Final Report for La Nana Bayou Watershed Characterization

TCEQ Contract #582-18-80205

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List of Acronyms

ANRA	Angelina Neches River Authority
AU	Assessment Unit
AVMA	American Veterinary Medical Association
CAFO	Concentrated Animal Feeding Operation
CRP	Clean Rivers Program
EPA	Environmental Protection Agency
GIS	Geographical Information System
HUC	Hydrologic Unit Code
LDC	Load Duration Curves
LULC	Land use land cover
MGD	Million gallons per day
MSL	Mean sea level
NASS	National Agricultural Statistics Service
NED	National Elevation Dataset
NLCD	National Land Cover Dataset
NPDES	National Pollution Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OSSF	On-site Sewage Facility
SSO	Sanitary Sewer Overflow
SSURGO	Soil Survey Geographic Database
SWCD	Soil and Water Conservation District
SWQM	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TNRIS	Texas Natural Resource Information System
TPDES	Texas Pollution Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
TWON	Texas Well-Owner Network
TWRI	Texas Water Resources Institute
TWS	Texas Watershed Stewards
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
WQMP	Water Quality Management Plan
WWTP	Wastewater Treatment Plant

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Project Background

Introduction

La Nana Bayou is a 32-mile freshwater stream that extends from the confluence of the Angelina River south of Nacogdoches in Nacogdoches County to the upstream perennial portion of the stream north of Nacogdoches in (Figure 1). La Nana Bayou consists of a single segment (0611B) and three assessment units (0611B_01, 0611B_02, and 0611B_03). Routine water quality monitoring began in 1996 and led to the inclusion of La Nana Bayou on the Texas 303(d) List in 2000 as being impaired for bacteria on the two downstream AUs (0611B_01 and 0611B_02) , while the upstream AU (0611B_03) has a concern for elevated *E. coli* concentrations. It remains impaired for not meeting its primary contact recreation standard. Concerns for elevated ammonia-nitrogen, nitrate-nitrogen, and total phosphorous exist in the downstream portion of the bayou.

La Nana Bayou is divided into three assessment units (AU) (Figure 1) that the Texas Commission on Environmental Quality uses to incrementally evaluate water quality in the stream. The two downstream AUs are impaired while the upstream AU has a concern for elevated *Escherichia coli* (*E. coli*) concentrations. The Angelina & Neches River Authority (ANRA) performs quarterly monitoring through the Clean Rivers Program (CRP) for field and conventional parameters, flow, and *E. coli* at one monitoring station in each AU (FY 17 Coordinated Monitoring Schedule available online at: https://cms.lcra.org/schedule.aspx?basin=6&FY=2017). This monitoring approach provides good spatial representation of data throughout La Nana Bayou; however, the quarterly monitoring regime reduces understanding of temporal variability in flow and pollutant loading in the waterbody.

Numerous potential contributors of pollutant loading in La Nana Bayou exist, but their potential effects on instream water quality are not well understood. The majority of the watershed is rural; however, the cities of Nacogdoches and Appleby are located in the center and northern part of the watershed respectively. This places common point and nonpoint sources of bacteria and nutrients within the watershed; however, the quantity of bacteria and nutrient loading that these sources contribute is not known. A complete assessment of point and nonpoint pollutant sources is needed to quantify the current loads, establish needed loading reductions to meet water quality standards, and develop an appropriate restoration strategy for the La Nana Bayou Watershed.

Project Goals

To address these needs, this project developed a clearer understanding of spatial and temporal *E. coli* concentration variability in the watershed and established a recent *E. coli* loading baseline. This was accomplished through planned supplemental monitoring at the three routinely monitored locations in the watershed. ANRA increased their quarterly monitoring regime to monthly for a one year period (March 2018 – February 2019). Further evaluation of potential *E. coli* loading in the watershed was completed with two intensive sampling events. ANRA used local knowledge and key stakeholder input to identify 25 potential monitoring locations for a one-time sampling event where numerous samples were taken along the La Nana Bayou, Bonita Creek, and other tributaries in the watershed on the same date to roughly identify areas with relatively higher *E. coli* concentrations in the stream. Data were analyzed to further refine understanding of *E. coli* loading across the watershed. Stream reaches with rapid *E. coli* increases were sampled with a second, more intensive monitoring event (75 locations) to further refine understanding of water quality within that reach. Watershed characteristics and potential

E. coli contributors were also studied to improve knowledge of potential *E. coli* sources affecting water quality. A Geographical Information System (GIS) was developed for the watershed and used to graphically display factors that potentially affect water quality.

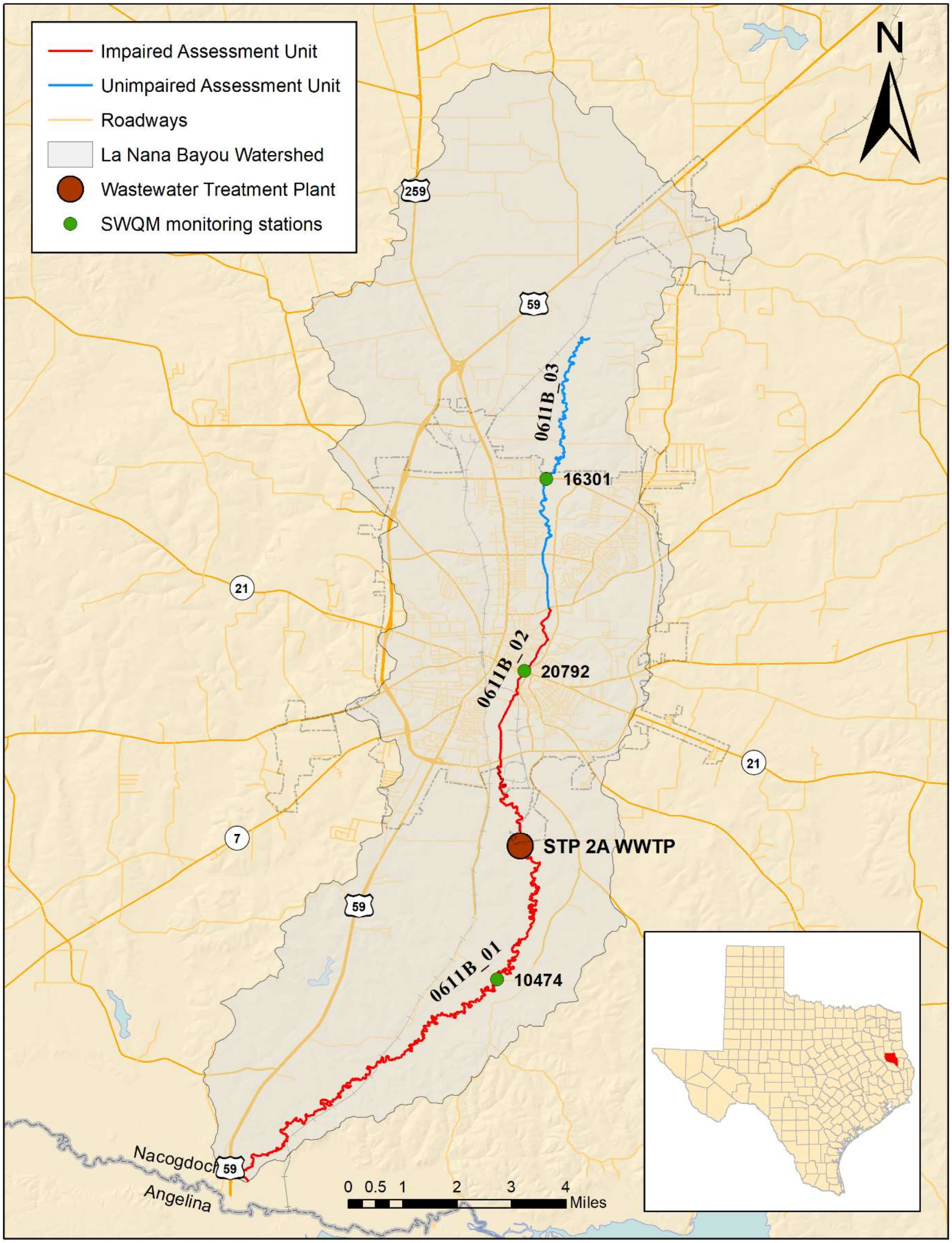

Figure 1: La Nana Bayou Watershed

Project Data Acquisition

Geographic Information System Inventory and Analysis

A watershed inventory was conducted to determine the current state of data resources within the watershed. After collection of the needed data, a watershed GIS analysis was performed to analyze potential sources of bacterial pollution using the most recently available information. Table 1 includes brief data descriptions, uses, and sources gathered and analyzed. GIS analysis is important for understanding the basic geography, topology, sources and causes of impairment, as well as their spatial relationships within a watershed.

Table 1: Descriptions, uses and sources of data used in GIS Analysis

Data Description	Use	Source
911 address structure points	Determine location and density of structures within the watershed with potential OSSFs	Nacogdoches County Engineering Dept
Air temperature and precipitation	Watershed characterization	NOAA
Average annual air temperature and precipitation	Watershed characterization	PRISM
City boundaries	General map layer; aid in determining potential OSSF extent	TNRIS
County boundaries	General map layer	TNRIS
Deer population estimates	Estimate spatial wildlife density and potential bacterial loads from deer	TPWD
Domestic animal population estimates	Estimate potential bacterial loads from domestic animals	AVMA 2012
E. coli, enterococci, specific conductance, nitrate, phosphorous	Understand constituent concentrations under variety of flow conditions and at different times	TCEQ
Feral hog population estimates	Estimate potential bacterial loads from feral hogs	TWRI 2009
General permits involving regulation of storm water	Locate the outfalls for TPDES permitted stormwater discharges and recognize potential problem areas	TCEQ
Wastewater permits	Locate outfalls for permitted wastewater discharges; understand permitted limits	TCEQ

Hydrography	Determine the flow relationships between the La Nana Bayou and its tributaries	USGS National Hydrography Dataset
Land use/land cover	Characterize the watershed and potential sources of pollution	NLCD, MRLC
Livestock population estimates	Estimate potential bacterial loads from livestock	USDA
Municipal & industrial WWTP discharge monitoring reports	Characterize the watershed and understand the possible effects of monthly discharges and concentration data	EPA
Population	Watershed characterization	US Census Bureau
Population projections	Estimate possible population growth within the watershed	TWDB
Sanitary Sewer Overflows (SSOs)	Estimate the bacterial load that could be attributed to SSO, and to recognize potential problem areas	TCEQ, EPA
Soil map unit boundaries and properties	Characterize the watershed	NRCS
Streamflow	Understand watershed hydrology; generate pollutant load estimates	USGS
TCEQ segments	Determine the location of official TCEQ River Segments and AUs	TCEQ
TCEQ Surface Water Quality Monitoring (SWQM) stations	Determine the location of active and historical SWQM stations	TCEQ
Urbanized areas	Characterize the watershed and potential sources of pollution; refine potential OSSF locations	US Census Bureau
Water and sewer service areas	Estimate the density and location of OSSFs	TCEQ
Water rights diversion points	Characterize water use within the watershed	TCEQ
Watershed topography	Estimate the elevation of the watershed utilizing DEMs	NED, USGS

La Nana Bayou Watershed Characteristics

Ecoregions

Ecoregions are land areas with ecosystems that contain similar quality and quantity of natural resources (Griffith, Bryce, Omernik, & Rogers, 2007). There are four separate delineated levels of ecoregions; level I being the most unrefined classification, and level IV is the most refined. The La Nana Bayou watershed is located in the Level III Ecoregion 35, known as the South Central Plains (Figure 2). Where the watershed is located in Ecoregion 35 is subdivided into the Level IV Ecoregions 32a and 35e, known as the Tertiary Uplands and Southern Tertiary Uplands. The landscape in the area of the Tertiary Uplands is mainly underlain by sand, silt, and gravel. The main land cover are pine-hardwood deciduous forests, with scattered areas of cropland and pastures.

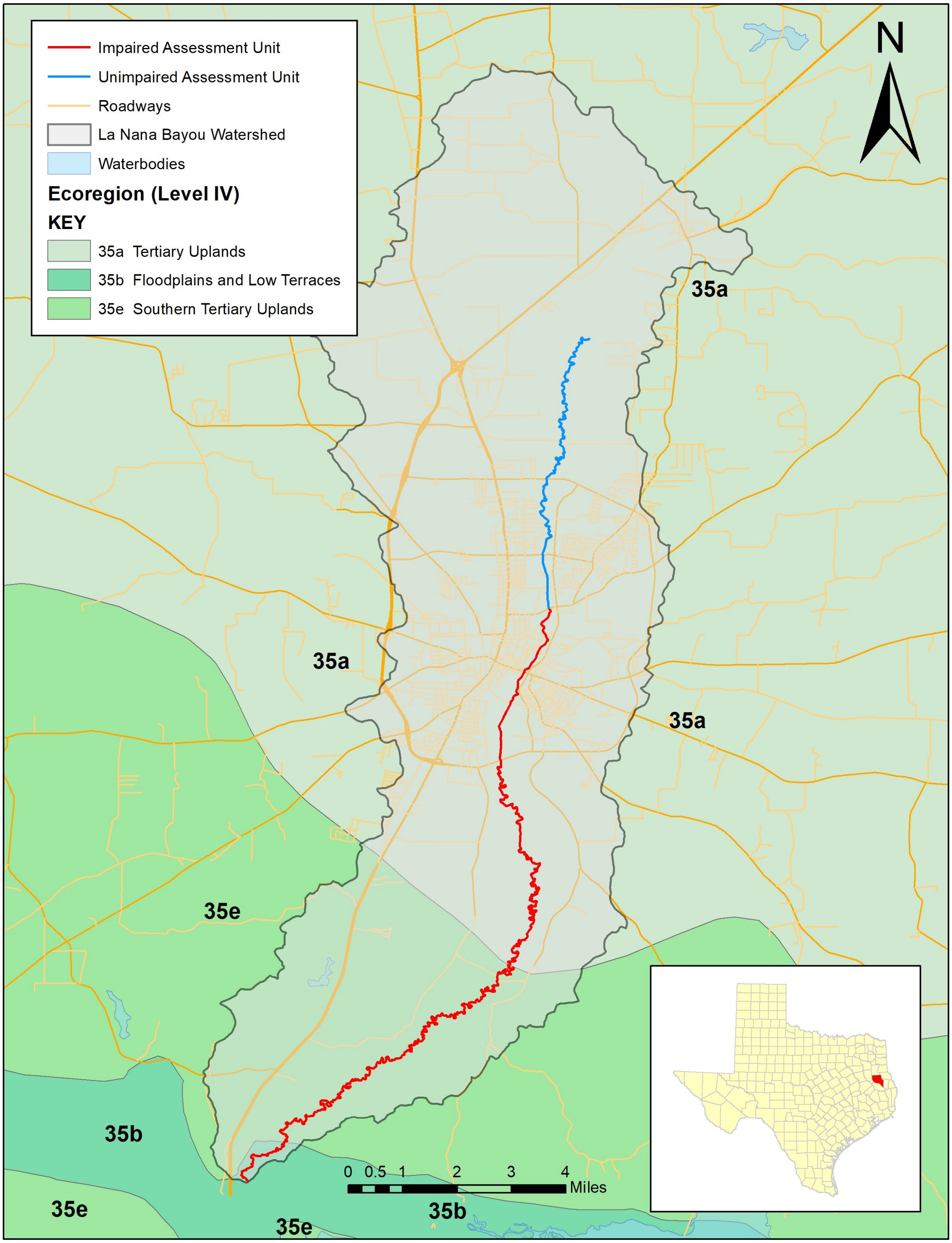

Figure 2: La Nana Bayou Watershed Ecoregions

Land use and Land Cover

Watershed land cover data was obtained from the 2011 National Land Cover Database (NLCD) (Homer et al. 2015). Forests (26.65%), developed (24.73%), and hay/pasture (19.8%) are dominate watershed land cover features (Figure 3, Table 2). The center of the La Nana Bayou watershed is predominantly urban, where it encompasses the city of Nacogdoches. The northern and southern areas of the watershed are predominantly rural in land-use, with more forest in the south and pastures in the north.

Table 2: Acres of land use/land cover by subwatershed (NLCD 2011)

	Land Use and Land Cover Categories									Total
	Developed	Barren Land	Shrub/ Scrub	Herbaceous	Hay/ Pasture	Cultivated Crops	Forest	Wetlands	Open Water	
Acres	13,173	162	6,931	2,635	10,546	132	14,194	5,289	202	53,264
Percent	24.73	0.3	13.01	4.95	19.8	0.25	26.65	9.93	0.38	100

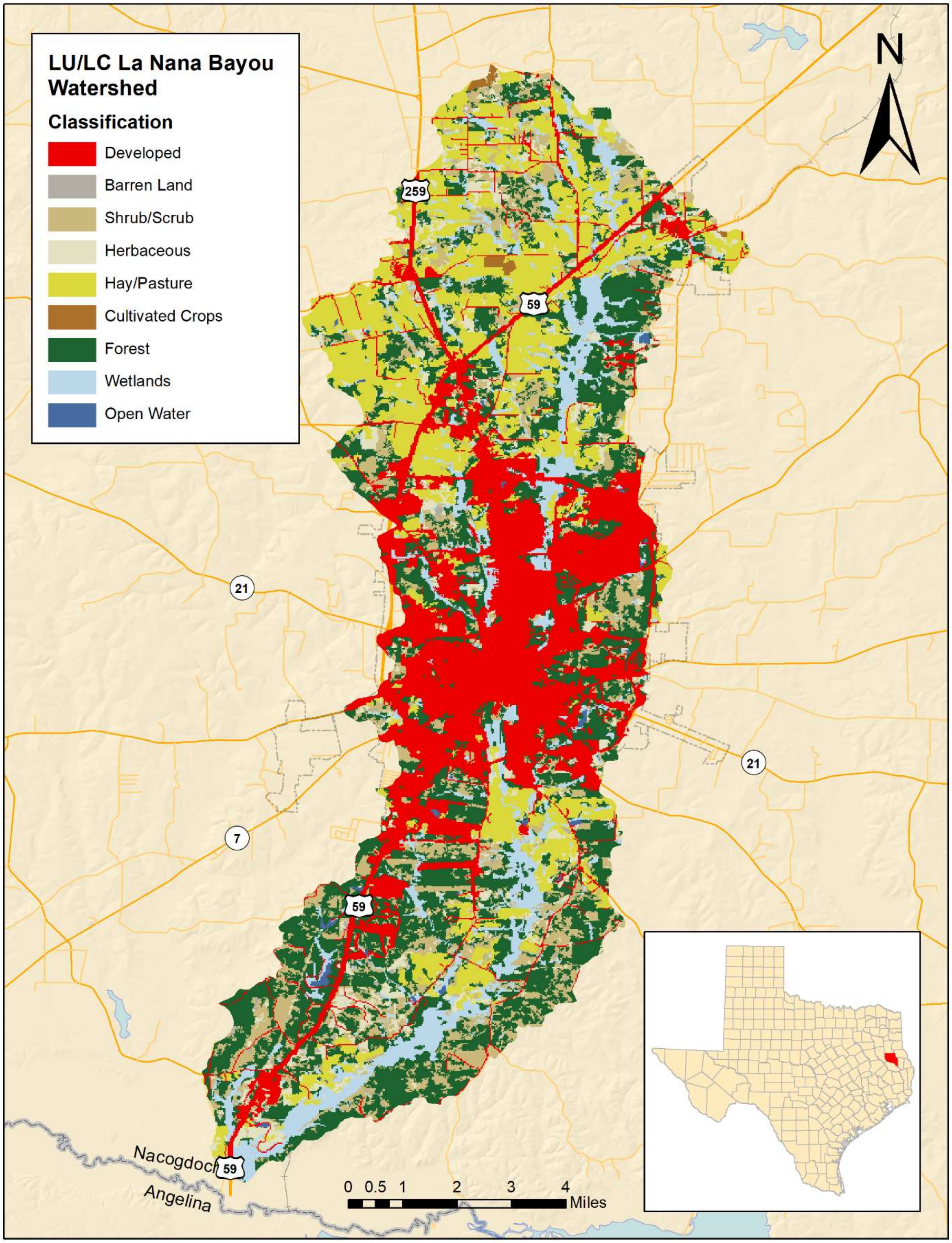

Figure 3: La Nana Bayou Watershed Land cover map

Topography

The hydrology of a watershed has many key components, including soil properties and topography. Slope and elevation determine the direction of water flow while elevation and soil properties effect the quantity and speed at which water will infiltrate into, flow over, or move through the soil into a water body. Development and other activities may be limited by soil properties in certain areas.

The elevation across the watershed ranges from approximately 188 ft above mean sea level (MSL) maximum elevation in the northern portion of the watershed to about 52 ft above MSL for the minimum elevation in the southern most portion of the watershed. Figure 4 shows the elevation of the watershed using information from the United States Geologic Survey (USGS) 10-m national elevation dataset (United States Geologic Survey, 2013) images as well as the decreasing elevation trend from the northern to southern portions of the watershed. The average slope of the watershed is less than 1%.

Soils

USDA NRCS provides information about soils collected by the National Cooperative Soil Survey, made available through the Soil Survey Geographic Database (SSURGO) database (United States Department of Agriculture Natural Resource Conservation Service, 2018b). This database describes components and properties of soils and provides a hydrologic rating for soils. These are groups of soils with similar runoff properties. These ratings are useful for considering the potential for runoff from properties under consistent rainfall and cover conditions. The majority of soils in the watershed are classified as “Type B” and “Type C” soils (Figure 5, Table 3). “Type C” soils, which are indicative of slow infiltration and having high runoff potential when wet, is the majority of soil types in the northern area of the watershed. “Type B” soils, which are indicative of moderate infiltration and having moderate runoff potential when wet, is the majority of soil types found in the central and southern areas of the watershed.

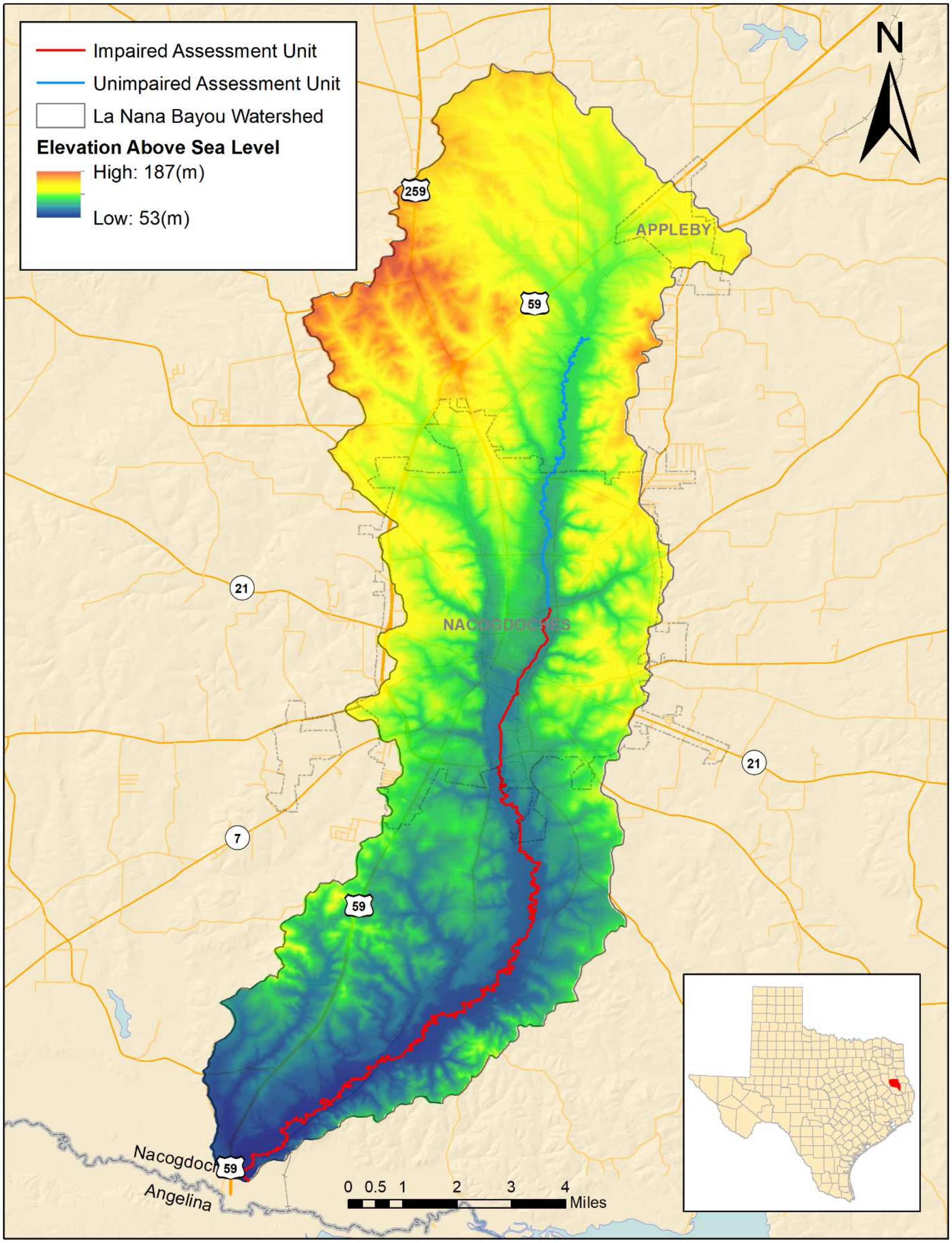

Figure 4: La Nana Bayou Watershed elevation map

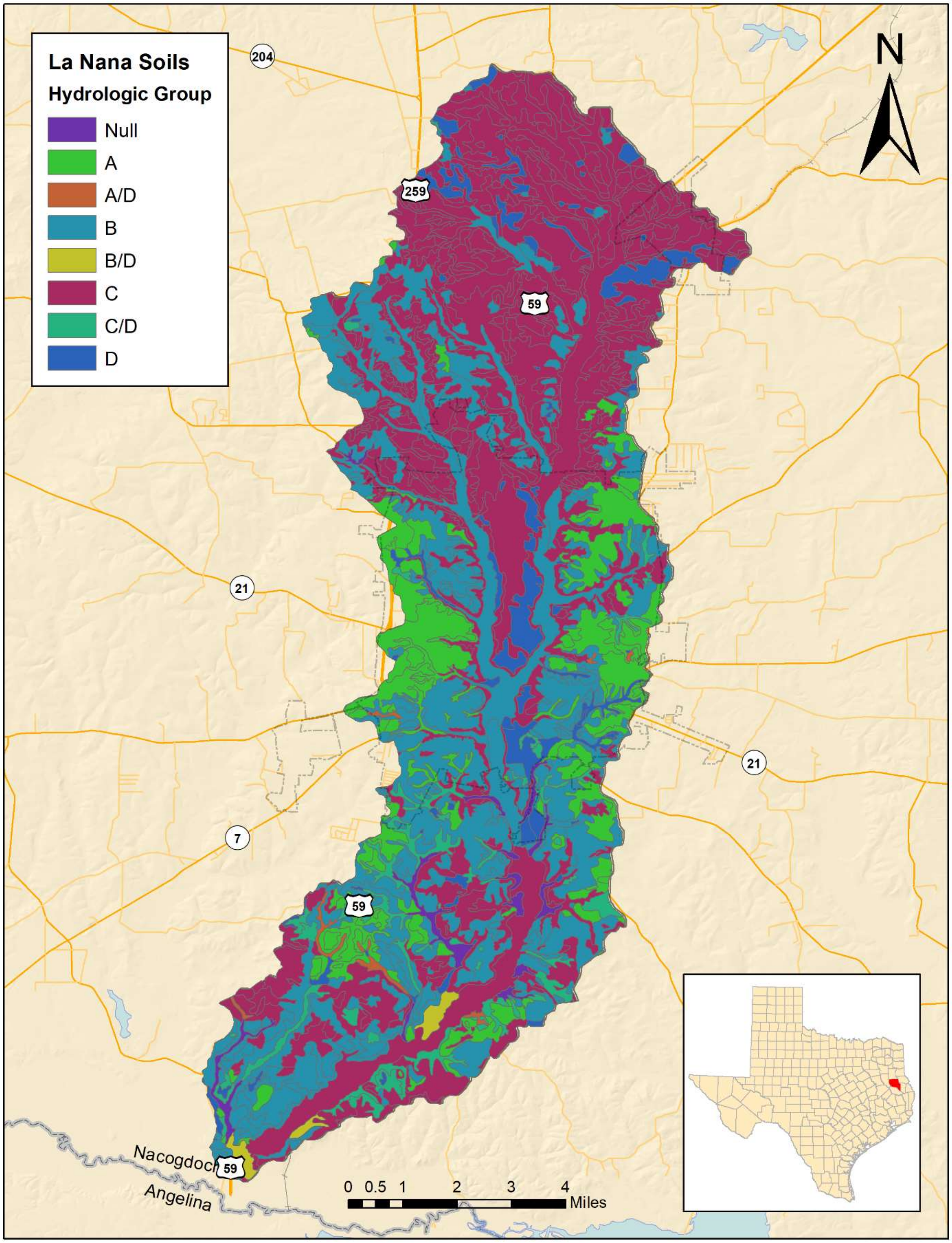

Figure 5: Soil hydrologic groups for La Nana Bayou

Table 3: Hydrologic soil groups and descriptions

Hydrologic Soil Group	Acres	Description
Null	713	Not rated (not surveyed or water body)
A	6,543	Soils have a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
A/D	212	See below[1]
B	16,160	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
B/D	320	See below[1]
C	24,693	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
C/D	1,873	See below[1]
D	2,746	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

[1]Per NRCS (United States Department of Agriculture Natural Resource Conservation Service, 2018a), "Certain wet soils are placed in Group D based solely on the presence of the water table within 60 centimeters [24 inches] of the surface, even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters [24 inches] below the surface in a soil where it would be higher in a natural state."

Climate

The La Nana Bayou watershed is located in eastern Texas and falls within the subtropical humid climate region (Larkin & Bomar 1983). This region's climate is characterized as a modified marine climate including warm summers with the occasional invasion of drier, cooler continental airflow offsetting the prevailing flow of tropical maritime air from the Gulf of Mexico. Precipitation data from the Nacogdoches, TX weather station indicates that the watershed's mean annual rainfall from 1981-2010 was 48.79 inches (Arguez et al., 2010). Average temperatures generally peak in August (95.2°F) the average low temperature generally bottoms out at 37.2°F in January (Figure 6) (National Oceanic and Atmospheric Administration, 2018). Additionally, October (4.59 inches) is noted as the wettest month, while July (3.01 inches) is typically the driest month. Average annual precipitation values across the study area from the PRISM Climate Group at Oregon State (PRISM Climate Group, 2016) indicate average annual rainfall ranges from 50 to 51 inches per year across the watershed (Figure 7).

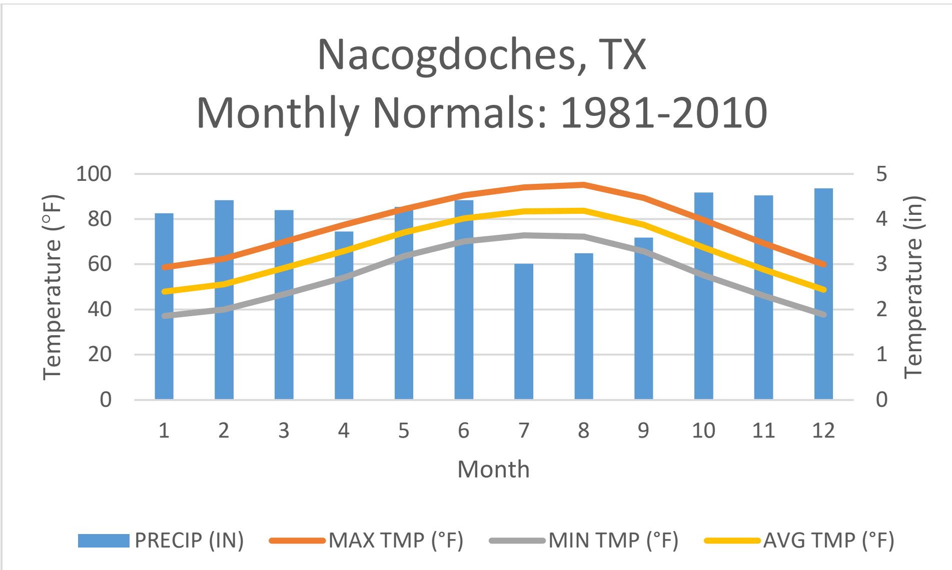

Figure 6: Watershed normal monthly precipitation by month and normal average, maximum, and minimum air temperature by month from 1981-2010

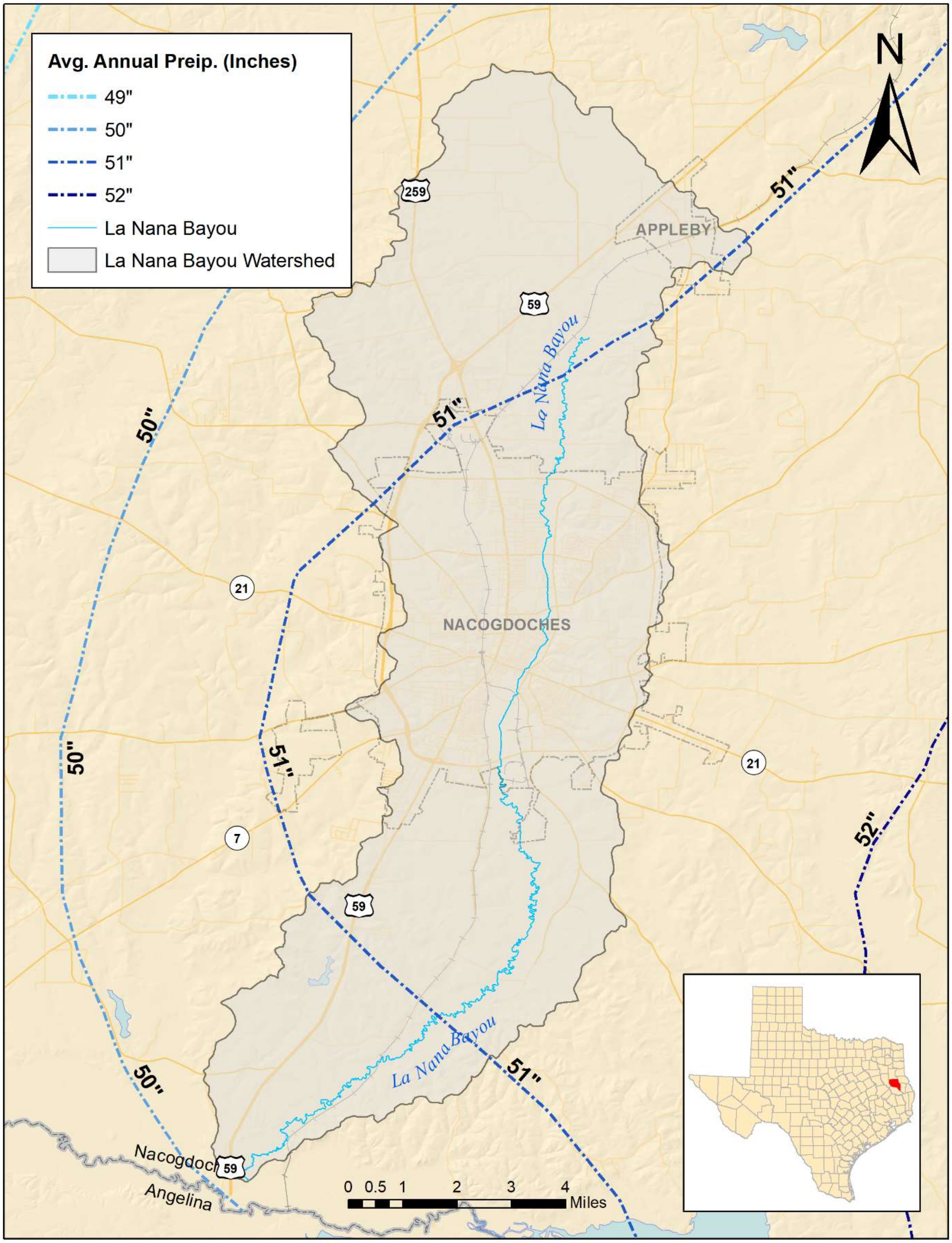

Figure 7: Spatial distribution of average annual rainfall in the La Nana Bayou

Point Source Discharges

Point sources of pollution are regulated end-of-pipe outlets for cooling water, wastewater, or stormwater originating from industrial or municipal treatment systems (TCEQ and TSSWCB 2016). Point sources of pollution are regulated by permits from the National Pollutant Discharge Elimination System (NPDES) and the Texas Pollutant Discharge Elimination System (TPDES). These can include municipal and industrial wastewater treatment plants (WWTP), general wastewater, and general stormwater permits. Other examples of point sources of pollution include Confined Animal Feeding Operations (CAFOs), concrete production, wastewater evaporation ponds, pesticide general permits, and Multi-Sector General Permits.

Wastewater Treatment and Other Direct Discharge Facilities

In the La Nana Bayou watershed, two facilities have had discharge permits according to TPDES. The only active WWTP in the watershed is STP 2A WWTP, permitted by the City of Nacogdoches, with TPDES permit #WQ0010342004 allows a final permitted discharge of 12.88 MGD into La Nana Bayou. The location of the WWTP in the watershed is depicted in Figure 1. D & M Water Supply previously held a permit within the watershed (#Wq0013927001), but is no longer active as of August 1, 2016.

Non-point Sources

Nonpoint source discharges, or nonpoint source pollution, occurs when rainfall causes runoff of pollutants into drainage ditches, lakes, rivers, or other water bodies (TCEQ and TSSCWB 2016). These sources can include bacteria from livestock or pet waste, wildlife waste, urban and agriculture runoff, failing OSSFs, and other sources.

Livestock

Grazing livestock or the use of manure fertilizer can introduce *E. coli* into the surrounding watershed. Direct deposition of fecal bacteria by domesticated animals is also possible. In order to quantify the livestock populations within the watershed, livestock statistics were obtained from the United States Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS). Since NASS data are county-based, populations for cattle, horses, poultry, and sheep/goats were estimated based upon percent rural area within the watershed (Table 4).

Table 4: Estimated livestock populations for La Nana Bayou

Livestock	Estimated Population
Cattle	2,665
Sheep/Goats	48
Horses	146
Poultry	961,130

Poultry Litter

Poultry litter from broiler operations in the watershed represents another potential *E. coli* source. TSSWCB requires poultry operations to maintain a Water Quality Management Plant (WQMP) to address potential runoff and are therefore not included in loading estimates.

Dogs

Dogs can be a major contributor to *E. coli* in a watershed where pet waste is allowed to remain on the ground surface. Based on nationwide survey data conducted by the American Veterinary Medical Association (AVMA), it is estimated that there are 0.584 dogs per household in the US, which equals approximately 8,838 dogs in the La Nana Bayou Watershed.

Deer and Feral Hogs

Wildlife present a special case, as they are prominent in every watershed, and are prone to congregate in stream and riparian areas. *E. coli* may be introduced into waterways through direct deposition or from the indirect transfer of fecal material via runoff. Since two-thirds of the watershed land area is rural, the potential for wildlife contributions of *E. coli* may be a significant factor to consider in future management measures. However, estimates of most wildlife including raccoons, opossums, and birds are difficult to ascertain.

The most commonly encountered wildlife, and most practical to manage are deer and feral hogs (Table 5). Deer populations were estimated based upon Texas Parks and Wildlife Department (TPWD) estimates of 45.2 acres per deer. Feral hogs were estimated based upon a density of 33.3 acres per hog (Wagner and Moench 2009).

Table 5: Estimated deer and feral hog populations for La Nana Bayou

Species	Estimated Population
Deer	879
Feral Hogs	1193

OSSFs

Since much of the watershed is rural, a number of residents will rely on OSSFs to treat their domestic wastewater. These OSSFs are often an acceptable alternative for households that are unable to connect to municipal wastewater systems or are out of municipalities' service range. If an OSSF is routinely inspected and properly managed, they can provide an adequate level of treatment and disinfection. However, failing OSSFs can lead to nonpoint bacterial contamination within a watershed. A total of 2,381 OSSF locations were estimated based upon 911 address data occurring outside of municipal service regions (Figure 8).

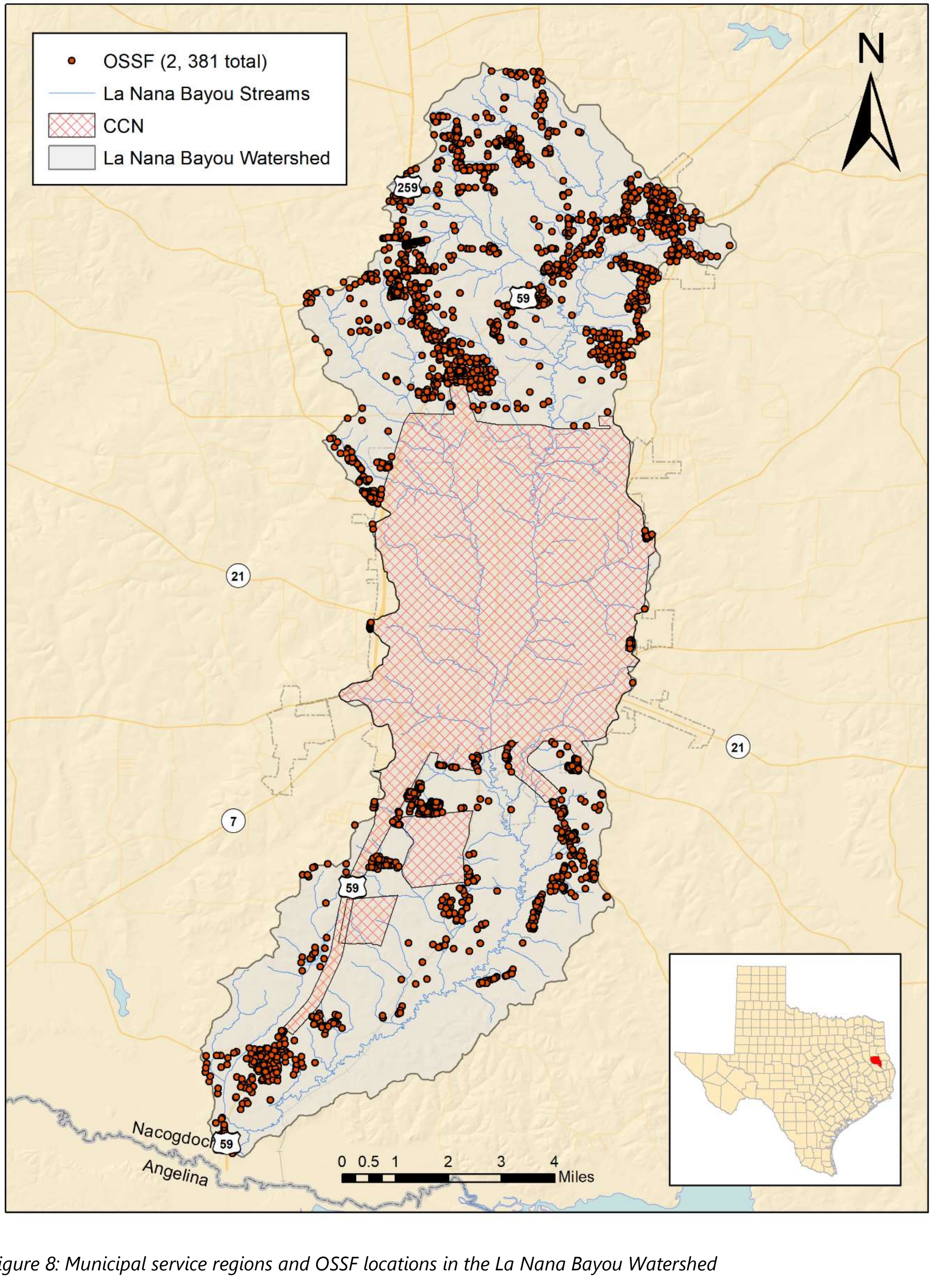

Figure 8: Municipal service regions and OSSF locations in the La Nana Bayou Watershed

Potential Bacterial Loadings

Pollutant maximum load estimates (Table 6) were calculated to improve knowledge regarding the distribution of potential *E. coli* loads and inform management decisions. Information regarding the number and distribution of evaluated species and published *E. coli* and fecal production rates were combined to estimate daily *E. coli* loading in the watershed. *E. coli* loading methodology and equations are available in Appendix A.

Table 6: Total calculated estimated potential E. coli loads from each evaluated pollutant source

Daily Loading (CFU/day)								
WWTP	Cattle	Horses	Sheep & Goat	Dogs	Deer	Feral Hogs	OSSF	TOTAL
6.19E+12	3.18E+13	3.3E+10	5.47E+11	2.21E+13	9.36E+11	1.03E+12	1.26E+14	1.89E+14

Water Quality

Field data collection

Results of ANRA water quality monitoring are shown in Table 7 (all *E. coli* data are shown in Appendix B). From March 2018 through February 2019, ANRA collected 12 monthly samples (4 CRP dates plus 8 additional events) at 3 sampling stations (Figure 1). Data were delivered to TCEQ for use in future waterbody assessments (Table 7, Appendix B).

Long-term *E. coli* data exists at each station, however the timeframe varies by sampling site (Figures 9, 10 and 11). Over time, each sampling location has had an ever-increasing trend in *E. coli* concentrations The data from March 2018 to February 2019 suggests that there is a net loading increase from the uppermost site (station 16301) downstream to the lowermost station (10474). *E. coli* concentrations increase between station 16301 and station 20792, but a reduction in *E. coli* concentrations occurs before reaching station 10474 (Table 7). This reduction could be a result of supplementary flow from additional tributaries, as well as treated WWTF effluent discharge downstream of station 20792 (Figure 1). The results support prior CRP findings that La Nana Bayou segment 0611B is impaired due to bacterial contamination of *E. coli* that exceeds the contact recreation threshold of 126 cfu/100mL.

Table 7: Sampling stations and data collected from March 2018 to February 2019 on La Nana Bayou

Station	Name	Samples	Geomean (MPN/100mL)
16301	La Nana Bayou at Loop 224 North	12	333.51
20792	La Nana Bayou Upstream of E Main	12	1012.74
10474	La Nana Bayou at CR 526	12	730.41

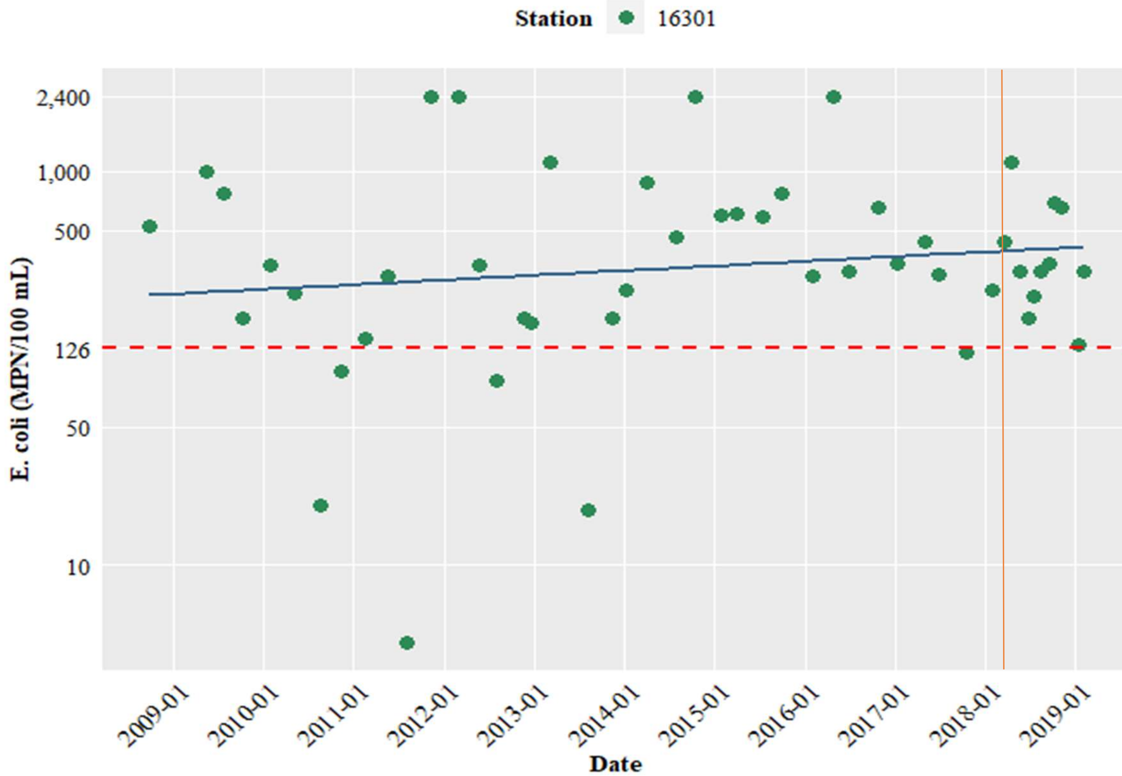

Figure 9: E. coli concentrations at station 16301. Red dotted line represents contact recreation threshold of 126 MPN/100mL. Solid blue line represents long-term trend. Solid orange line marks the start of Characterization Project

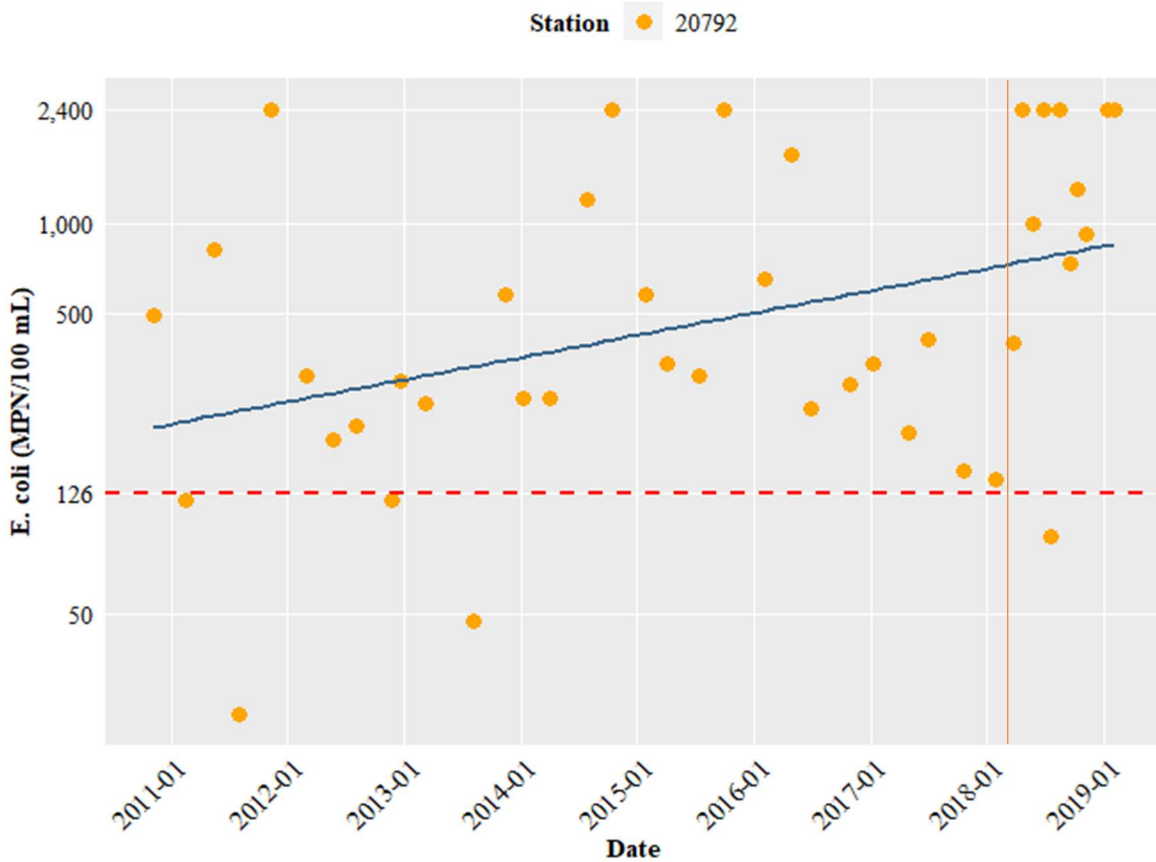

Figure 10: E. coli concentrations at station 20792. Red dotted line represents contact recreation threshold of 126 MPN/100mL. Solid blue line represents long-term trend. Solid orange line marks the start of Characterization Project.

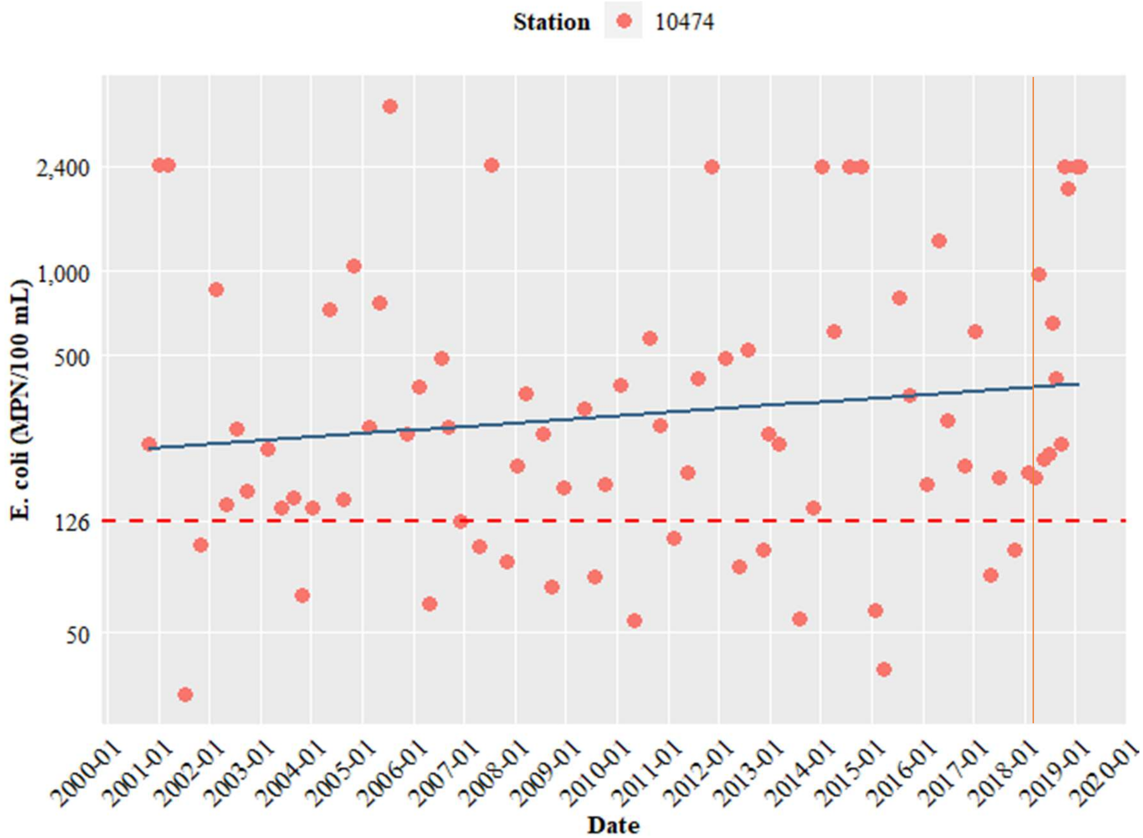

Figure 11: E. coli concentrations at station 10474. Red dotted line represents contact recreation threshold of 126 MPN/100mL. Solid blue line represents long-term trend. Solid orange line marks the start of Characterization Project.

Nitrate nitrogen (Figure 12), ammonia nitrogen (Figure 13) and total phosphorus concentrations (Figure 14) are consistently higher in the downstream portion of the bayou (station 10474). In May, July, and August 2018, the nitrate nitrogen concentrations of station 10474 exceeded the freshwater screening level (1.95 mg/L), while the nitrate concentrations of the other two stations have been under the threshold throughout the project period. Station 10474 has had elevated total phosphorous concentrations above the screening level (0.69 mg/L) for most of its recorded history. ANRA samples from March to September 2018 were also above the screening criterion of 0.69 mg/mL . Total phosphorus concentrations for the other two stations have remained below the screening criterion (Figure 14).

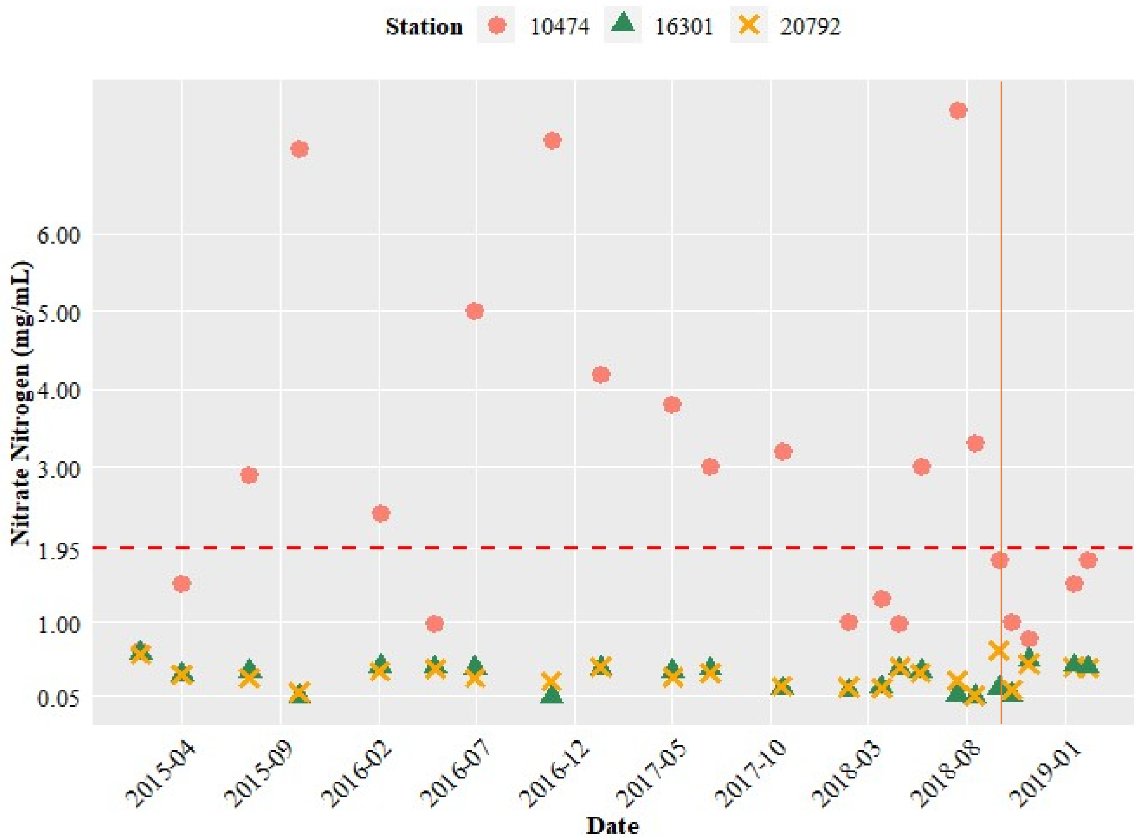

Figure 12: Nitrate Nitrogen (mg/ml) data. Values less than the detection limit of 0.05mg/ml are plotted as 0.05 mg/ml. Red dotted line is the screening level of 1.95 mg/L. Solid orange line marks the start of the La Nana Bayou Characterization project.

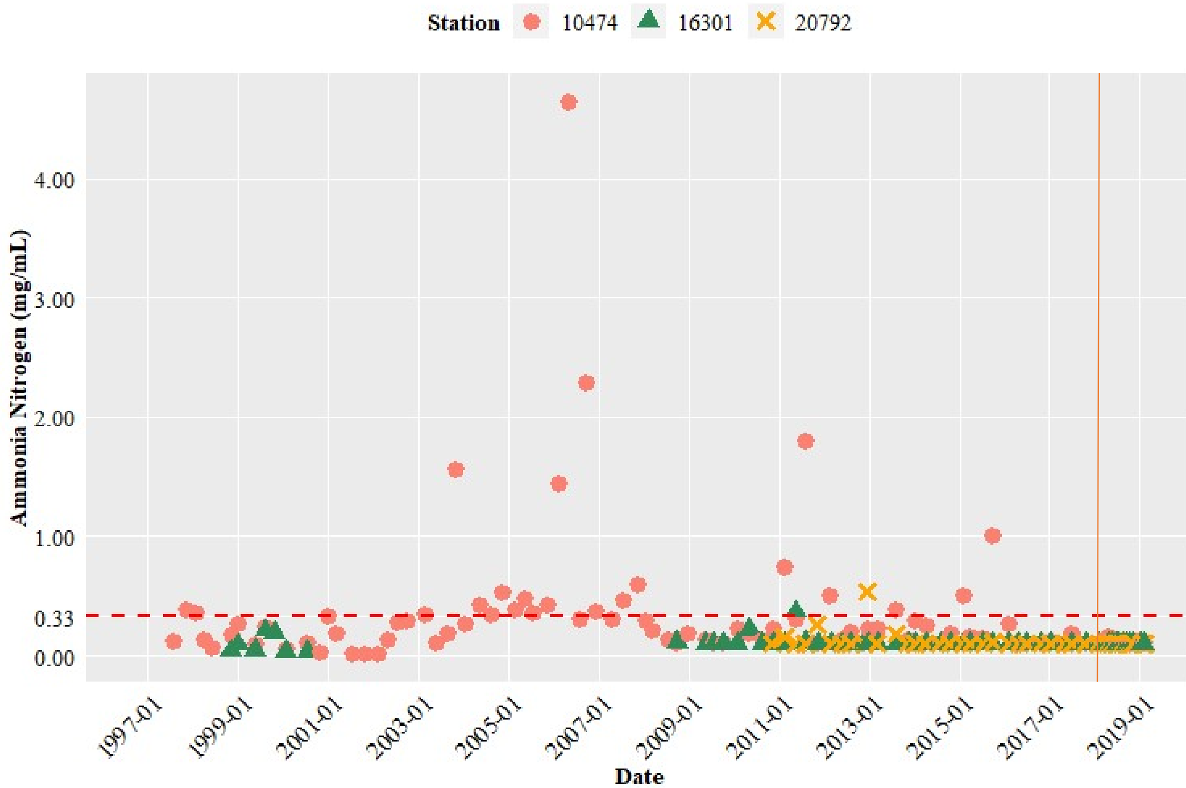

Figure 13: Ammonia Nitrogen (mg/ml) data. Values less than the detection limit of 0.01mg/ml are plotted as 0.01 mg/ml. Solid orange line marks the start of the La Nana Bayou Characterization project.

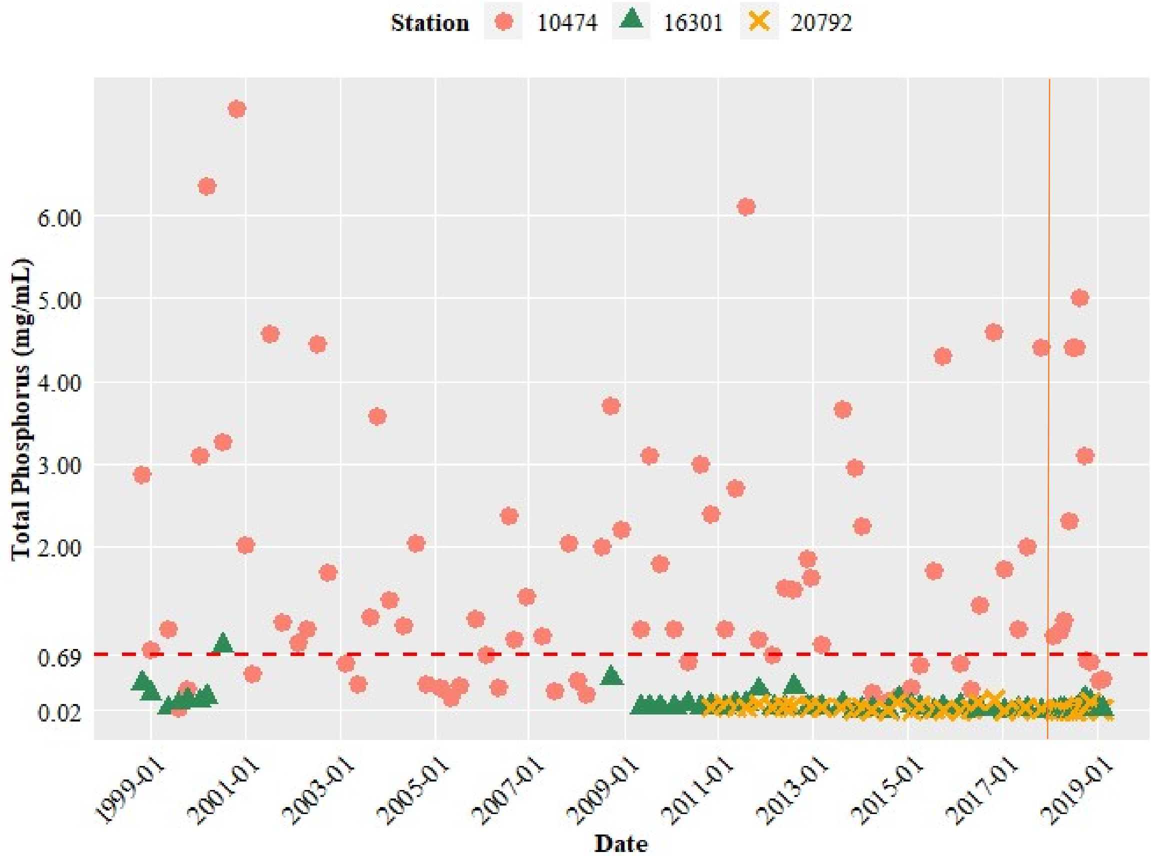

Figure 14: Total Phosphorus (mg/ml) data. Values less than the detection limit of 0.02mg/ml are plotted as 0.02 mg/ml. Red dotted line is the screening level of 0.69 mg/L. Solid orange line marks the start of the La Nana Bayou Characterization project.

Load Duration Curves

Load Duration Curves (LDC) further illustrates the dispersal of the data and how water quality relates to given flow volume. LDCs are used to estimate measured pollutant loads and compare them to allowable loads within multiple flow conditions. The difference in measured and estimated loads equates to a needed pollutant loading reduction to meet water quality standards. LDCs can also generally indicate if point or nonpoint source pollution are primary contributors, but they cannot identify specific sources of pollution. If loads are higher than allowable during high flow periods, nonpoint sources of pollution are usually primary contributors. During low flow periods, elevated loads are generally associated with point sources or direct deposition to the waterbody. Generally, LDCs indicate that *E. coli* loads are elevated during all flow conditions thus suggesting the influences of both point and nonpoint sources of *E. coli* (Figures 15, 16, 17). Needed numerical and percentage based loading reductions indicate the need for sizable load reductions under all flow conditions at all sites (Tables 8, 9 and 10). The moist flow condition presents a conservative load reduction target as high flows cannot be feasibly managed.

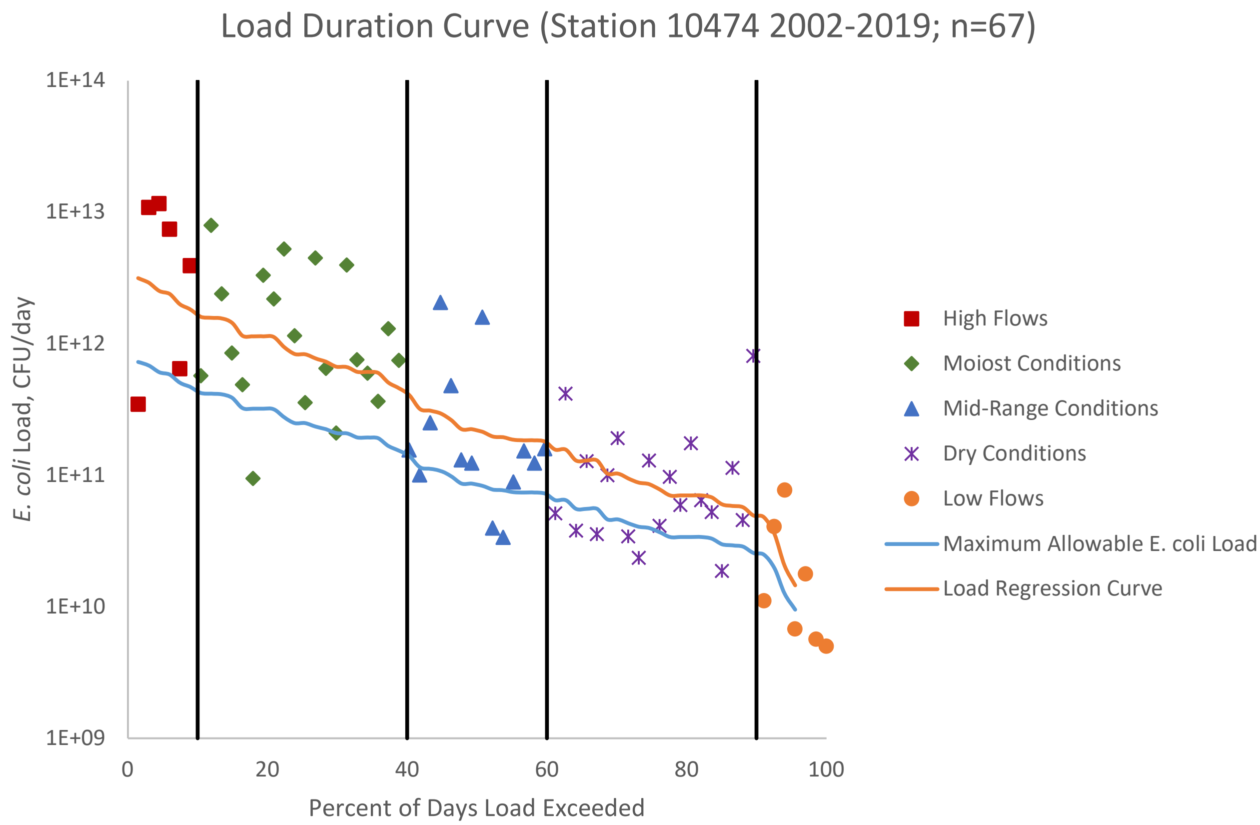

Figure 15: E. coli LDC at station 10474 for monitored flow regimes

Table 8: E. coli loads and reductions need to meet the water quality goal at station 10474

Flow Conditions	% Exceedence	Daily Loading (cfu/day)	Annual Loading (cfu/year)	% Reduction Needed	Annual Load Reduction Needed
High	0-10%	2.46E+12	8.99E+14	75.64%	6.81E+14
Moist	10-40%	9.48E+11	3.46E+14	70.33%	2.46E+14
Mid-range	40-60%	2.42E+11	8.82E+13	61.69%	5.48E+13
Dry	60-90%	9.14E+10	3.33E+13	53.47%	1.82E+13
Low	90-100%	1.98E+10	7.24E+12	31.18%	3.00E+12

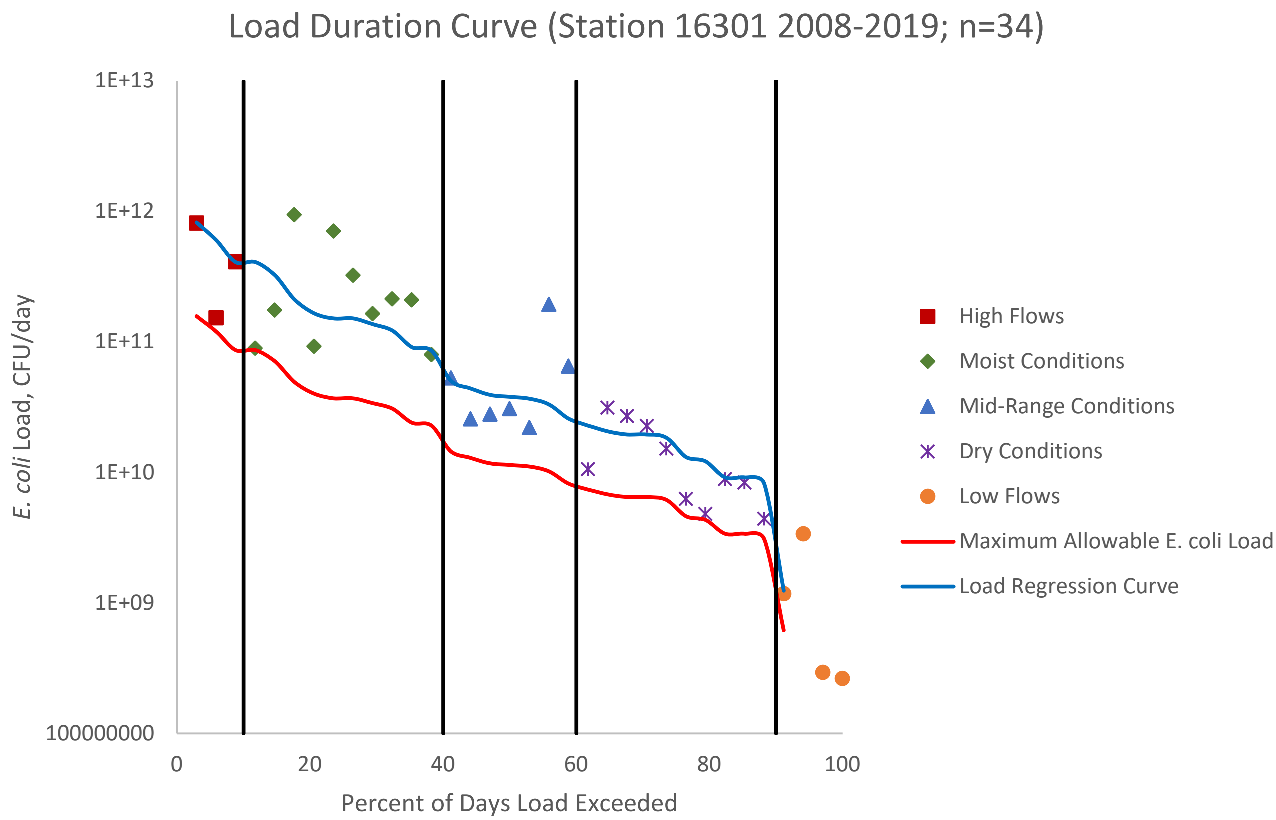

Figure 16: E. coli LDC at station 16301 for monitored flow regimes

Table 9: E. coli loads and reductions need to meet the water quality goal at station 16301

Flow Conditions	% Exceedence	Daily Loading (cfu/day)	Annual Loading (cfu/year)	% Reduction Needed	Annual Load Reduction Needed
High	0-10%	6.12E+11	2.23E+14	79.95%	1.79E+14
Moist	10-40%	1.85E+11	6.74E+13	75.74%	5.17E+13
Mid-range	40-60%	3.82E+10	1.39E+13	69.91%	9.77E+12
Dry	60-90%	1.53E+10	5.58E+12	65.28%	3.68E+12
Low	90-100%	8.32E+08	3.04E+11	45.77%	1.46E+11

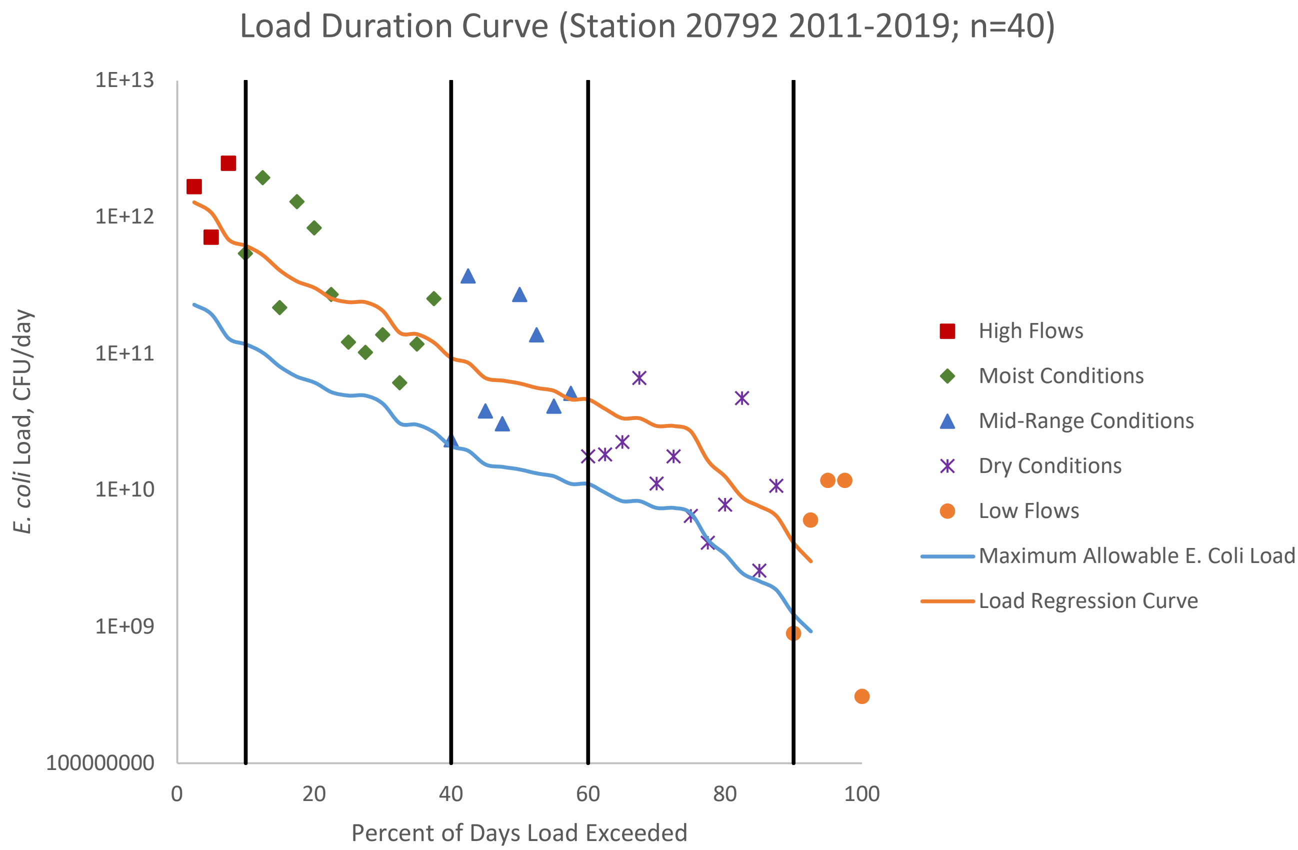

Figure 17: E. coli LDC at station 20792 for monitored flow regimes

Table 10: E. coli loads and reductions need to meet the water quality goal at station 20792

Flow Conditions	% Exceedence	Daily Loading (cfu/day)	Annual Loading (cfu/year)	% Reduction Needed	Annual Load Reduction Needed
High	0-10%	1.01E+12	3.70E+14	81.77%	3.03E+14
Moist	10-40%	2.94E+11	1.07E+14	79.43%	8.58E+13
Mid-range	40-60%	6.55E+10	2.39E+13	76.67%	1.84E+13
Dry	60-90%	2.42E+10	8.84E+12	74.06%	6.62E+12
Low	90-100%	2.30E+09	8.40E+11	67.87%	5.79E+11

Exploratory Bacteria Loading Area Sampling

Exploratory Monitoring

TWRI cooperated with ANRA to plan targeted monitoring on La Nana Bayou, Bonita Creek, and their tributaries. Twenty-five sites were initially chosen for monitoring; however lack of access to two sites required sampling at alternate sites (Table 11). This exploratory approach was used to develop a spatial understanding of *E. coli* concentrations at a single point in time (Figure 18). Waterbodys were sampled by TWRI and ANRA staff on May 8, 2018. Sampling on each waterbody was conducted independently of each other; however, all samples collected within a particular stream were collected on the same day in a downstream to upstream order. The number of sampling sites was maximized for each waterbody but the ability to sample depended on ambient flow conditions on the sampling day.

Table 11: Exploratory Monitoring Site Descriptions and Locations

Station ID	Description of Location	Latitude	Longitude	*E. coli* (CFU/100 mL)
LNB 1	La Nana at US 59	31.71708	-94.62377	340
BAN 1	Banita Creek at US 59	31.7031	-94.64037	2000
LNB 2	La Nana @ FM 2864	31.74168	-94.63923	40
LNB 3	La Nana at CR 210/Old Post Oak Rd	31.66167	-94.63844	1300
TB 1	Toliver Branch at CR 210/Old Post Oak Rd	31.66249	-94.64632	230
LNB 4	La Nana at North Loop 224	31.65213	-94.64225	1100
BON 1	Bonita Creek at North Loop 224	31.65222	-94.66472	1300
BON 2	Bonita Creek at W Austin St	31.63181	-94.65842	310
LNB 5	La Nana at E Austin St	31.63199	-94.64322	460
LNB 6	La Nana at E Starr Ave	31.61764	-94.6416	920
BON 3	Bonita Creek at dead end of Rusk St (trailhead)	31.61845	-94.65779	410
BON 4	Bonita Creek at US 59/Loop 224/ Industrial Blvd	31.66709	-94.67535	770
LNB 7	La Nana at E Main	31.60083	-94.64818	390
BON 5	Bonita Creek @ W Pilar St	31.60373	-94.65844	290
BONT 1	Unnamed Tributary of Bonita Creek at Old Tyler Rd	31.61462	-94.66071	490
LNT 3	Unnamed Trib of La Nana at 1411/Appleby Sand Rd	31.62057	-94.63475	730
LNT4	Unnamed Tributary of La Nana @ FM1275	31.57033	-94.64559	410
BON 6	Bonita Creek at Martin Luther King Jr Blvd	31.59312	-94.65358	250
LNB 8	La Nana at Martin Luther King Jr Blvd	31.59262	-94.65182	440
BONT 2	Unnamed Tributary of Bonita Creek at S Fredonia St	31.5966	-94.65773	730
LNB 9	La Nana at South Loop 224/SE Stallings Dr	31.57734	-94.65449	290
LNB 10	La Nana at CR 526	31.51894	-94.65554	160
UNT 1	unnamed trib @ Press Rd	31.582	-94.65823	1200
LNB A1	La Nana at E College St (Alternate)	31.62317	-94.642	340
LNB A3	La Nana at Park St (Alternate)	31.60607	-94.6446	490

Exploratory Monitoring Assessment

Following data collection, *E. coli* enumeration results were reviewed to identify where changes in *E. coli* concentrations occur (Figure 19), and prioritized to aid in determination of sites for subsequent monitoring. Data were grouped by contact recreation water quality standard thresholds (Table 12). Areas displaying rapid increases in *E. coli* concentration (>0.1 CFU/100 ml/meter), or elevated levels of *E.*

coli above water quality standards were designated as very high priority. Stream reaches where *E. coli* levels occurred below the secondary contact 2 recreation standard were designated as high priority. Slow decreases in *E. coli* concentrations (<0.1 CFU/100 ml/meter) that occurred below secondary contact 1 recreation standards were designated as moderate priority.

Table 12: Texas recreation water quality standards

Standard Category	Description of Use	*E. coli* criterion (cfu/100 mL)
Primary Contact	Swimming, wading by children, skiing, whitewater sports, diving	126
Secondary Contact 1	Fishing, canoeing, kayaking, boating	630
Secondary Contact 2	Fishing, canoeing, kayaking, boating with minimal access available	1030
Noncontact	Shoreline activities (hiking, birding) or access prohibited by law	2060

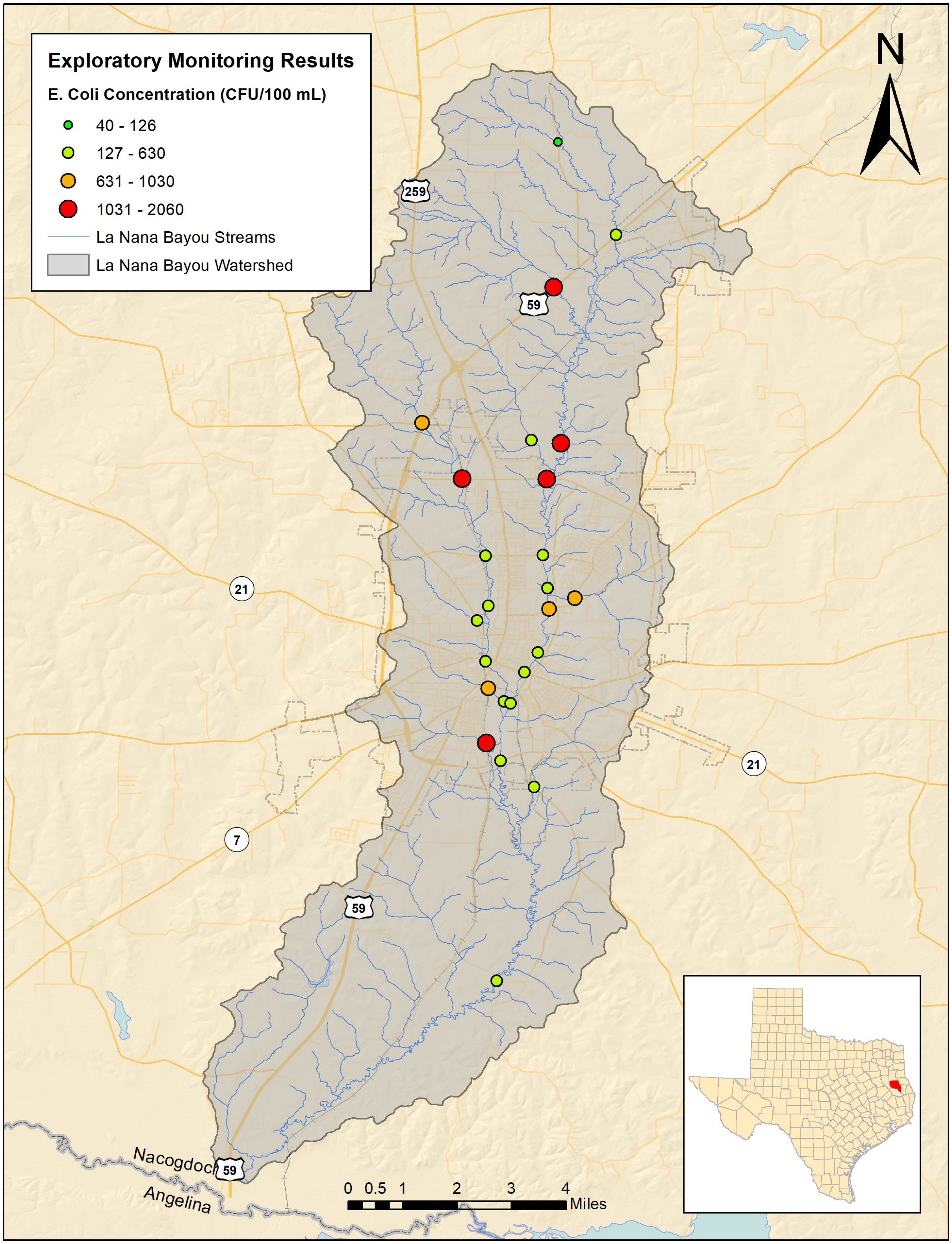

Figure 18: La Nana Bayou exploratory monitoring results

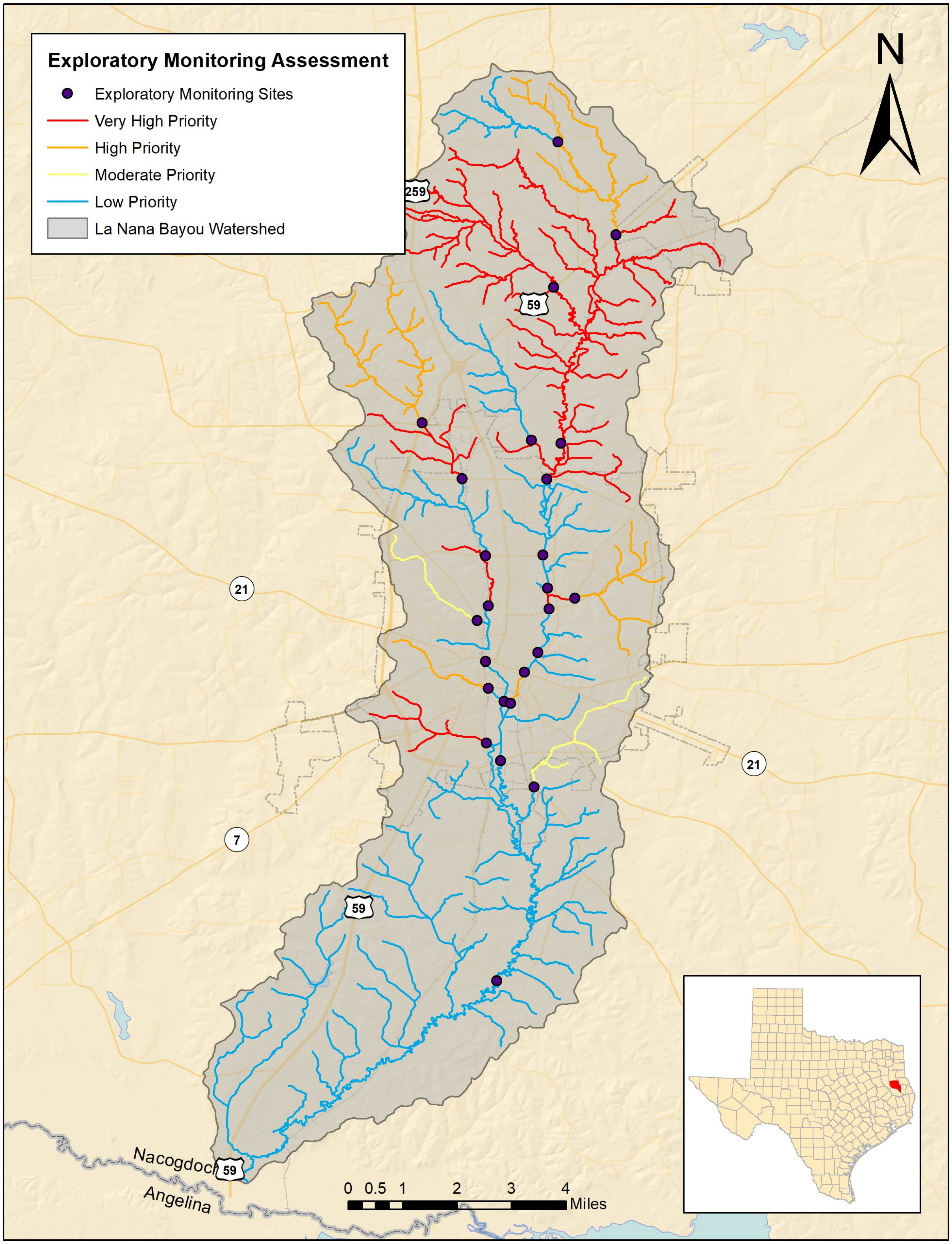

Figure 19: La Nana Bayou exploratory monitoring assessment

Investigative Sampling

A second round of more intensive sampling was conducted in selected areas within the stream reaches monitored during the first round of sampling. Sampling sites for the second round were selected based on accessibility and ability to further isolate streams found to have rapid increases in observed *E. coli* concentrations during the first round of sampling and/or elevated *E. coli* concentrations. Specific sampling locations were selected to capture water quality downstream or upstream of potential influences where access was available.

TWRI and ANRA staff used the same sampling approach in Round 2 where samples were collected in a downstream to upstream manner. In total, 75 individual sampling points were monitored during the one-day sampling event that occurred on December 3, 2018 (Table 13).

Table 13: Site descriptions for Investigative Sampling

Station ID	Description of Location	Latitude	Longitude	*E. coli* (CFU/100 mL)
LNB 1	La Nana at US 59	31.71708	-94.62377	260
LNB A1	La Nana at E College St	31.62317	-94.642	2420
LNB A3	La Nana at Park St	31.60607	-94.6446	2420
BAN 1	Banita Creek at US 59	31.7031	-94.64037	93
LNB 2	La Nana @ FM 2864	31.74168	-94.63923	52
LNB 3	La Nana at CR 210/Old Post Oak Rd	31.66167	-94.63844	59
TB 1	Toliver Branch at CR 210/Old Post Oak Rd	31.66249	-94.64632	68
LNB 4	La Nana at North Loop 224	31.65213	-94.64225	160
BON 1	Bonita Creek at North Loop 224	31.65222	-94.66472	130
BON 2	Bonita Creek at W Austin St	31.63181	-94.65842	120
LNB 5	La Nana at E Austin St	31.63199	-94.64322	2420
LNB 6	La Nana at E Starr Ave	31.61764	-94.6416	2420
BON 3	Bonita Creek at dead end of Rusk St (trailhead)	31.61845	-94.65779	160
BON 4	Bonita Creek at US 59/Loop 224/ Industrial Blvd	31.66709	-94.67535	1200
LNB 7	La Nana at E Main	31.60083	-94.64818	920
BON 5	Bonita Creek @ W Pilar St	31.60373	-94.65844	220
BONT 1	Unnamed Tributary of Bonita Creek at Old Tyler Rd	31.61462	-94.66071	270
LNT 3	Unnamed Trib of La Nana at 1411/Appleby Sand Rd	31.62057	-94.63475	170
LNT4	Unnamed Tributary of La Nana @ FM1275	31.57033	-94.64559	120
BON 6	Bonita Creek at Martin Luther King Jr Blvd	31.59312	-94.65358	180
LNB 8	La Nana at Martin Luther King Jr Blvd	31.59262	-94.65182	1100
BONT 2	Unnamed Tributary of Bonita Creek at S Fredonia St	31.5966	-94.65773	870
LNB 9	La Nana at South Loop 224/SE Stallings Dr	31.57734	-94.65449	1300
LNB 10	La Nana at CR 526	31.51894	-94.65554	140
UNT 1	Unnamed trib @ Press Rd	31.582	-94.65823	110

UNT 2	Unnamed trib @Pioneer Drive	31.583599	-94.663303	360
UNT 3	Unnamed trib @ Meadowbrook Dr	31.584500	-94.672153	59
UNT 4	Unnamed trib @ S Fredonia St	31.586049	-94.674886	150
UNT 5	Unnamed trib @ US59	31.588552	-94.680003	46
BONT 2-2	Unnamed Tributary of Bonita Creek at South St	31.597418	-94.6608	720
BONT 2-3	Unnamed Tributary of Bonita Creek at Sunset Ave	31.599726	-94.664663	520
BONT 2-4	Unnamed Tributary of Bonita Creek at Durst St	31.602129	-94.672843	2420
BON 6-2	Bonita Creek at S Church St	31.599683	-94.654576	290
BONT 1-2	Unnamed Tributary of Bonita Creek at W Austin St	31.631919	-94.674964	38
BON 3-2	Bonita Creek at W Austin St	31.631796	-94.659831	44
BON 2-2	Bonita Creek at Westward Dr	31.652516	-94.687744	58
BON 1-2	Bonita Creek at US59	31.659347	-94.677926	32
BON 1-3	Bonita Creek at US59/FM343	31.664621	-94.676415	240
BON 1-4	Bonita Creek at Industrial Dr	31.66632	-94.668011	19
BON 4-2	Bonita Creek at Earnest McLain Rd	31.674596	-94.675574	130
LNB 10-2	La Nana at Press Rd	31.567467	-94.657852	2420
LNB 10-3	La Nana at SE Stallings Dr	31.576421	-94.657058	60
LNT 4-2	Unnamed Tributary of La Nana @ SE Stallings Dr	31.579623	-94.640994	170
LNT 4-3	Unnamed Tributary of La Nana @ Woden Rd	31.582249	-94.635187	79
LNT 4-4	Unnamed Tributary of La Nana @ E Main St	31.592121	-94.626405	240
LNBA3-2	La Nana at Martinsville St	31.610973	-94.642756	2420
LNB 6-2	La Nana at N University Dr	31.621128	-94.639879	29
LNT 3-2	Unnamed Tributary of La Nana at E Starr Ave	31.621684	-94.629339	73
LNT 3-3	Unnamed Tributary of La Nana at E Starr Ave	31.626393	-94.623238	440
LNT 3-4	Unnamed Tributary of La Nana at E Starr Ave	31.627115	-94.619646	520
LNT 3-5	Unnamed Tributary of La Nana at Stones Throw	31.633519	-94.619907	770
LNBA1-2	La Nana at North Dr	31.629994	-94.639619	2420
LNB 5-2	La Nana at N University Dr	31.639737	-94.639734	54
LNB 4-2	La Nana at Waterford Dr	31.649303	-94.622863	23
TB 1-2	Toliver Branch at CR 202/Loveless Ln	31.668774	-94.649143	160
TB 1-3	Toliver Branch at CR 205	31.679816	-94.653383	78
LNB 3-2	La Nana at US 59	31.708082	-94.63425	100
LNB 3-3	La Nana at US 59	31.711722	-94.630002	240
LNB 3-4	La Nana at FM 2864	31.714172	-94.633885	12
LNB 3-5	La Nana at US 59	31.712566	-94.62897	71
LNB 3-6	La Nana at CR 106	31.720349	-94.631304	130
LNB 3-7	La Nana at FM 2864	31.721534	-94.633948	19
LNB 3-8	La Nana at CR 112/ Sparks Rd	31.733588	-94.648142	230
LNB 3-9	La Nana at CR 250	31.714951	-94.624033	210
LNB 3-10	La Nana at CR 250	31.716981	-94.623178	130

LNB 3-11	La Nana at Village Dr	31.719243	-94.616771	72
LNB 3-12	La Nana at FM 941/ Appleby Sand Rd	31.714294	-94.603997	150
BAN 1-2	Banita Creek at Geldmeier Rd	31.711513	-94.649096	83
BAN 1-3	Banita Creek at Steve Lilly Rd	31.727421	-94.664157	490
BAN 1-4	Banita Creek at Steve Lilly Rd	31.727412	-94.670314	290
BAN 1-5	Banita Creek at US 259	31.723394	-94.677551	1
BAN 1-6	Banita Creek at US 259	31.721488	-94.677574	39
LNB 1-2	La Nana at FM 2864	31.729448	-94.635047	920
LNB 1-3	La Nana at CR 120	31.744235	-94.638918	120
LNB 1-4	La Nana at FM 2864	31.747593	-94.640535	100

Investigative Monitoring Assessment

Following data collection, *E. coli* enumeration results were reviewed to identify where sizable changes in *E. coli* concentrations occur. The same assessment approach was used on this data to identify priority areas for potential future investigations. *E. coli* concentrations were plotted across the watershed (Figure 20) and potential priority areas for future evaluation and possible management measures were identified from these data (Figure 21).

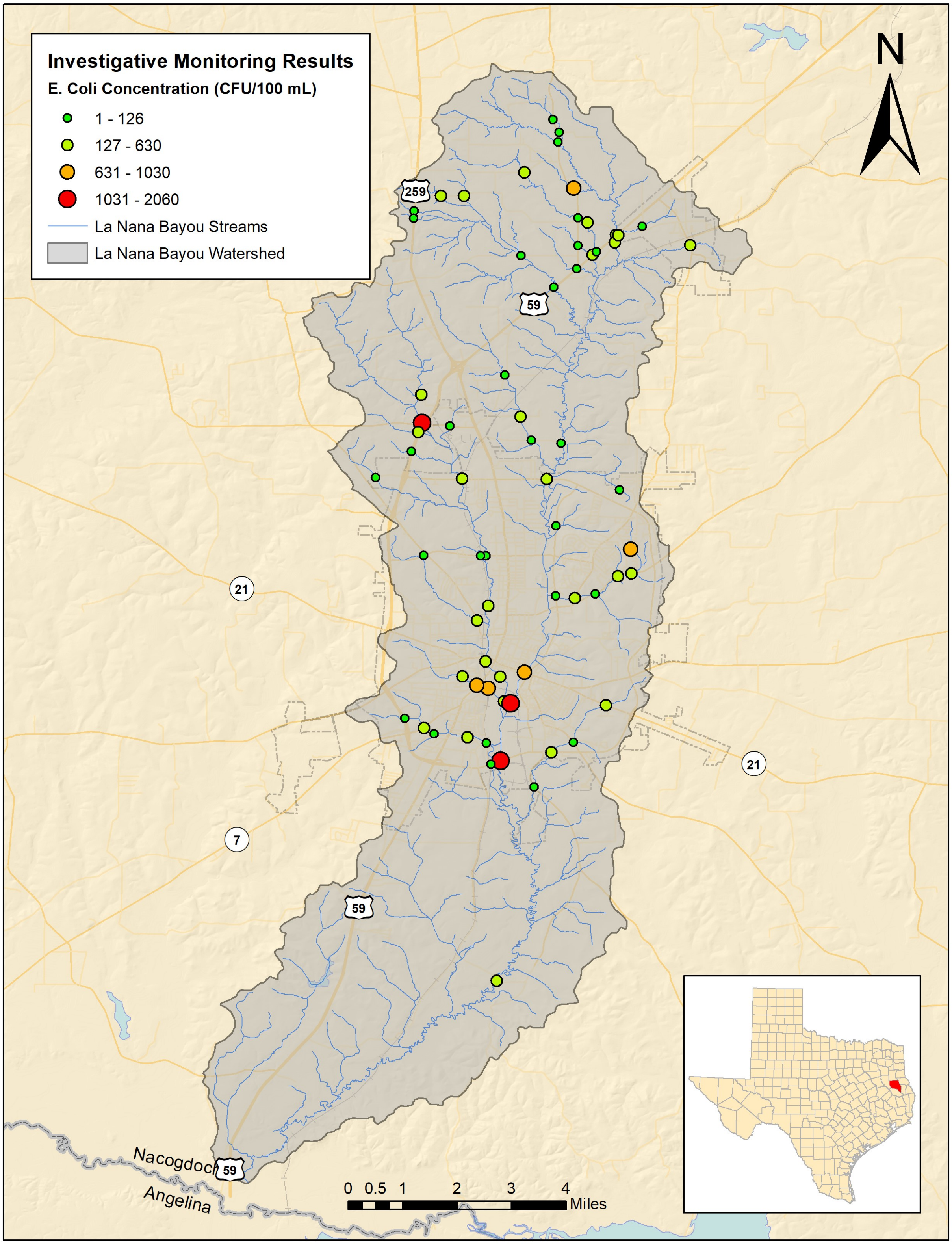

Figure 20: La Nana Bayou investigative monitoring results

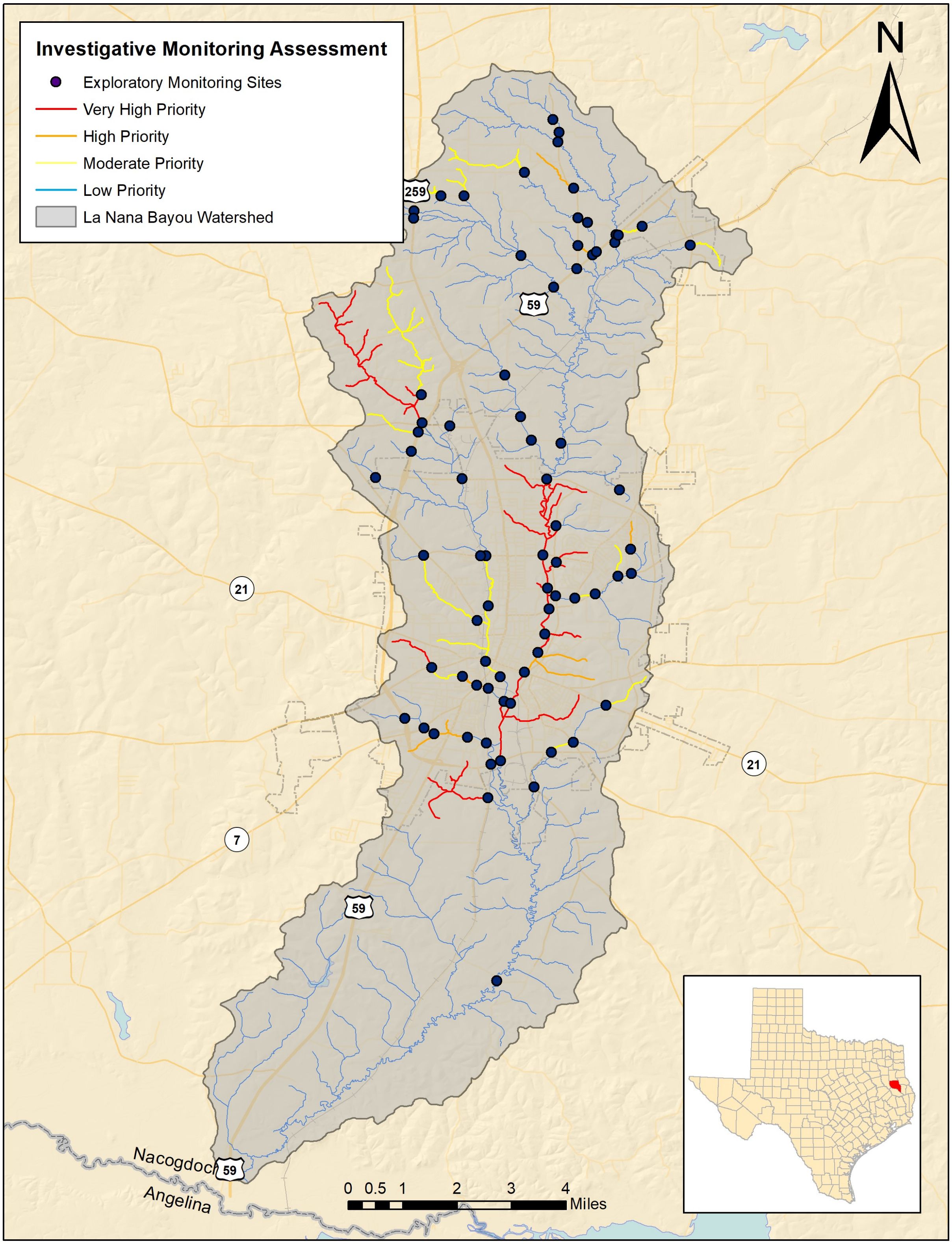

Figure 21: La Nana Bayou investigative monitoring assessment

Intensive Monitoring Discussion

This intensive monitoring study was developed and implemented as an approach to potentially identify areas within the La Nana Bayou watershed that may be contributing larger concentrations of *E. coli* than surrounding areas. Through this process, several stream segments were identified where *E. coli* concentrations increased rapidly or had elevated levels of *E. coli* compared to adjacent stream reaches. This enabled further refined analysis where additional samples were collected throughout the watershed that specifically targeted streams with rapid increases in *E. coli* concentrations.

No obvious contributors of *E. coli* to any creek were identified through the two rounds of monitoring. In urban areas, such as the city of Nacogdoches, potential sources of *E. coli* could be from stormwater infrastructure or wastewater infrastructure. In rural areas outside of the city of Nacogdoches, potential sources of *E. coli* may include failing OSSFs, feral hogs, livestock, or wildlife.

Education and Outreach

As is common in many watersheds, the public at-large is often unaware of the nature or extent of impairments to local waterbodies. In order to properly begin to engage the public, education and outreach programs are necessary to raise awareness about local water quality issues. Knowledge can empower local stakeholders to take action and aid in the restoration and development of a watershed management plan.

Over the course of the La Nana Bayou Characterization Project, two educational and outreach programs were held within the watershed (Table 14). These included Texas Well-owner Network (TWON), and Texas Watershed Stewards (TWS). Both programs are managed by Texas A&M AgriLife Extension and are offered statewide for stakeholder education.

TWON is geared to stakeholders whose primary source of water is from household wells. Based upon geographical analysis of 911 addresses within the watershed, there are an estimated 2,381 households in the watershed utilizing OSSFs (Figure 8). As they are outside of the Nacogdoches municipal service area, most will also be on private well water systems. In the TWON program, free well water testing is provided and experts in well maintenance educate well-owners on proper well management, maintenance and construction. Proper septic tank maintenance and function are also a topic of discussion. This program was held on November 7, 2018, and was attended by 42 people.

TWS is a “crash-course” in all things watershed related. Topics include the water cycle, human uses of water, point and non-point pollution sources, water quality, best management practices and groundwater issues. It often serves as a good springboard into the watershed planning process, as it gives attendees the basic knowledge needed to understand the processes in watershed management. This program was held on May 22, 2019 and was attended by 18 people.

Additionally, TWRI and ANRA met with local stakeholder groups to discuss water quality in the La Nana Bayou watershed. (Table 14). These included CRP meetings, local soil and water conservation districts, extension meetings, and local government officials.

In all, education and outreach activities were well received by those in attendance, and have helped to foster relationships between TWRI, Texas A&M AgriLife Extension, ANRA, and local stakeholders. Connections made through these and potential future education events will be of great value to any future watershed planning activities.

Table 14: Education and Outreach Events

Date	Location	Event	Attendance
5/30/2018	Lufkin	ANRA Annual CRP Stakeholder Mtg	15 local citizens, Local/State/Fed Government
9/5/2018	Overton	Regional Extension Prog. Planning Mtg	35 Extension Agents/Specialists
11/1/2018	Nacogdoches	Pineywoods RC&D Annual Mtg	28 citizens, Local/State Gov, Non-profits
11/7/2018	Lufkin	Texas Well Owner Network	40 area citizens
5/22/2019	Lufkin	Texas Watershed Stewards	18 area citizens
5/22/2019	Lufkin	*The Ag Report and Call-in* radio show (KRBA 1340 AM)	Lucas Gregory and Angelina County Agent Cary Sims discussed water quality issues on the air
6/6/2019	Nacogdoches	Nacogdoches County SWCD Board Mtg	15 board members, State/Fed Government
6/17/2019	Lufkin	ANRA Annual CRP Stakeholder Mtg	16 local citizens, Local/State/Fed Government
7/16/2019	Nacogdoches	State Rep Travis Clardy	ANRA General Manager Kelley Holcomb, Rep Clardy, staff
8/15/2019	Nacogdoches	Nacogdoches City Engineer Steve Bartlett	ANRA General Manager Kelley Holcomb, Steve Bartlett

Amount of Project Funding and Amount Spent

Table 15: Project Budget

Total Project Budget (as of 8/15/2019)					
Match Amount:	$56,519	**Total Match as of this Report:**	$54,792.10	**Balance:**	$1,726.90
Federal Amount:	$84,778	**Total Federal Spent as of this Report:**	$77,007.00	**Balance:**	$7,771.00
Total Contract Amount:	$141,297	**Total Spent as of this Report:**	$131,799.10	**Balance:**	$9497.90

Summary of All Tasks Reports

Table 16: Project Task Reports

ID#	Sub Task #	Deliverable	Date Sent
7953	3.3	Draft E&O Task Report	06/03/2019
7954	3.3	Final E&O Task Report	07/02/2019
7956	4.2	Documentation of Data Gaps	06/14/2018
7957	4.3	Draft Data Inventory	06/14/2018
7958	4.3	Final Data Inventory	09/13/2018
7960	4.4	Documentation of estimated load Reductions needed	06/03/2019
7959	4.4	Documentation of Pollution Loading Estimates	02/04/2019
7992	5.4	Draft Routine Monitoring and Assessment Report	06/03/2019
7993	5.4	Final Routine Monitoring and Assessment Report	07/01/2019
7995	6.1	Documentation of exploratory sampling events	06/14/2018
7994	6.1	Exploratory site monitoring selection	10/27/2017
7996	6.2	Exploratory monitoring data assessment results	12/14/2018
7997	6.2	Site selection for investigative monitoring	10/19/2018
7998	6.3	Documentation of field monitoring readiness review	04/16/2018
8001	6.6	Draft Exploratory Data Assessment	12/14/2018
8004	6.6	Final Exploratory Data Assessment	08/15/2019

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Appendix A: *E. coli* loading calculations

La Nana Bayou Watershed Pollutant Load Estimates

Pollutant load estimates were calculated to improve knowledge regarding the distribution of potential *E. coli* loads and inform management decisions, worst case scenario *E. coli* contributions were mapped across the watershed. Information regarding the number and distribution of evaluated species and published *E. coli* and fecal production rates were combined to estimate daily *E. coli* loading in the watershed.

Animal Estimates

The number of animals within the watershed was estimated based on best available information. Published data (USDA NASS 2012 Census of Agriculture) or known animal densities (TPWD estimates for deer; literature values for feral hogs) were used to establish populations when available for cattle, feral hogs, deer, horses, goats, and sheep. Appropriate land use and land cover (LULC) categories were used to calculate the proportionate populations of cattle, feral hogs, and deer in the watershed. For cattle, the forest, shrub/scrub, herbaceous, and pasture/hay LULC categories were used. For feral hogs and deer, the forest, shrub/scrub, herbaceous, pasture/hay, cultivated crop, and wetlands LULC categories were used. The populations of horses, goats, and sheep were calculated using the proportion of urbanized and un-urbanized area in the watershed. The dog population was estimated based on dog ownership statistics by household (AVMA 2015) and the number of housing units estimated in the watershed (US Census Bureau, 2010).

Animal estimates were then converted to animal units (AU) to allow comparisons between species. One AU is 1,000 lbs of animal weight and is commonly used to quantify the grazing impact of livestock and similar animals. Dogs were not converted to AUs as the conversion factor does not apply to this animal. Animal unit conversion factors (Table 16) were multiplied by subwatershed animal estimates to calculate subwatershed AUs.

Table 17: AU conversion factors (Wagner and Moench 2009)

Animal	AU Conversion Factor
Cattle	1.000
Horse	1.250
Goat	0.170
Sheep	0.200
Feral Hog	0.125
Deer	0.112

Animal *E. coli* Load Calculations

Average daily *E. coli* production differs by species due to many factors. Wagner and Moench (2009) completed an extensive literature review and documented the range of fecal coliform production per AU for a variety of species. These numbers were converted to *E. coli* using a 0.63 conversion factor created by dividing the *E. coli* water quality standard (126 cfu/100 mL) by the old fecal coliform water quality standard (200 cfu/100 mL). This yielded estimated daily *E.coli* production rates per AU (Table 17). Dog *E. coli* production was identified from published literature values (Teague et al. 2009) and feral hog numbers were adapted from USEPA 2001. These rates were multiplied by the number of AUs in each subwatershed to calculate the maximum potential *E. coli* load for each evaluated animal species within each subwatershed (Table 6).

Table 18: E. coli loading coefficients used to calculate potential subwatershed E. coli loads

Potential Pollutant Source	*E. coli* Loading Coefficient	Source
Cattle	5.39E+09 (cfu/AU/day)	Wagner & Moench 2009
Deer	9.45E+09 (cfu/AU/day)	
Horses	1.83E+08 (cfu/AU/day)	
Sheep	1.83E+11 (cfu/AU/day)	
Goats	1.60E+10 (cfu/AU/day)	
Feral Hogs	6.93E+09 (cfu/AU/day)	USEPA 2001
Dogs	2.50E+09 (cfu/dog/day)	Teague et al. 2009
OSSFs	4.42E+10 (cfu/OSSF/day)	Lowe et al. 2007; USEPA 2001; USEPA 2003; U.S. Census Bureau 2010
WWTFs	Varies: actual discharge monitoring data utilized	EPA ECHO Database

OSSF *E. coli* Load Calculation

The number of failing OSSFs in each subwatershed was calculated by multiplying the subwatershed failure rate estimated to be 50% of the corresponding number of OSSFs. This number was used to calculate the potential *E. coli* load from OSSFs using the quantity of *E. coli* expected in effluent from a failing OSSF as calculated in the equations below

Where:

- 10^6 cfu/100 mL = fecal coliform concentration in OSSF effluent (Lowe et al. 2007)
- 0.63 = fecal coliform to *E. coli* conversion factor (*E. coli* standard/fecal coliform standard)
- 70 = gallons of effluent produce per person per day (USEPA 2003)
- 3785.41 = mL per gallon
- 2.65 = average number of people per household in the watershed (US Census Bureau, 2010)

$$\boldsymbol{OSSF\ E.coli\ Load} = \#\ of\ failing\ OSSFs * \frac{10^6 cfu}{100mL} * 0.63 * \frac{70\ gallons}{person} * \frac{3785.41\ mL}{1\ gallon} * \frac{2.65\ people}{household} = 4.42x10^{10} cfu/OSSF$$

WWTF *E. coli* Load Calculation

Measured flow rates and *E. coli* concentrations reported to EPA were used to calculate an estimated *E. coli* load from WWTFs in the watershed. To calculate the load, flow rate was converted from million gallons per day to mL and multiplied by the reported *E. coli* concentrations as shown in the equation below.

$$\boldsymbol{WWTP\ E.coli\ Load} = reported\ flow\ (MGD) * 3.785412x10^9 \left(\frac{mL}{million\ gallons}\right) * E.coli\ concentration\ \left(\frac{cfu}{100\ mL}\right)$$

Appendix B: E. coli Field Data

Station ID	Description	Date	Collecting Entity	E Coli Value (MPN/100mL)
10474	La Nana Bayou at CR 526	03/21/2018	ANRA	180
10474	La Nana Bayou at CR 526	04/18/2018	ANRA	980
10474	La Nana Bayou at CR 526	05/21/2018	ANRA	210
10474	La Nana Bayou at CR 526	06/26/2018	ANRA	220
10474	La Nana Bayou at CR 526	07/17/2018	ANRA	650
10474	La Nana Bayou at CR 526	08/13/2018	ANRA	410
10474	La Nana Bayou at CR 526	09/19/2018	ANRA	240
10474	La Nana Bayou at CR 526	10/09/2018	ANRA	2400
10474	La Nana Bayou at CR 526	11/05/2018	ANRA	2000
10474	La Nana Bayou at CR 526	12/17/2018	ANRA	1600
10474	La Nana Bayou at CR 526	01/14/2019	ANRA	2400
10474	La Nana Bayou at CR 526	02/04/2019	ANRA	2400
16301	La Nana Bayou at Loop 224 North	03/21/2018	ANRA	440
16301	La Nana Bayou at Loop 224 North	04/18/2018	ANRA	1100
16301	La Nana Bayou at Loop 224 North	05/21/2018	ANRA	310
16301	La Nana Bayou at Loop 224 North	06/26/2018	ANRA	180
16301	La Nana Bayou at Loop 224 North	07/17/2018	ANRA	230
16301	La Nana Bayou at Loop 224 North	08/13/2018	ANRA	310
16301	La Nana Bayou at Loop 224 North	09/19/2018	ANRA	340

16301	La Nana Bayou at Loop 224 North	10/09/2018	ANRA	690
16301	La Nana Bayou at Loop 224 North	11/05/2018	ANRA	650
16301	La Nana Bayou at Loop 224 North	12/17/2018	ANRA	160
16301	La Nana Bayou at Loop 224 North	01/14/2019	ANRA	130
16301	La Nana Bayou at Loop 224 North	02/04/2019	ANRA	400
20792	La Nana Bayou Upstream of E Main	03/21/2018	ANRA	2400
20792	La Nana Bayou Upstream of E Main	04/18/2018	ANRA	1000
20792	La Nana Bayou Upstream of E Main	05/21/2018	ANRA	2400
20792	La Nana Bayou Upstream of E Main	06/26/2018	ANRA	91
20792	La Nana Bayou Upstream of E Main	07/17/2018	ANRA	2400
20792	La Nana Bayou Upstream of E Main	08/13/2018	ANRA	730
20792	La Nana Bayou Upstream of E Main	09/19/2018	ANRA	1300
20792	La Nana Bayou Upstream of E Main	10/09/2018	ANRA	920
20792	La Nana Bayou Upstream of E Main	11/05/2018	ANRA	460
20792	La Nana Bayou Upstream of E Main	12/17/2018	ANRA	2400
20792	La Nana Bayou Upstream of E Main	01/14/2019	ANRA	2400
20792	La Nana Bayou Upstream of E Main	02/04/2019	ANRA	400