SSOs vary, though most were the result of lift station or manhole overflows due to heavy rain, power failures to pumps, or sewage pipes clogged by materials not recommended for flushing or pouring down drain pipes. Other than SSO event reports, no compliance or pollutant loading data associated with SSOs are available. The pollutant loads associated with individual events are likely to vary widely depending on the amount and makeup of the discharge.

Table 11. 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

Wastewater treatment facility, WWTF

Table 12 Estimated sanitary sewer overflow receiving volumes

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

4.2: Nonpoint Source Pollution (NPS)

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 polluted water from leaking chemicals or improperly functioning OSSFs, fertilizers, herbicides, pesticides, oil, grease, toxic chemicals, sediment, bacteria, nutrients, and many other substances.

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 systems and their locations, ages, types, and functional statuses in the watershed are unavailable, making it difficult to determine their real effects on water quality. To estimate the number of systems and approximate their locations, an approach using 911 address points, 2010 Census data, and recent remotely-sensed imagery was used to estimate the number of OSSFs (Gregory et al. 2013). OSSF locations were estimated by validating 911 addressees as household structures (determined by remotely-sensed imagery) located outside of WWTF service areas. This method of locating potential OSSF sites was utilized given the unavailability of georeferenced OSSF locations from regional databases. This method produced an estimate of 9,086 OSSFs within the watershed and 25 OSSFs within 100 yards of water bodies. The highest densities of OSSFs are suburban areas just outside of wastewater service boundaries (Figure 19).

OSSF density can also affect overall treatment performance. If the systems installed are not appropriately designed, soil 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 the risk of OSSF failures 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 water quality.

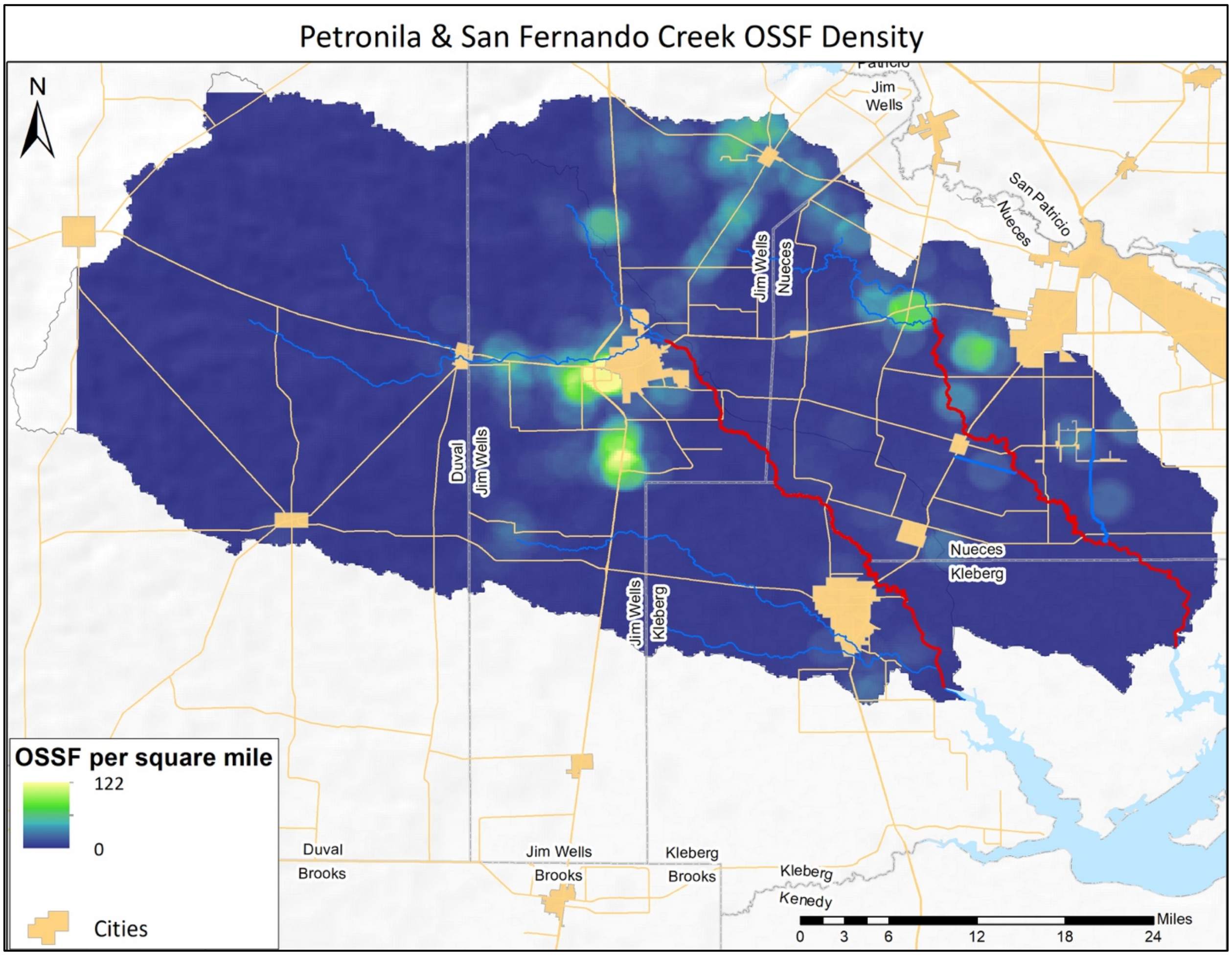


Figure 19. On-site sewage facility (OSSF) density

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 of field soil properties affects the ability of conventional OSSFs to treat wastewater by percolation. Soil suitability rankings were 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).

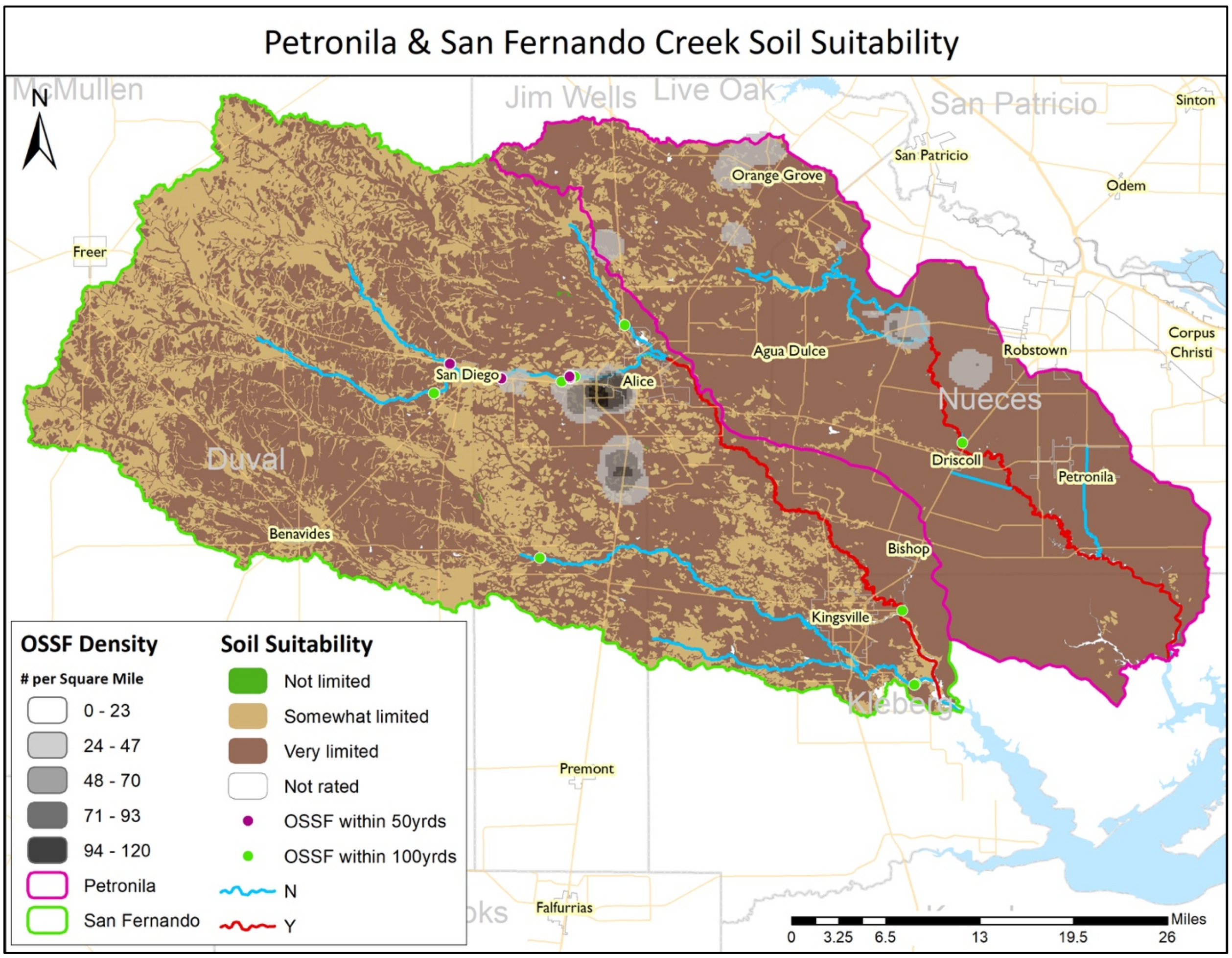


Figure 20. Soil suitability and OSSF density

Urban Runoff

Two potential pollution sources of bacteria and nutrients are the improper application of fertilizers and improper disposal of pet waste within the watershed. Stormwater runoff from lawns, parking lots, and dog parks will wash fertilizers and waste into water bodies. Runoff from urban areas will become more of a concern as population centers expand the amount of impermeable surfaces within the watershed. Housing developments, shopping centers, and industrial and/or business parks are examples of urban expansion that increases impermeability within the watershed. Increased runoff from these types of areas can affect water quality by carrying more NPS pollution like bacteria and nutrients 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 over the landscape rather than being confined and deposit urine and fecal matter onto the land surface as well as directly into water bodies if accessible. Fecal matter deposited within the watershed can be transported to the adjacent creek(s) during runoff events, which contributes to the total bacterial load in the water body.

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. Using both approaches, cattle populations projected 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

Wildlife is another contributor to *E. coli* and nutrient loads in the watershed. Riparian areas provide the most suitable wildlife habitat in the watershed, leading most wildlife to spend the majority of their time in these areas. The amount of fecal deposition is directly related to time spent in a given area, thus wildlife feces is considered as a major source in the watershed. Wildlife population density estimates are limited to deer and feral hogs since information regarding other species is not available.

The Texas Parks and Wildlife Department (TPWD) conducts deer population surveys within the state of Texas at the deer management unit (DMU), formerly known as Resource Management Unit (RMU), level. DMUs are developed based on 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. Density averages for DMU 8 East was 61.7 ac/deer and DMU 9 was 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. Using this combination of information, deer densities were applied to each LULC class within the watershed except for open water, baren land, and developed land yielding an estimate of 17,593 deer in the watershed (Table 14).

Feral hogs are a non-native, invasive species rapidly expanding throughout Texas, inhabiting similar areas as white-tailed deer. They are especially fond of places where there is dense cover with food and water readily available. They are also known to wallow in available water and mud holes. It is obvious that riparian corridors are prime habitat for feral hogs; therefore, they spend much of their time near the creek. This preference for riparian areas does not preclude their use of non-riparian areas. Reclusive by nature, feral hogs are something of a nocturnal species. They typically remain in thick cover during the day and venture away from cover at night into more open areas of the watershed such as cropland, pastures, or rangeland. Feral hogs are significant contributors of pollutants to creeks and rivers across the state through direct and indirect fecal loading. In addition, extensive rooting and wallowing in riparian areas by feral hogs cause 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. Similar to deer, stakeholders provided feedback regarding feral hog density cropland dominated portions of the watershed and agreed to apply only 10% of the average density in these areas. Using this combination of information an estimated 23,759 feral hogs are in the watershed (Table 14).

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 and include a variety of birds and mammals that can contribute significantly to bacteria loading in the watershed. However, the lack of information regarding population estimates for these animals and their fecal production rates prevent their impacts from being quantified. Additionally, managing most wild animal populations is practically impossible due to wildlife management and preservation laws. Therefore, we acknowledge that many other bacteria sources from wildlife exist; however, we are unable to assess their impacts or plan management to directly affect these sources.

Pets

Dogs and cats can contribute to fecal bacteria loading when waste and bacteria runoff from lawns, parks, and other areas. This type of loading is easily avoided by pet owners properly disposing of pet waste. 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 estimated in the U.S. Census block data. Based on these assumptions, we estimated 11,431 dogs and 18,289 cats in the watershed (Table 15).

Table 15. Estimated household pet population

County	Households*	Cat	Dog
Duval	3,339	1,855	1,159
Jim Wells	13,660	7,589	4,743
Kleberg	11,091	6,162	3,851
Nueces	4,830	2,683	1,677
Total	32,920	18,289	11,431

*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 necessarily considered major sources of bacteria or nutrients, the accumulation of trash tends to lead to additional dumping. Many dumped items 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 in general is bad for the environment and local stakeholders have a strong desire to address this pollutant source in the watershed.

Nutrient Sources

Nutrient loading to area waterbodies has been identified as a significant concern for water quality in the creeks and downstream in Baffin Bay. Nutrients in a watershed can come from various sources including nonpoint (animal waste, fertilizers, natural) and point sources (domestic and industrial wastewater). Regardless of source, nutrient loading to a waterbody can cause excess aquatic plant growth which may ultimately lead to eutrophication of the waterbody 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. Generally, 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 comprehensive assessment since wastewater, wildlife, feral hogs, and confined animal feeding operations were not considered.

Chapter 5 Pollutant Source Assessment

5.1: Introduction

Multiple approaches were used to assess watershed pollutant loadings to provide a more complete evaluation of potential pollution sources and their impacts on water quality. Each approach provides a piece of information needed 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 spatial water quality data analysis, load duration curves and spatial analysis of potential *E. coli* sources.

This chapter estimated the load capacity and the current load of *E.coli* within the watershed. The Spatially Explicit Load Enrichment Calculation Tool (SELECT) is used to highlight areas of highest potential pollutant sources. By estimating the relative potential contribution of different fecal bacteria sources across the watershed, areas can be prioritized as to when and where management measures should occur. The number of management measures needed to reach water quality goals can also be estimated.

5.2: Water Quality Monitoring

The *2020 Texas Integrated Report* identified four AUs in the watershed as impaired due to elevated bacteria concentration; they are AUs 2203_01, 2204_01, 2204_02, and 2492A_01. These same AUs have elevated levels of chlorophyll-a. 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, the TCEQ Regional Office, and less frequently through special projects and studies conducted by organizations within the watershed. Historically, the measured data from these entities have indicated the same levels of concern for bacteria and nutrient content within the watershed.

E. coli and *Enterococcus* Data Assessment

Twenty years of near-monthly data from 5 stations in the San Fernando and Petronila Creek watershed have highlighted that the creeks are quite dynamic and that *E. coli* and *Enterococcus* loading across the watershed is both spatially and temporally variable. The presence and volume of streamflow strongly influence the measured bacteria concentrations. Monitoring sites that have sustained flow for much of the year tend to have lower geometric means under routine conditions.

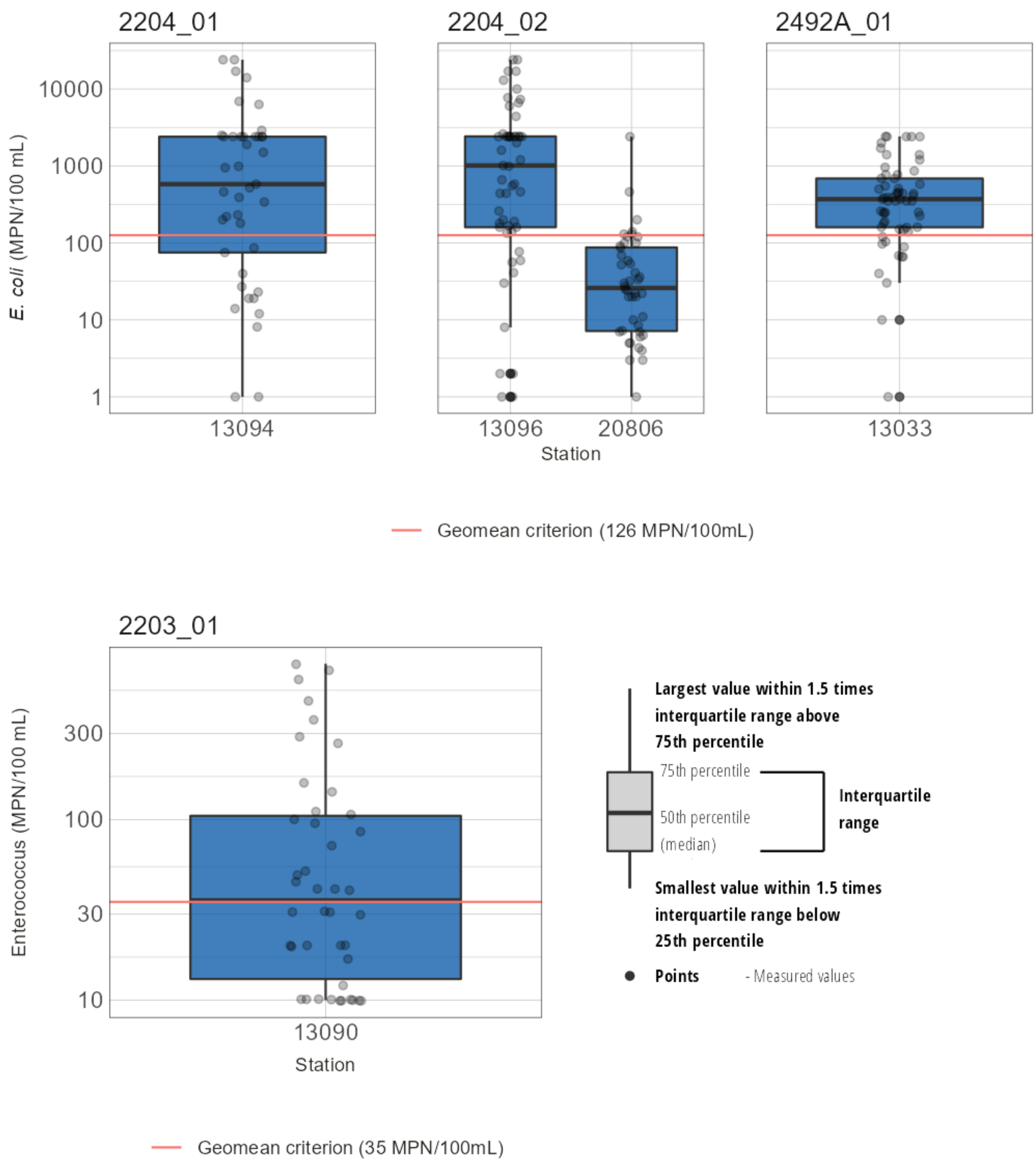


Figure 21. *E. coli* and *Enterococcus* concentration measurements taken between 2000 and 2021

Bacteria concentrations across the watershed exhibit a wide range of measured values (Figure 21, Table 16). In the freshwater portions of Petronila and San Fernando Creek, *E. coli* are commonly elevated above the water quality standard with the exception of 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).

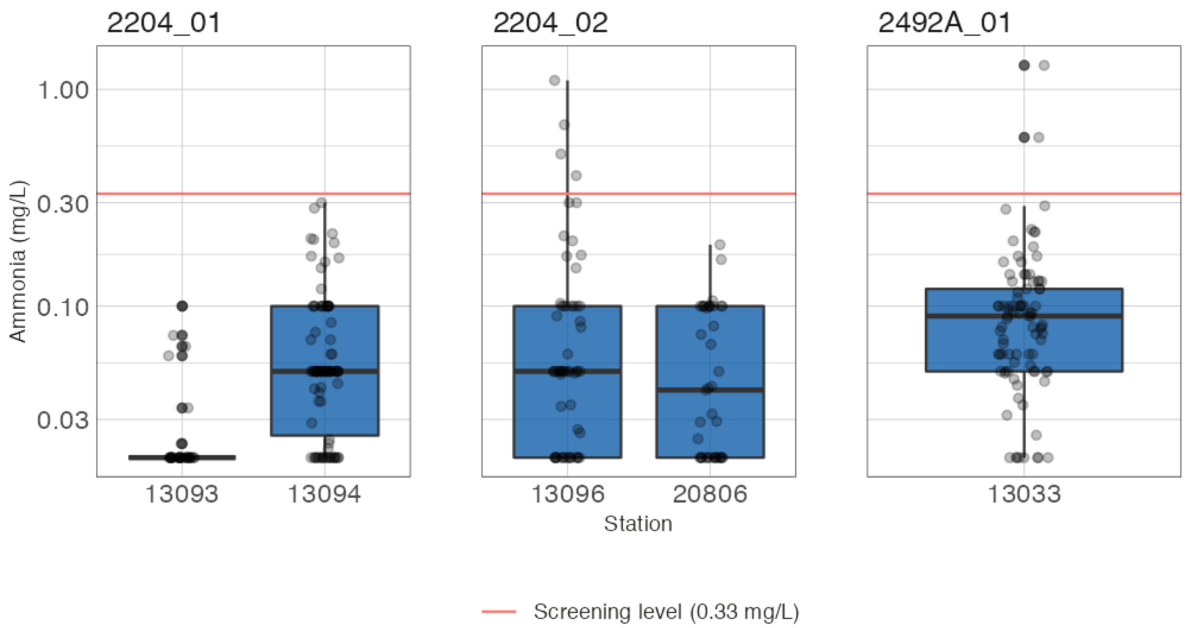
Table 16. *E. coli* & *Enterococcus* summary (2001 through 2021)

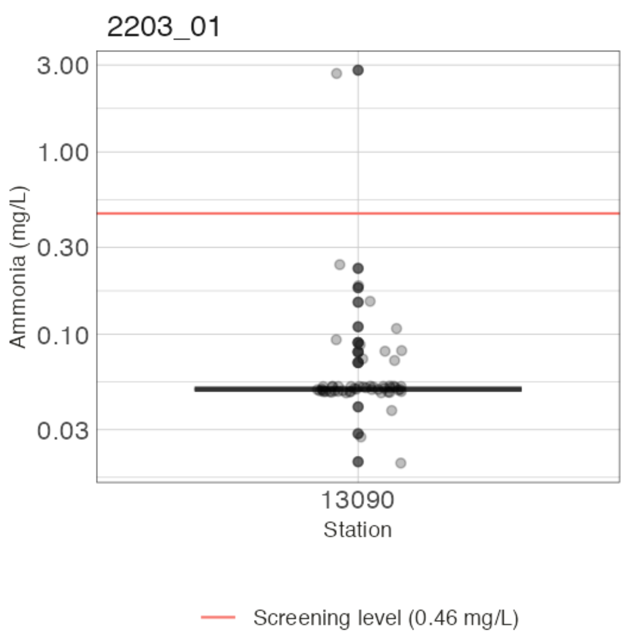
Station	AUs	Samples	Water Body	Minimum (MPN/100 mL)	Maximum (MPN/100 mL)	Geometric Mean (MPN/100 mL)
13033	2492A_01	57	San Fernando	1	2,400	303.6
13090*	2203_01	42	Petronila Tidal	10	730	44.9
13094	2204_01	42	Petronila	1	24,000	419.4
21598		1	Petronila	-	-	-
13096	2204_02	53	Petronila	1	2,420	592.5
20806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

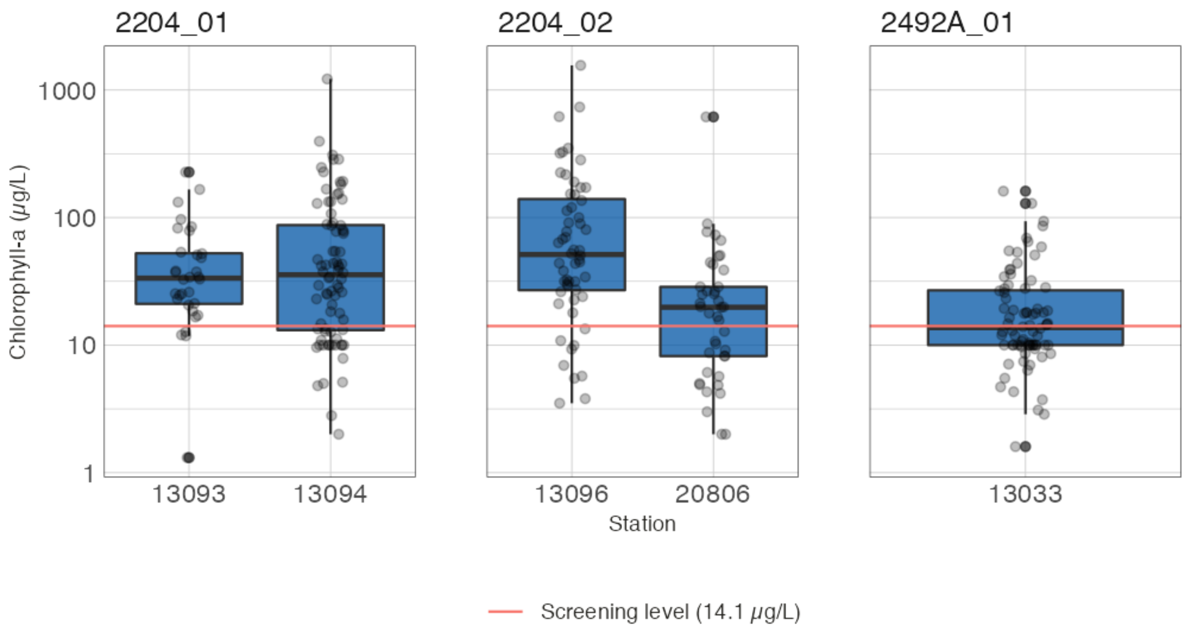
Assessment unit, AU; most probable number, MPN; milliliter, mL
*The Enterococcus standard of 35 MPN/100mL applies at this station

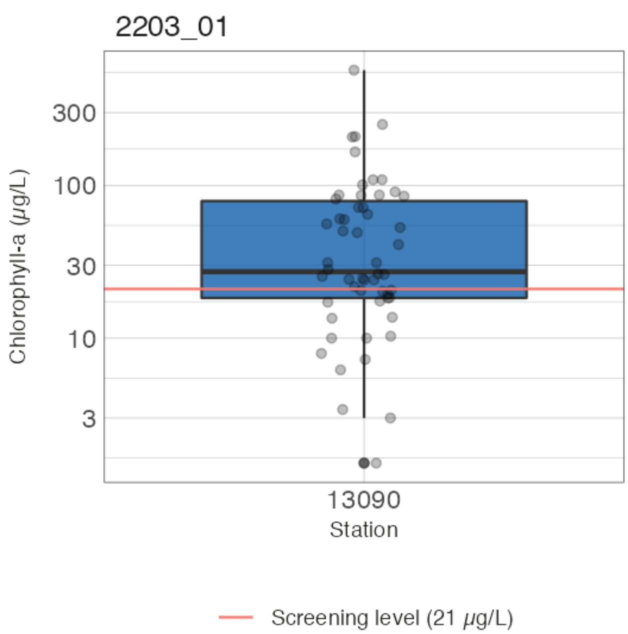
Nutrients

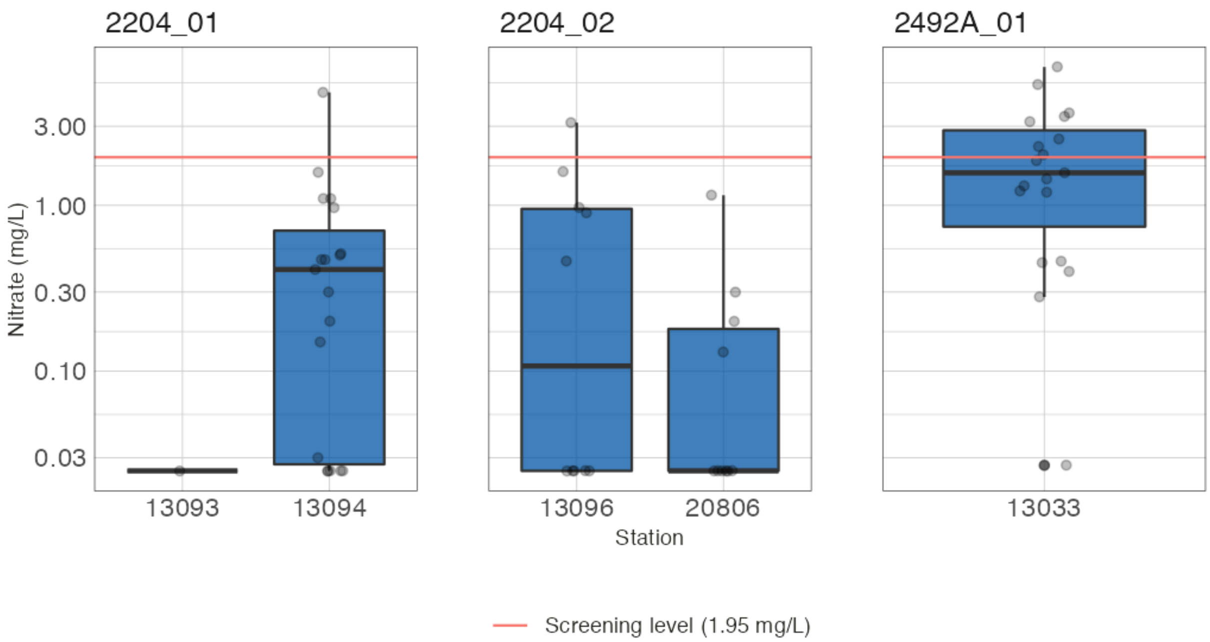
All assessment units in the watershed have average nutrient concentrations above state screening criteria. Figure 22 and Table 17 show nutrient concentration summaries for stations within each AU. AUs 2492_01, 2203_01, 2204_01, and 2204_02 have higher chlorophyll-a concentrations than expected while AU 2492A also includes higher than expected concentrations of nitrate and total phosphorus.

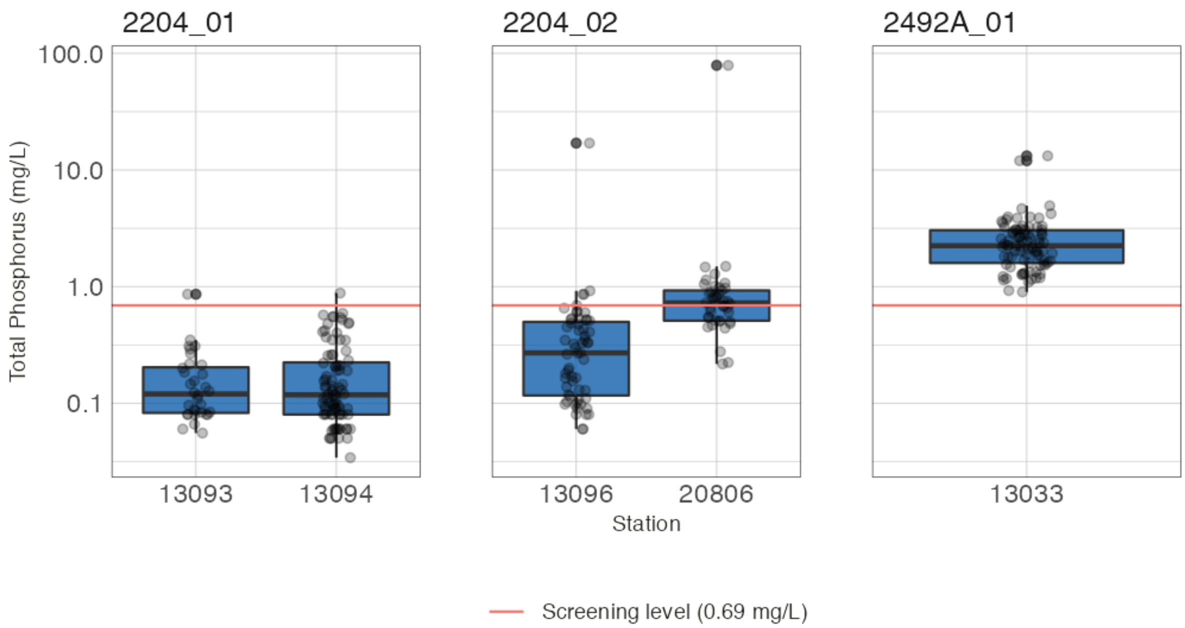

2204_01
2204_02
2492A_01
Ammonia (mg/L)
1.00
0.30
0.10
0.03
13093
13094
13096
20806
13033
Station
Screening level (0.33 mg/L)


2203_01
Ammonia (mg/L)
3.00
1.00
0.30
0.10
0.03
13090
Station
Screening level (0.46 mg/L)


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


2203_01
Chlorophyll-a (μg/L)
300
100
30
10
3
13090
Station
Screening level (21 μg/L)


2204_01
2204_02
2492A_01
3.00
1.00
0.30
0.10
0.03
Nitrate (mg/L)
13093
13094
13096
20806
13033
Station
Screening level (1.95 mg/L)



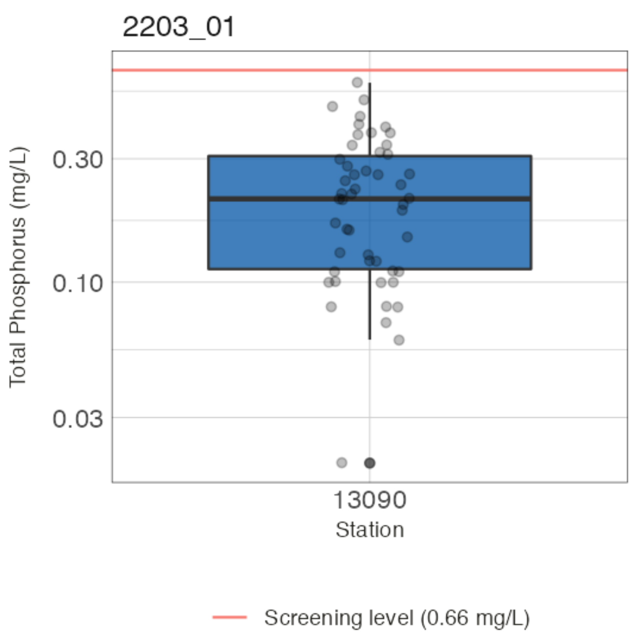


Figure 22. Boxplots of Ammonia, Chlorophyll-a, Nitrate, and Total Phosphorous at stations with more than five measurement values from 2001 - 2021

Table 17. Nutrient summary statistics

<table>
<tr><th>Station ID</th><th>AU</th><th>Water Body</th><th>Mean Nitrate (mg/L)</th><th>Mean Ammonia (mg/L)</th><th>Mean Chlorophyll-a (µg/L)</th><th>Mean Total Phosphorus (mg/L)</th></tr>
<tr><td>13033</td><td>2492A_01</td><td>San Fernando Creek</td><td>2.08</td><td>0.11</td><td>23.48</td><td>2.56</td></tr>
<tr><td>13090</td><td>2203_01</td><td>Petronila Creek Tidal</td><td>0.5</td><td>0.11</td><td>61.9</td><td>0.23</td></tr>
<tr><td>13094</td><td rowspan="2">2204_01</td><td rowspan="4">Petronila Creek Above Tidal</td><td>0.67</td><td>0.07</td><td>82.19</td><td>0.19</td></tr>
<tr><td>21598</td><td>No data</td><td>No data</td><td>No data</td><td>No data</td></tr>
<tr><td>13096</td><td rowspan="2">2204_02</td><td>0.72</td><td>0.11</td><td>131.07</td><td>0.6</td></tr>
<tr><td>20806</td><td>0.19</td><td>0.06</td><td>38.3</td><td>2.65</td></tr>
</table>

Assessment unit, AU; milligrams, mg; micrograms, μg; liter, L

5.3: Load Duration Curve (LDC) 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 load reductions of a particular pollutant to achieve the established water quality goal. LDCs 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) using 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 to use and is representative of conditions across each waterhsed. Nutrient LDCs were not developed since nutrient standards have not been established for Texas. Currently, only statewide nutrient screening criteria exist to allow further data gathering to support standards development. As such, using these values to develop local nutrient reduction goals was deemed inappropriate due to inherent uncertainty associated with application of a statewide value to local water quality management. 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. Daily average streamflows from the previous 22 years were available for this assessment. 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 nonpoint sources of *E. coli* are influencing instream water quality.

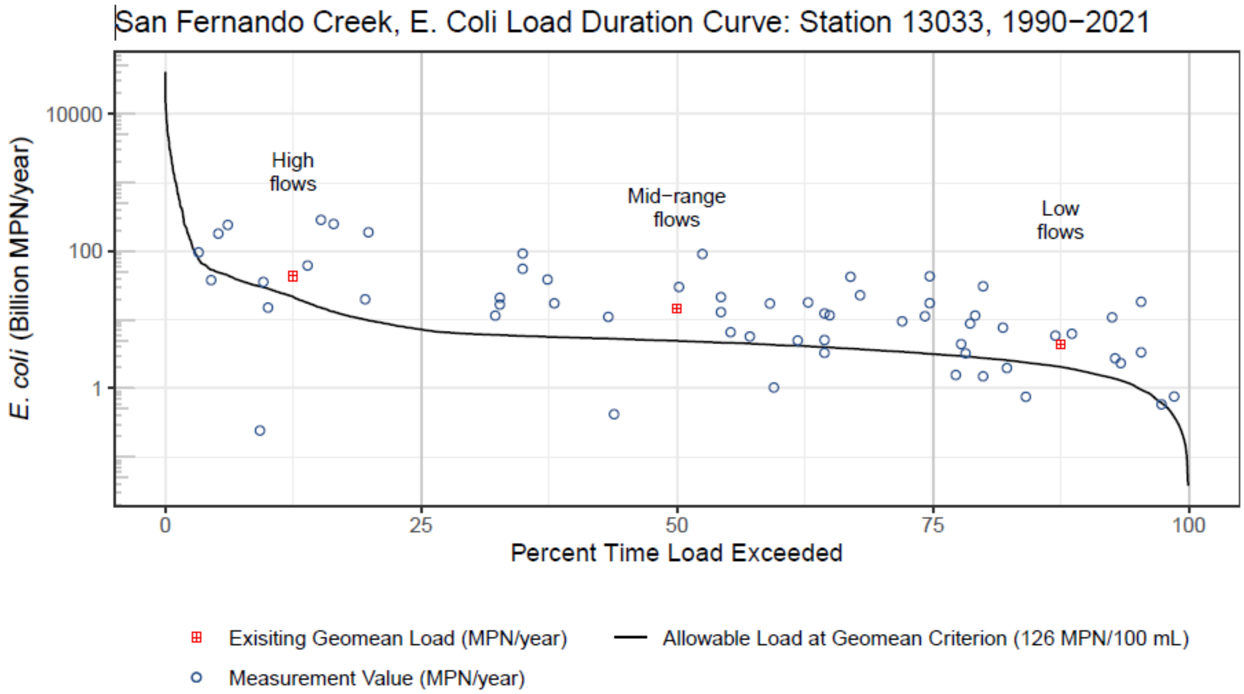


Figure 23. San Fernando Creek station 13033 *E. coli* LDC

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 nonpoint sources of *E. coli* are influencing instream water quality.

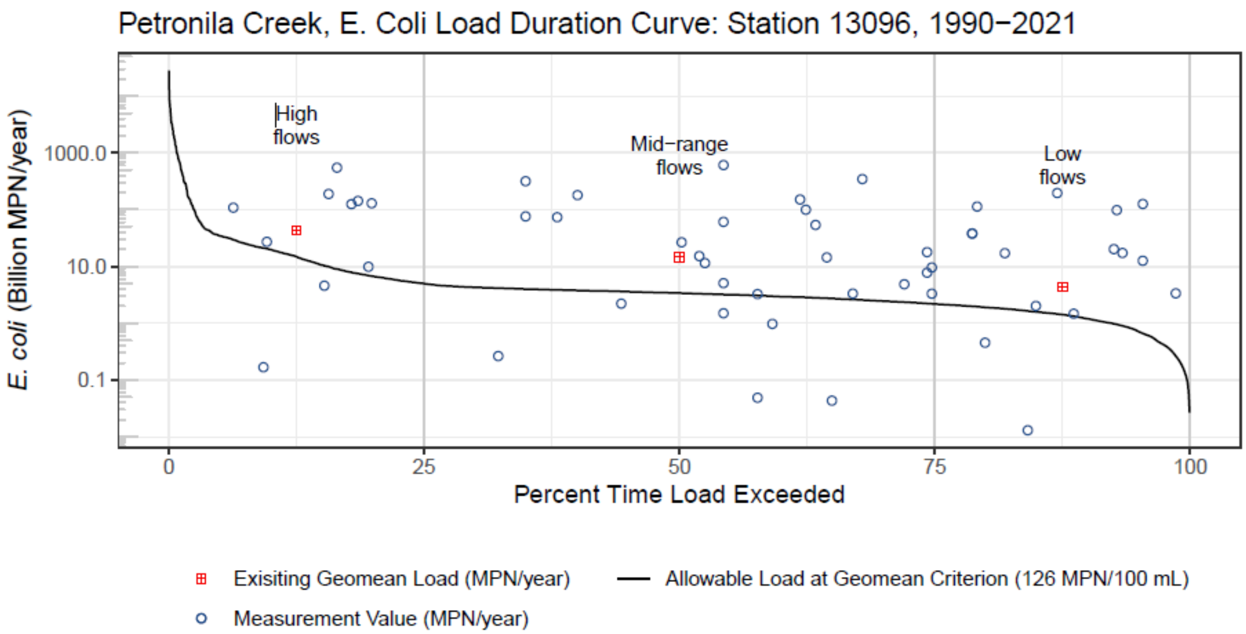


Figure 24. Petronila Creek station 13096 *E. coli* LDC

Annualized Reductions

Based on LDC analysis, both San Fernando and Petronila Creek water bodies exhibit bacteria load exceedance under all flow conditions indicating the need for loading reductions to meet water quality standards. Estimated annual load reductions needed to meet the water 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 enough to eventually 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 colony forming units (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 (cubic feet per second)	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%		

Most probable number, MPN

Table 19. Estimated *E. coli* load reductions needed to meet primary contact water quality criteria in Petronila Creek (based on the 126 colony forming units (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 (cubic feet per second)	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%		

Most probable number, MPN

5.4: Spatial Analysis of Potential *E. coli* Loading

Potential pollutant loading distribution across the watersheds were evaluated using a Geographic Information System (GIS) based approach was applied using a methodology similar to the Spatially Explicit Load Enrichment Calculation Tool (SELECT, 2021). Publicly available information described earlier in the Pollutant Sources chapter, land use/land cover, soils data plus stakeholder feedback was used to identify likely 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). These are areas of the larger watershed defined by USGS based on hydrological features and are generally of similar sizes. For WPP purposes, the HUCs are referred to as subbasins and are given a numeric ID number. The San Fernando Creek watershed includes subbasins 1 -34 and the Petronila Creek watershed includes subbasins 35 – 51 (Figure 25). These subbasin IDs are used for prioritizing management recommendations later in the WPP.

Bacteria loading estimates are presented on color coded maps to allow easy comparisons of potential loading between subbasins and to facilitate best management practice implementation prioritization (Figure 25; 26; 27; 28, 29; 30; 31). It must be pointed out that 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 scenario of bacteria loading in the watershed and does not represent actual bacteria loading to area waterbodies.

Deer

White-tailed deer are the primary wildlife species in the watershed and one that has been well studied and that sufficient data exists to estimate their populations and fecal bacteria contributions across the watershed. Other exotic wildlife species exist in the watershed, but their distribution and numbers are largely unknown. White-tailed deer are adaptable animals that prefer habitats with ample food and cover; however, they are known to feed on crops and vegetation around homesteads. Based on white-tailed deer density data from Texas Parks and Wildlife and suitable habitat availability, it was estimated that San Fernando Creek is home to 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).

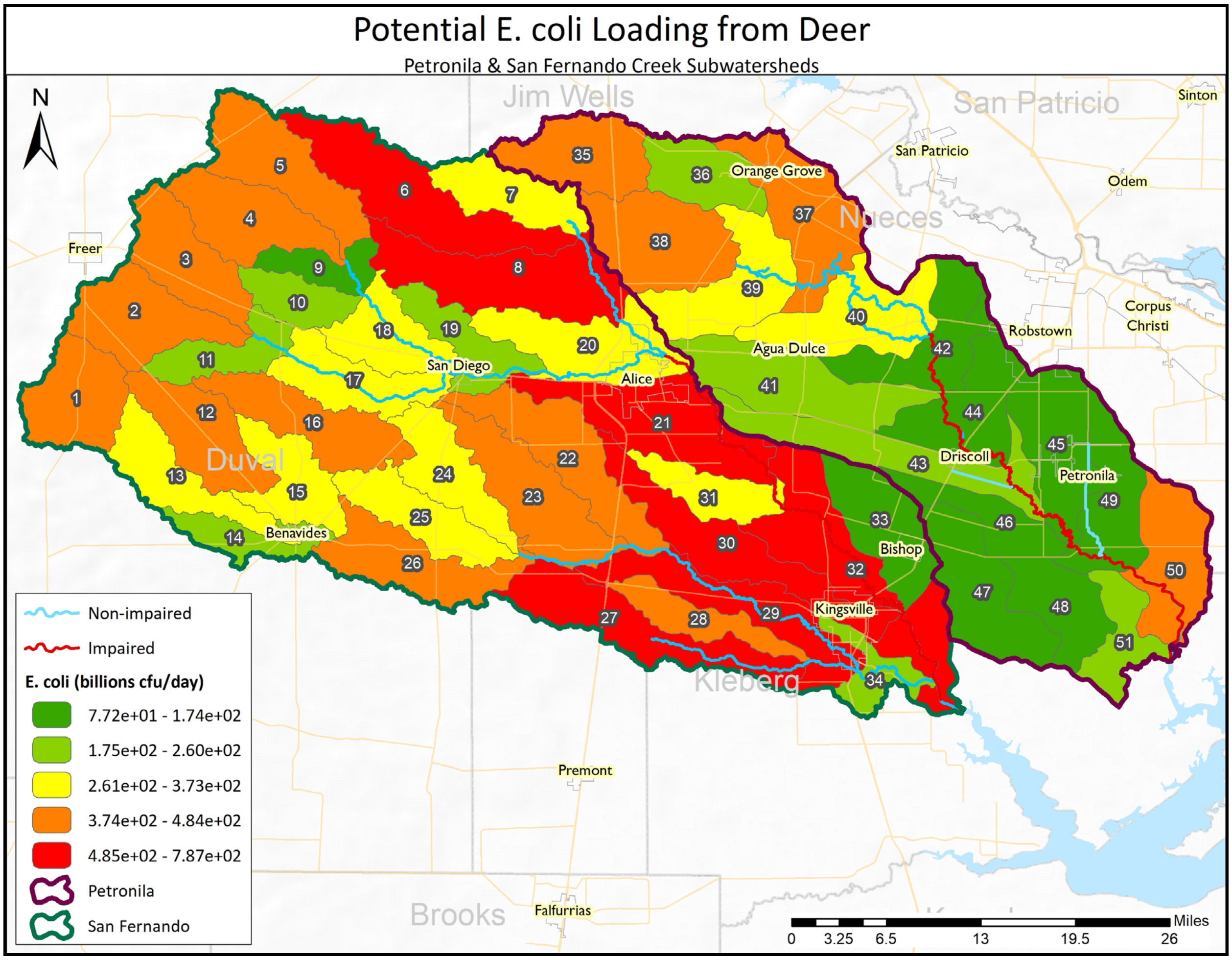


Figure 25. Estimated potential *E. coli* loads from deer

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 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 for them to contribute to *E. coli* to area waters 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).

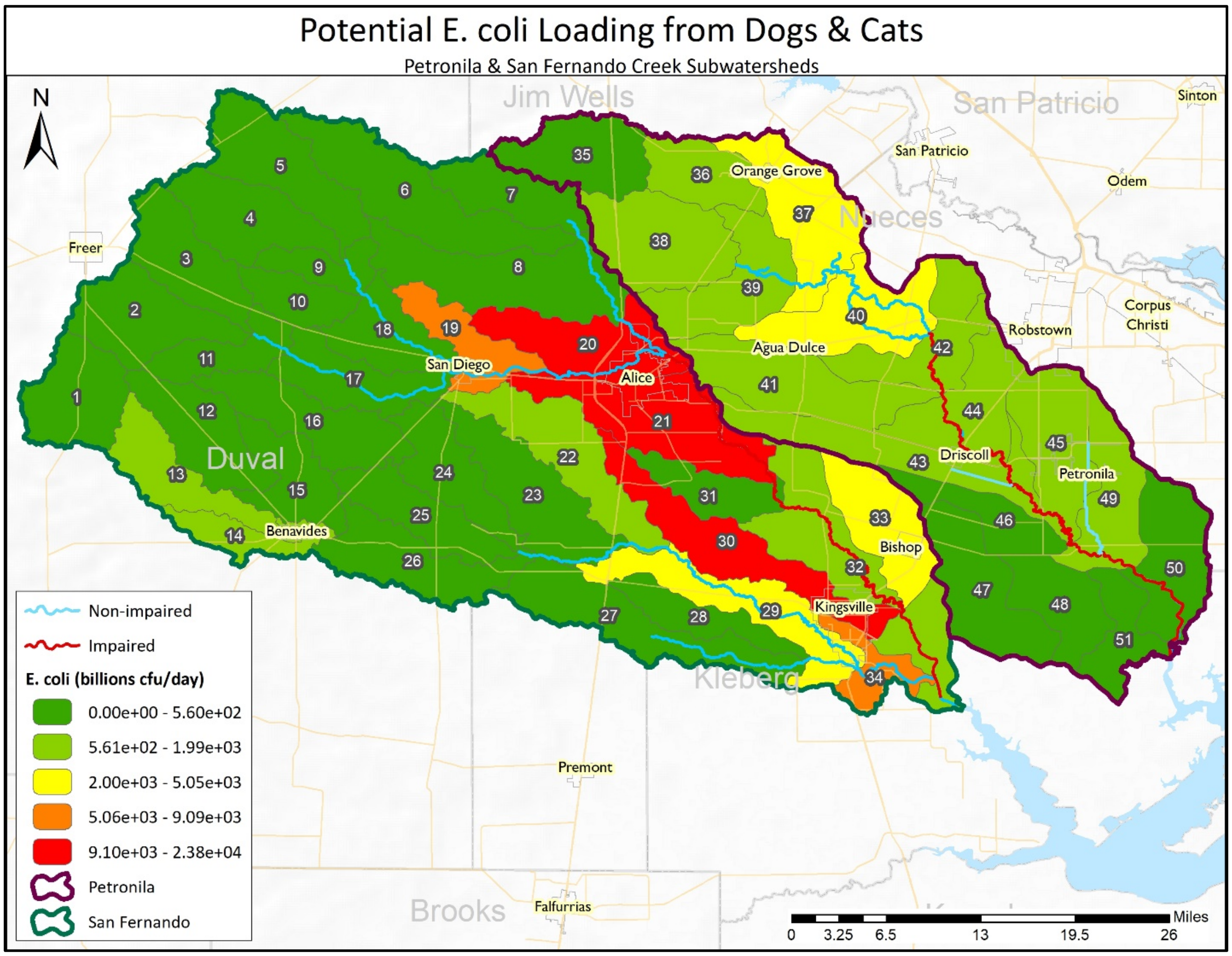


Figure 26. Estimated potential *E. coli* loads from dogs and cats

Feral Hogs

Current population estimates of feral hogs in Texas alone range from 1 to 3 million individuals (Mayer 2009; Mapston 2010). Feral hogs contribute to *E. coli* bacteria loadings through the direct deposition of fecal matter into streams while wading or wallowing in riparian areas and through deposition of fecal matter across the landscape. Additionally, 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 habitats and migratory corridors for feral hogs as they search for food. While complete removal of feral hog populations is unlikely, habitat management and trapping programs can limit populations and associated damage. Assessment results indicate the highest potential daily loadings from feral hogs occur in subbasins 6 and 8 in San Fernando Creek and subbasins 35 and 38 in Petronila Creek watersheds (Figure 27).

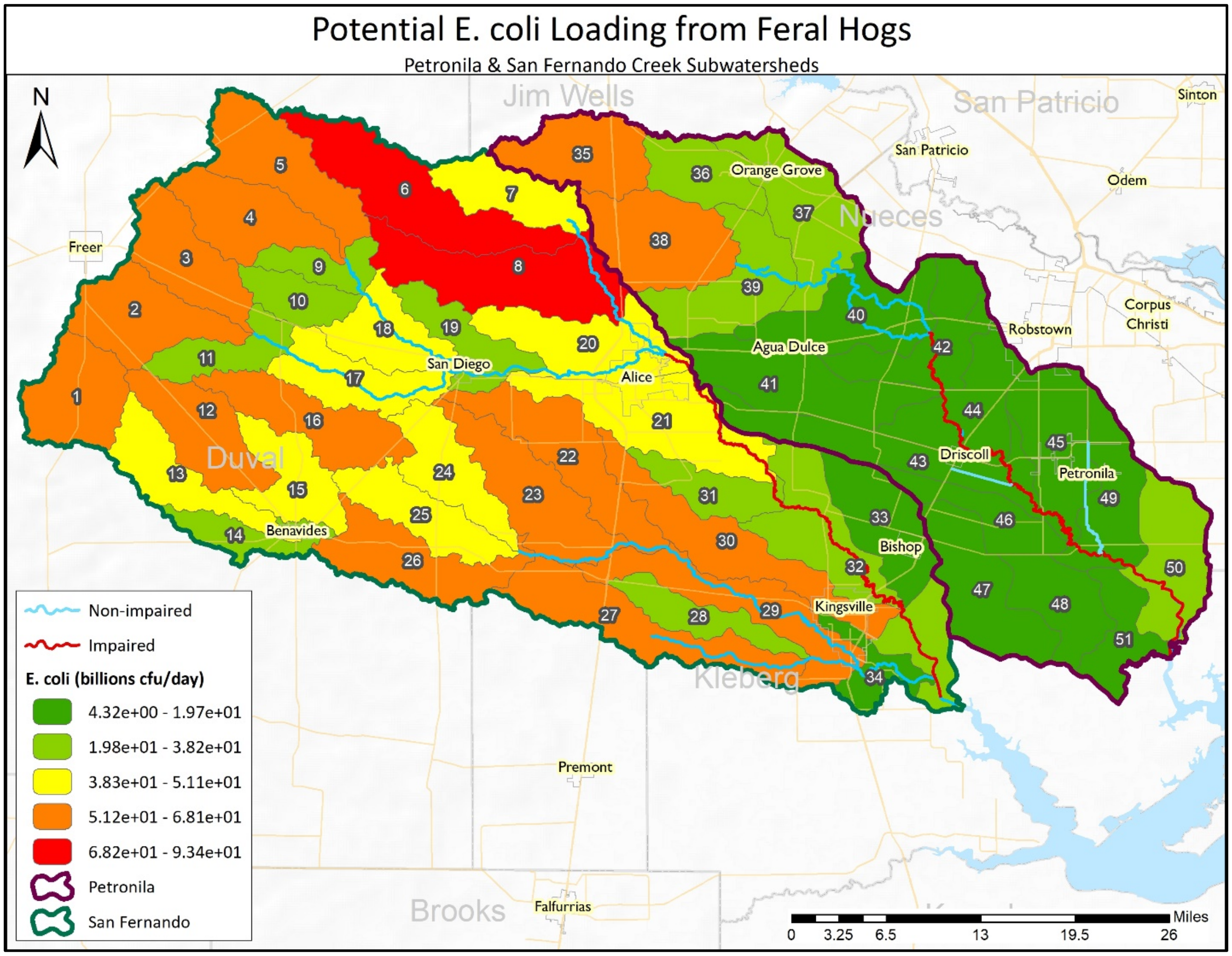


Figure 27. Estimated potential *E. coli* loads from feral hogs

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 were used to estimates potential *E. coli* loads. The spatial distribution of relative *E. coli* loading potential for each type of livestock was calculated and summed to produce the total potential *E. coli* load from livestock within 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.

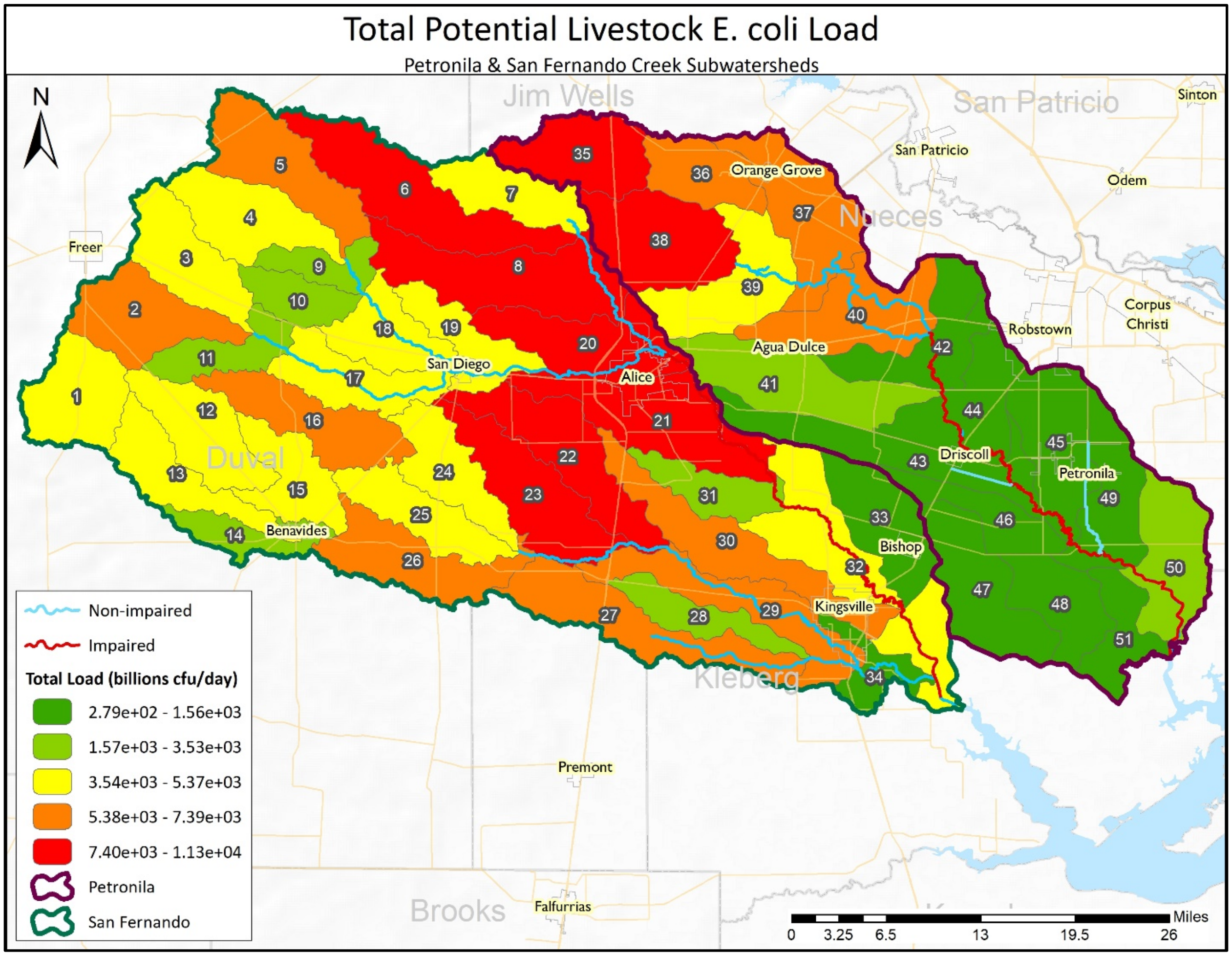


Figure 28. Estimated potential *E. coli* loads from livestock

OSSFs

Failing or unmaintained OSSFs can contribute bacteria loads to water bodies, especially those where effluent is released near the water bodies. Within the San Fernando and Petronila Creek watershed approximately 4-12% of OSSFs are assumed to fail during a given year (Reed et al. 2001). It was estimated that there are approximately 9,086 OSSFs within the watershed based on the most 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).

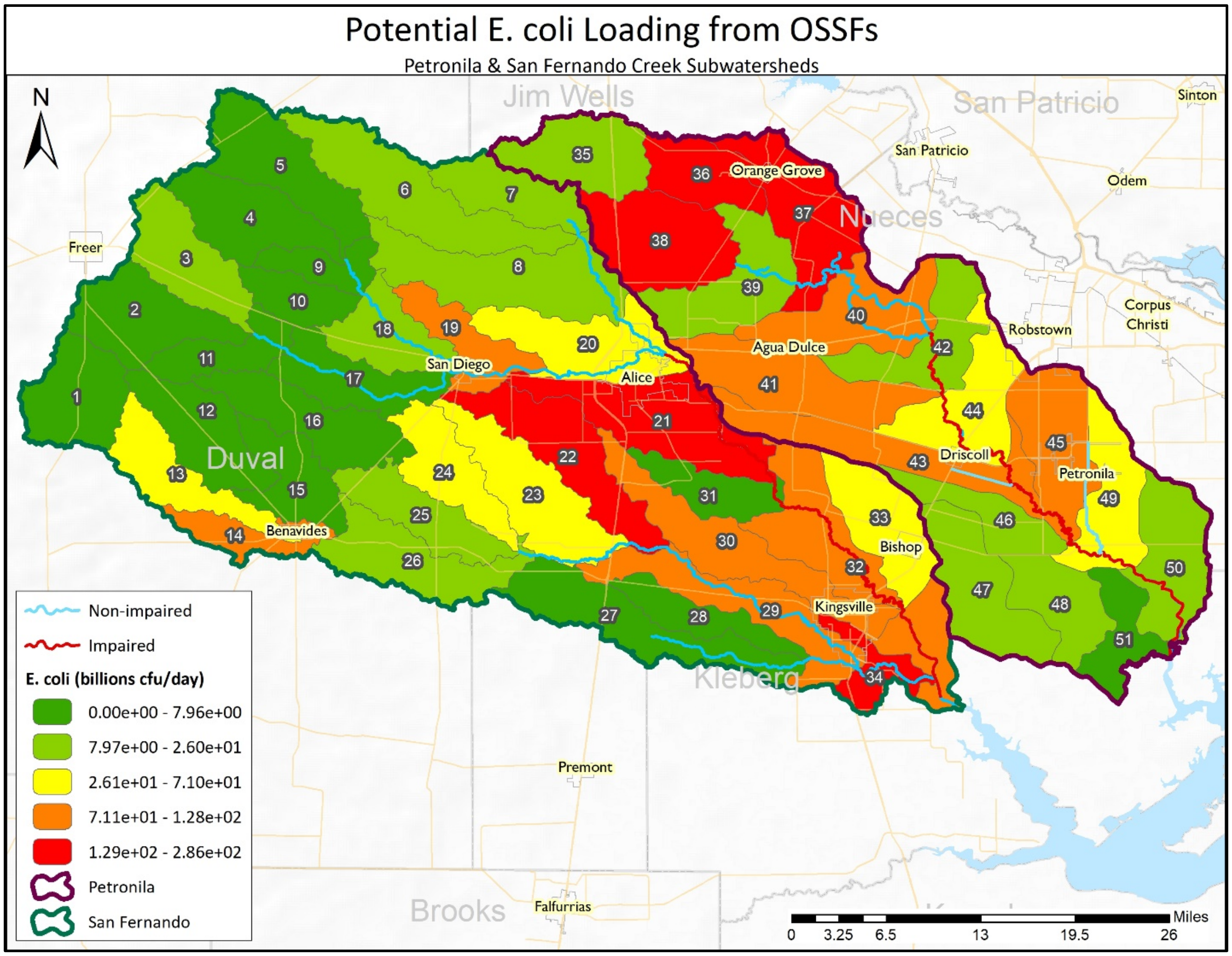


Figure 29. Estimated potential *E. coli* loads from OSSFs

WWTFs

Currently there are 15 active permitted wastewater discharges in the watershed. These wastewater discharges are regulated by TCEQ and are required to report average monthly discharges and *E. coli* concentrations. Although the permitted discharge volumes and bacteria concentrations are typically below permitted values, almost half of the WWTFs have been in violation of *E.* coli discharge limits for at least one quarter in recent years. To appropriately address the potential *E. coli* load from WWTFs, the calculation used the maximum permitted discharges and concentrations 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).

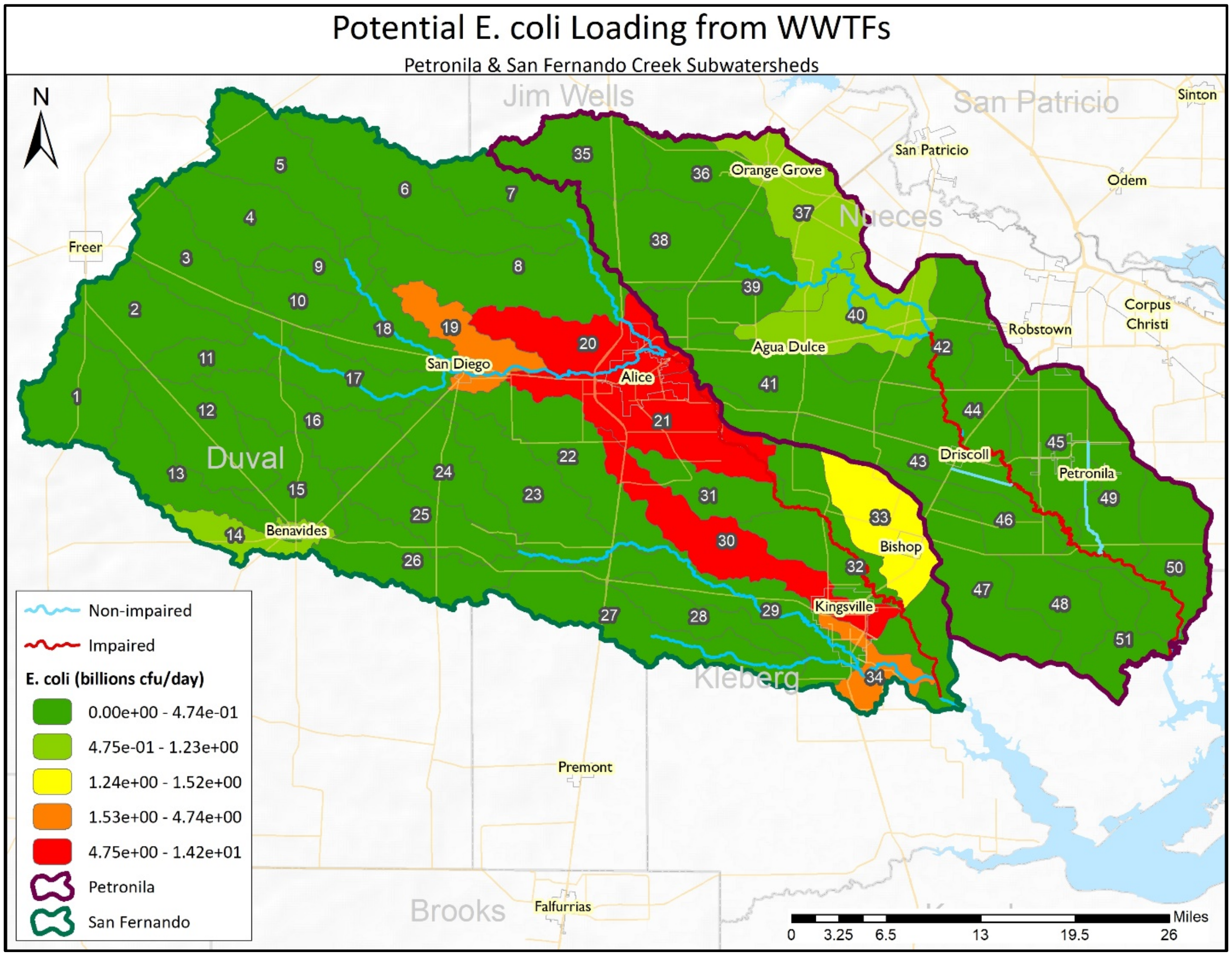


Figure 30. Estimated potential *E. coli* loads from WWTFs

Total Potential *E. coli* Load

Total potential *E. coli* loadings 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).

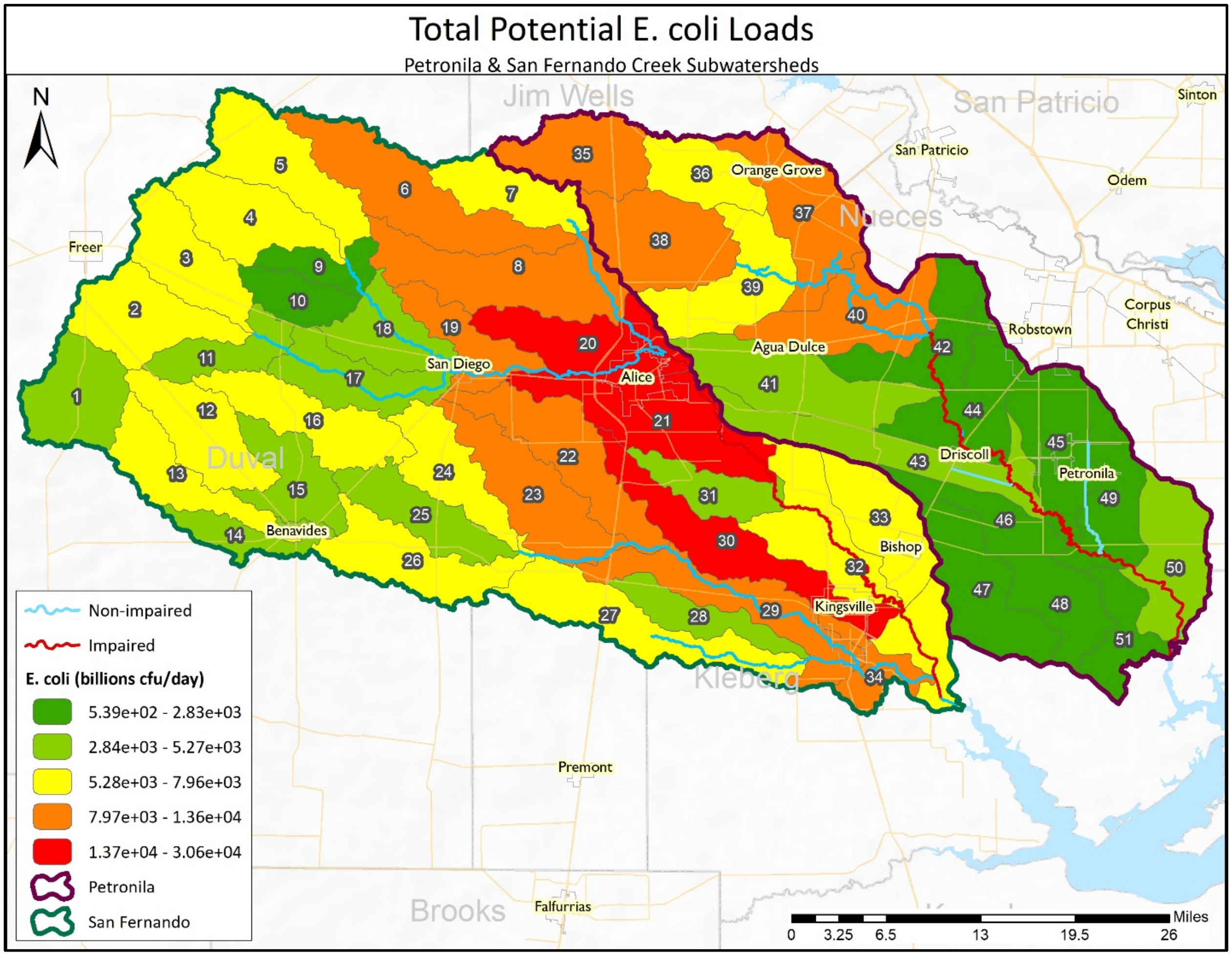


Figure 31. Estimated potential *E. coli* loads from all assessed sources