Little River, San Gabriel River, and Big Elm Creek Watershed Inventory

Segments: 1213_01, 1213_04, 1213A_01, 1214_01, 1214_02

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Texas Water Resources Institute
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Brian Jonescu, Stephen Muela,
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Authored and Prepared by:
Brian Jonescu, Stephen Muela, Kirby Peddicord, Allen Berthold
Texas A&M AgriLife Research – Texas Water Resources Institute

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List of Abbreviations

AVMA	American Veterinary Medical Association
CAFO	Concentrated Animal Feeding Operation
CACG	Capital Area Council of Governments
CAMS	Continuous Ambient Monitoring Stations
CTCG	Central Texas Council of Governments
DEM	Digital Elevation Model
EPA	Environmental Protection Agency
GIS	Geographic Information Systems
HUC	Hydrologic Unit Code
LULC	Land Use Land Cover
MGD	Million gallons per day
MRLC	Multi-Resolution Land Characteristics Consortium
MSGP	Multi-sector General Permit
NASS	National Agricultural Statistics Service
NCSS	National Cooperative Soil Survey
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NPDES	National Pollution Discharge Elimination System
NMP	Nutrient Management Plan
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OSSF	On-Site Sewage Facilities
SSO	Sanitary Sewer Overflows
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TNRIS	Texas Natural Resources Information System
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQMP	Water Quality Management Plans
WWTP	Wastewater Treatment Plant

Introduction

The Little River, San Gabriel River, and Big Elm Creek watersheds (referred to as the Little River watershed from this point on) spans 717,312 acres across five counties in Central Texas, including McLennan, Falls, Bell, Milam, and Williamson (Figure 1). The Little River forms from the confluence of the Leon and Lampasas Rivers below Belton Lake and Stillhouse Hollow Lake. It flows southeast from Bell County until the confluence with the Brazos River in Milam County. Big Elm Creek forms in McLennan County south of Moody and flows southeasterly towards the Little River north of Cameron. The San Gabriel River flows out of Granger Lake in Williamson County and flows easterly until it joins the Little River in Milam County, southwest of Cameron.

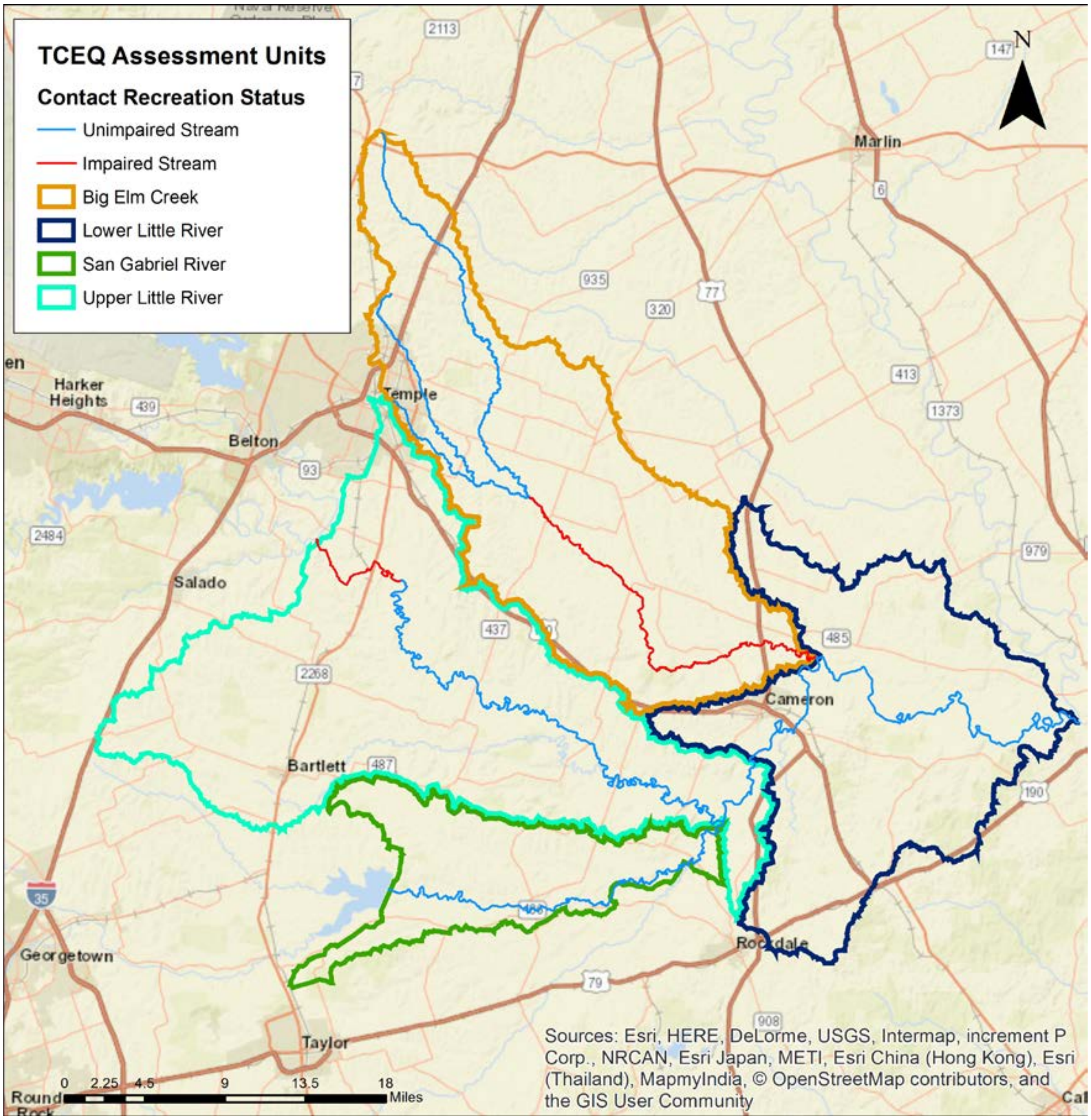

Figure 1. Map of the Little River, San Gabriel River, and Big Elm Creek Watersheds.

The city of Cameron (population 5,552) and parts of Temple (population 66,102) are the largest urban areas within the Little River watershed. The Little River crosses through two major ecoregions—the Blackland Prairie and Oak Woodlands. The majority of the watershed is within the Blackland Prairie Region, but a small portion of the watershed in Milam County is in the Oak Woodlands Region. Annual rainfall in the watershed varies between 34 – 38 inches. The sandy clay or clay loam soils support significant agriculture in the western portion of the watershed.

The Little River watershed is included in the Texas Integrated Report of Surface Water Quality as impaired due to elevated levels of *E. coli* by the Texas Commission on Environmental Quality (TCEQ). Data availability within the Little River watershed is limited, including information regarding sources of *E. coli* within the watershed and other factors that may influence pollution sources. Because of these issues, a watershed inventory will be developed with data and information pertaining to water quality impairments and issues in the watershed.

GIS Inventory

In order to improve the availability of spatial data and help the Texas Water Resources Institute (TWRI) personnel, a Geographic Information System (GIS) inventory was conducted to determine the available GIS data for the Little River watershed. The most recently available geographic information was used to create an updated map of watershed characteristics. This process is essential to identifying the potential sources of pollution and beginning the restoration process within the watershed. The physical features of the watershed were combined into a single map by including data for elevation, soils, watershed area, reservoirs, and stream networks. These features are useful for establishing monitoring sites because they highlight accessible points on the river and the locations of existing USGS gages. Additional information related to possible sources of pollution was also aggregated into a comprehensive GIS map, including Texas Pollutant Discharge Elimination System (TPDES) permitted discharges. The Land Use for the Little River watershed was updated and used to determine possible bacterial loadings. This process estimated the load contributions for wildlife, domestic livestock, and leakage from on-site sewage facilities (OSSF). GIS data layers were combined and used to create maps that highlighted different aspects of the watershed. Table 1 includes brief data descriptions, uses, and sources.

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	CTCG and CACG
Air temperature and precipitation	Watershed characterization	NOAA
Average annual air temperature and precipitation	Watershed characterization	PRISM 2012
City boundaries	General map layer	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	Measure concentration of bacterial loads under a 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 stormwater	Locate the outfalls for TPDES permitted discharges and recognize potential problem areas	TCEQ
Hydrography	Determine the flow relationships between the Little River and its tributaries	USGS
Irrigation districts	Characterize water use within the watershed	TCEQ
Land use/land cover	Characterize the watershed and potential sources of pollution	NLCD, MRLC
Livestock population estimates	Estimate potential bacterial loads from livestock	USDA NASS 2012
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 2013
Sanitary Sewer Overflows (SSOs)	Estimate the bacterial load that could be attributed to SSO, and to recognize potential problem areas	TCEQ
Soil map unit boundaries and properties	Characterize the watershed	NRCS
Streamflow	Measure historical and current	USGS
TCEQ segments	Determine the location of official TCEQ River Segments	TCEQ 2012
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	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

Physical Features

Land Use Land Cover

Land Use and Land Cover (LULC) data was found using the National Land Cover Database (NLCD). The data found on the NLCD was compiled by a consortium of nine federal agencies. Multi-seasonal Landsat images were compiled into a continuous land cover data layer. This land cover layer now includes 1,780 Landsat images with a 30-m resolution. A map of the LULC for the Little River watershed was created and is displayed in Figure 2. The LULC is represented by the following categories and definitions (USGS, 2014):

Open Water - areas of open water, generally with less than 25% cover of vegetation or soil.

Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.

Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.

Developed High Intensity - highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.

Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.

Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.

Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

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

Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

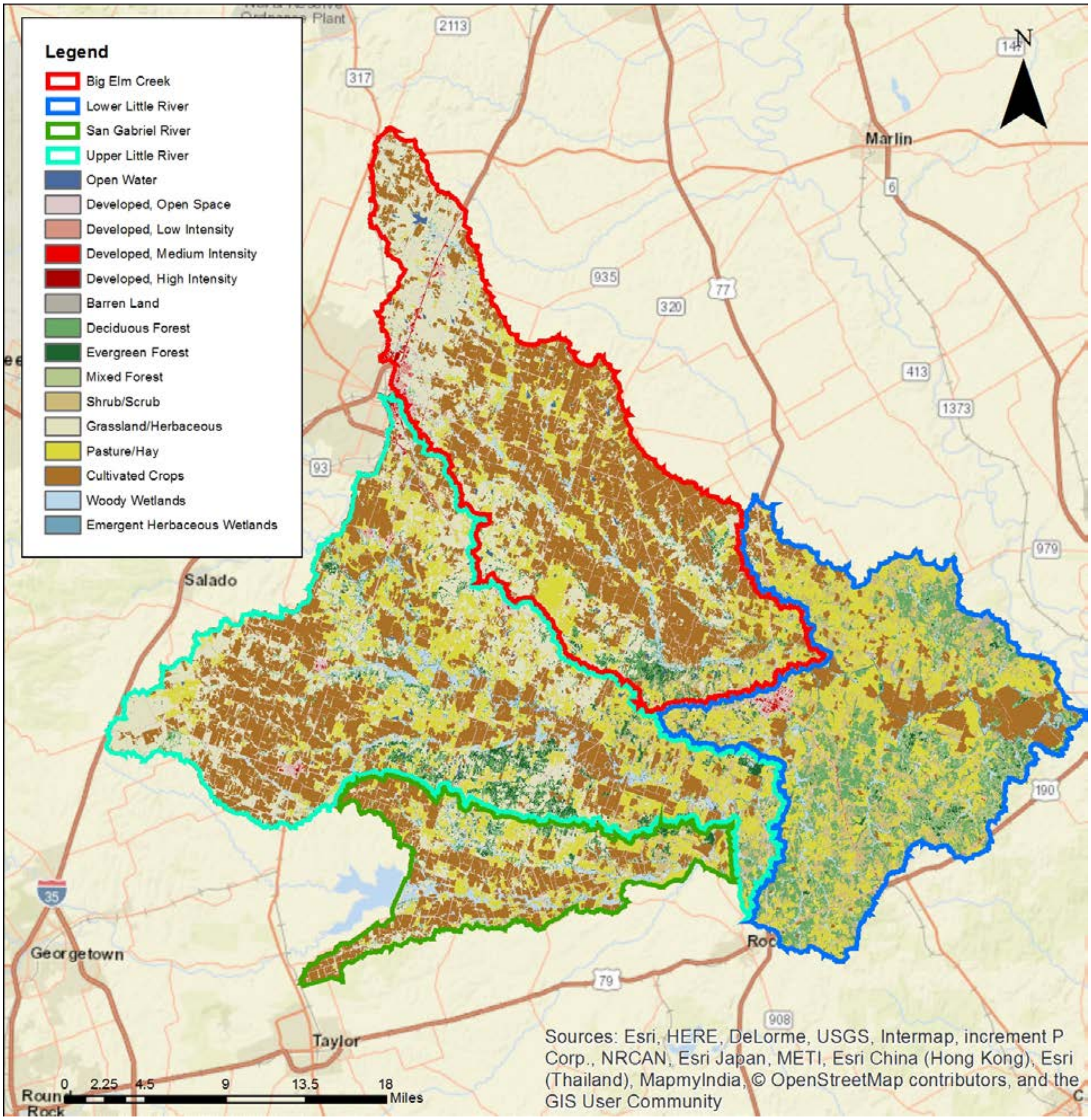

Figure 2. Land use map for the watershed.

The LULC categories were created with the intention of allowing governmental agencies to assess ecosystem health and to develop land management strategies (NLCD 2011). Table 2 shows the percentages of each land use category for each subwatershed and for the overall Little River watershed.

Table 2. LULC areas for subwatersheds and the total watershed.

NLCD Classification	Acres					
	Big Elm Creek	San Gabriel River	Lower Little River	Upper Little River	Total	Percent
Open Water	1,223	155	1,107	1,592	4,077	0.57%
Developed, open space	13,215	5,756	8,888	16,480	44,339	6.18%
Developed, low intensity	1,729	50	819	1,395	3,993	0.56%
Developed, medium intensity	781	13	394	669	1,857	0.26%
Developed, high intensity	359	5	99	335	798	0.11%
Barren Land	143	0	873	253	1,269	0.18%
Deciduous Forest	6,183	2,971	34,139	12,443	55,736	7.77%
Evergreen Forest	2,285	1,407	2,294	6,393	12,379	1.73%
Mixed Forest	160	10	8,186	94	8,450	1.18%
Shrub/Scrub	4,601	3,563	33,997	7,725	49,886	6.95%
Herbaceous	60,520	12,161	4,495	68,119	145,295	20.26%
Hay/Pasture	26,849	15,598	55,511	48,802	146,760	20.46%
Cultivated Crops	82,560	28,298	23,063	80,311	214,232	29.87%
Woody Wetlands	6,473	5,160	5,668	10,227	27,528	3.84%
Emergent Herbaceous Wetlands	31	27	585	71	714	0.10%
Total	207,112	75,174	180,118	254,909	717,313	100.00%

Digital Elevation Models (DEM)

In order to determine the slope and elevation of the watershed, DEM data was downloaded from the National Elevation Dataset (NED). The NED is the elevation layer used for the national map. This elevation data is maintained by the USGS and offers the best resolution for the United States (~30 m). This data is presented using the geographic coordinate system North America Datum of 1983 (NAD 1983). The NED was utilized to determine the slope of the Little River watershed.

Stream Network

A spatial GIS layer of the stream network for the watershed was obtained from the National Hydrography Dataset (NHD), which is maintained by the United States Geological Survey (USGS, 2010b). The NHD is a digital vector dataset that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages. NHD incorporates a flow network and additional linked information to allow for connectivity analysis. This data was used to produce general reference maps and to analyze surface water systems.

Hydrologic Unit Code (HUC)

In order to determine the watershed and subwatershed boundaries, the Hydrologic Unit Code (HUC) GIS for the state of Texas was downloaded from the TCEQ environmental GIS database. HUCs are categorized from sub-basin to watershed to subwatershed. Each successive category is assigned a unique code. This layer includes information on subwatersheds up to the 6th level. These HUC categories are used across the United States and are accepted as the Federal standard for delineating watershed boundaries. Federal and State agencies use the smallest subwatersheds for site-specific watershed analyses.

County Boundaries/Roads/Populated Areas

County boundaries were used to create general reference maps and to incorporate the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) livestock data with the watershed boundaries. Populated area data was necessary to determine the locations and densities of residences that have OSSFs for bacterial loading estimations. This information was downloaded from the Texas Natural Resources Information System. This shapefile data was compiled by state and federal agencies including: Texas Department of Transportation, Texas Parks and Wildlife Department (TPWD), and the Federal census. Additional data on the geographic location of registered 911 addresses was obtained from the Central Texas Council of Government.

Soils

Soil properties were necessary to characterize the watershed and to incorporate into the OSSFs' density analysis. Soil data was obtained from the National Cooperative Soil Survey. This information is compiled by private entities and governmental agencies in accordance with the National Resources Conservation Service's (NRCS) soil classifications.

Monitoring Stations

TCEQ Surface Water Quality Monitoring (SWQM) Stations

The locations of the SWQM stations are available from the TCEQ website. Historical water quality data is maintained by the TCEQ and put into the Surface Water Quality Monitoring Information System (SWQMIS) database. The Little River watershed has 23 SWQM (both active and inactive) sites along its tributaries and main river channel (Table 3 and Figure 3). There are no Continuous Ambient Monitoring Stations (CAMS) along the Little River, but a review of the SWQMIS database suggests that there are six sites that are routinely monitored. Stations 13535, 14016, and 16385 on Big Elm Creek (AU ID: 1213A) are monitored once a month by TWRI personnel.

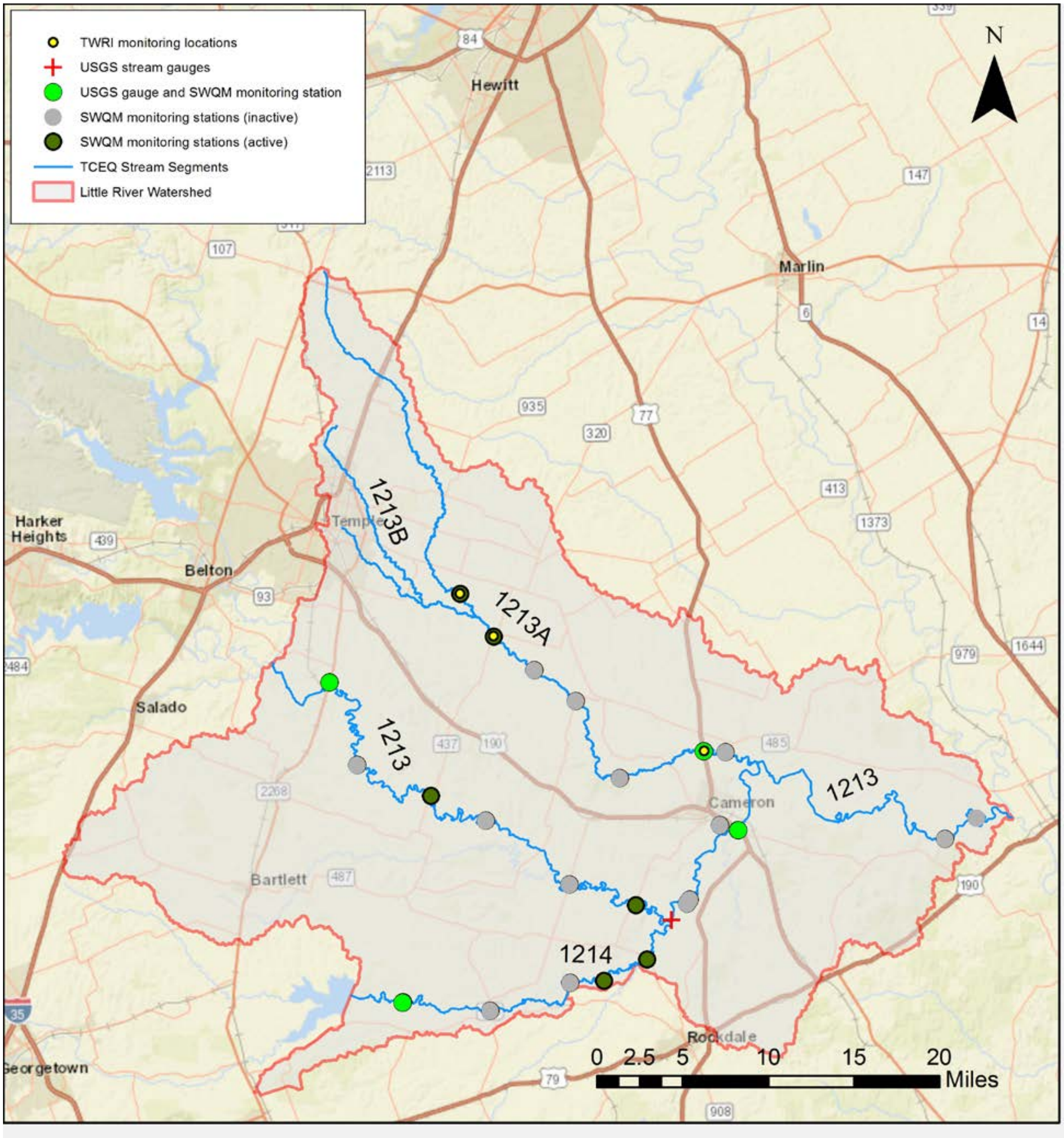

Figure 3. TCEQ and USGS Stations within the watershed.

Table 3. TCEQ SWQM Stations within the watershed.

TCEQ Station No.	Latitude	Longitude	Station Location Description	Station Type (mainstem, tributary, or pond)	Status	Bacterial/Flow Data Date Range
11887	30.825001	-96.744446	LITTLE RIVER 63 METERS UPSTREAM OF MILAM CR 264 NORTH OF GAUSE	Mainstem	Inactive	11/13/1981-12/1/1991
11888	30.835793	-96.947334	LITTLE RIVER AT US 77 BRIDGE SOUTHEAST OF CAMERON	Mainstem	Active	02/20/2001-current
11889	30.774286	-96.998718	LITTLE RIVER 1.7 KILOMETERS DOWNSTREAM OF CONFLUENCE WITH ACKERMAN SLOUGH	Mainstem	Inactive	08/23/1990
11890	30.777779	-96.996109	LITTLE RIVER 2.09 KILOMETERS DOWNSTREAM OF CONFLUENCE WITH ACKERMAN SLOUGH 453 METERS UPSTREAM OF CONFLUENCE WITH UNNAMMED TRIBUTARY	Mainstem	Inactive	N/A
11891	30.8475	-97.194725	LITTLE RIVER IMMEDIATELY DOWNSTREAM OF MILAM CR 106/BRYANT STA. BRIDGE NORTHEAST OF DAVILLA	Mainstem	Inactive	N/A
11892	30.727509	-97.038773	SAN GABRIEL RIVER AT FM 487 NORTHWEST OF ROCKDALE	Mainstem	Active	02/20/2001-07/28/2015
13534	30.901945	-96.958336	BIG ELM CREEK AT MILAM CR 340 NORTHEAST OF CAMERON	Tributary	Inactive	N/A
13535	31.039946	-97.216202	BIG ELM CREEK IMMEDIATELY DOWNSTREAM OF SEATON ROAD EAST OF TEMPLE	Tributary	Active	12/17/2015-current
13544	30.77389	-97.048615	LITTLE RIVER IMMEDIATELY DOWNSTREAM OF FM 1600 SOUTHWEST OF CAMERON	Mainstem	Active	05/25/2005-current
13545	30.89642	-97.319931	LITTLE RIVER IMMEDIATELY UPSTREAM OF REED CEMETERY ROAD SOUTHWEST OF ROGERS	Mainstem	Inactive	N/A
13546	30.966629	-97.345985	LITTLE RIVER IMMEDIATELY DOWNSTREAM OF SH 95 NEAR LITTLE RIVER ACADEMY	Mainstem	Active	10/15/2014-current
13648	30.694677	-97.278793	SAN GABRIEL RIVER AT WILLIAMSON CR 428 0.2 MILES NORTH OF LANEPORT 7.5 MILES NORTHWEST OF THRALL	Mainstem	Active	10/11/2011-current

TCEQ Station No.	Latitude	Longitude	Station Location Description	Station Type (mainstem, tributary, or pond)	Status	Bacterial/Flow Data Date Range
13810	30.792353	-97.113754	LITTLE RIVER AT FM 486 SOUTHWEST OF CAMERON	Mainstem	Inactive	N/A
13812	30.974167	-97.144722	BIG ELM CREEK IMMEDIATELY DOWNSTREAM OF BIG ELM CREEK ROAD WEST OF TEMPLE	Tributary	Inactive	N/A
13813	30.947332	-97.104507	BIG ELM CREEK AT FM 1915 NORTHWEST OF CAMERON	Tributary	Inactive	N/A
13814	30.881588	-97.062325	BIG ELM CREEK AT MILAM CR 147 NORTHWEST OF CAMERON	Tributary	Inactive	N/A
14016	31.003298	-97.183777	BIG ELM CREEK IMMEDIATELY DOWNSTREAM OF FM 437 NORTH OF ROGERS IN BELL COUNTY	Tributary	Active	01/17/2016-current
16385	30.9032	-96.979469	BIG ELM CREEK IMMEDIATELY UPSTREAM OF US 77 4.6 MILES NORTH OF CAMERON	Tributary	Active	09/22/2004-current
16409	30.869299	-97.248154	LITTLE RIVER AT FM 437 NORTHEAST OF DAVILLA	Mainstem	Active	11/18/2004--07/15/2014
17499	30.840166	-96.965034	LITTLE RIVER AT CITY OF CAMERON PWS INTAKE LOCATED AT EAST END OF EAST GILLIS STREET 4.23 KM UPSTREAM OF US 77 1.4 KM SE OF CAMERON	Mainstem	Inactive	11/09/2001-08/11/2005
17651	30.710064	-97.081223	SAN GABRIEL RIVER AT MILAM CR 429 SOUTH OF FM 487 NORTHWEST OF ROCKDALE	Mainstem	Active	10/27/2015-current
17652	30.686499	-97.193245	SAN GABRIEL RIVER AT FM 486 0.5 MILES SOUTH OF THE CITY OF SAN GABRIEL	Mainstem	Inactive	01/28/2003-04/29/2003
17653	30.70886	-97.114532	ALLIGATOR CREEK 100 M UPSTREAM OF THE CONFLUENCE OF THE SAN GABRIEL RIVER AT THE END OF MILAN CR 412	Tributary	Inactive	04/29/2003
20526	30.84219	-96.71297	LITTLE RIVER 6.085 KILOMETERS UPSTREAM OF THE CONFLUENCE WITH THE BRAZOS RIVER	Mainstem	Inactive	08/31/2009

U.S. Geological Survey's (USGS) National Water Information Systems

Historical and current data can be downloaded from the USGS network of 1.5 million monitoring sites across the country. This data encompasses 850,000 station years' worth of streamflow, gage height, surface water quality, and rainfall measurements. These stations were reviewed using the Texas Water Dashboard map viewer that is maintained by the USGS. Streamflow and gage data were obtained from the four stations on the Little River and its tributaries. All USGS gages are currently recording data, and most have historical data starting in 2007. Each station records discharge and gage height, while a smaller number have limited precipitation data (Figure 3 and Table 4).

Table 4. USGS Gages within the watershed.

Station Number	Station Description	Latitude	Longitude	Discharge Data		Gage Height Data	
				Start Date	End Date	Start Date	End Date
8104500	Little River near Little River, TX	30.9665723	-97.346113	10/1/2007	Continuous	10/1/2007	Continuous
8105700	San Gabriel River at Laneport, TX	30.694361	-97.278884	10/1/2007	Continuous	10/1/2007	Continuous
8106500	Little River near Cameron, TX	30.8351905	-96.946651	10/1/2007	Continuous	10/1/2007	Continuous
8108250*	Big Elm Creek at SH 77 near Cameron TX	30.9032438	-96.979153	3/11/2008	1/20/2017	10/1/2007	Continuous
8106350	Little River near Rockdale, TX	30.7607484	-97.013875	10/29/2007	Continuous	10/1/2007	Continuous

* Streamflow is computed only when above a gage height of 10.84 ft or 500 cfs

Bacteria Source Survey

Permitted Discharges

Permitted discharges are point source pollution that are permitted by the TCEQ through the TPDES. The TPDES itself is modeled after the Environmental Protection Agency's (EPA) National Pollution Discharge Elimination System (NPDES). These permits allow certain industries to operate and discharge their necessary wastes into water systems, although domestic wastewater is permitted differently than non-domestic industrial wastewater. Examples of permitted emitters include Concentrated Animal Feeding Operations (CAFOs), aquaculture, forest roads, industrial wastewater, stormwater, and municipal wastewater. Facilities within the watershed were issued general permits for Concrete Production (TXG110000), Concentrated Animal Feeding Operations

(TXG92000), Wastewater Evaporation Ponds (WQG100000), Phase II MS4 Permits for urbanized areas (TXR040000), Multi-Sector General Permits (TXR050000), and Pesticide General Permit (TXG870000.

The discharge of washout from concrete production facilities has little effect on overall bacterial loads in the watershed but can influence other water quality parameters including total suspended solids and turbidity. Therefore, a full inventory of concrete facilities was not included within this bacterial source survey. Stormwater discharges from urbanized areas may have a significant impact on bacterial loads within the watershed. There were 64 Phase II MS4 Permits issued to the counties that are located throughout portions of the watershed; however, only two permits actually discharged stormwater into the Little River watershed. Multi-Sector General Permits (MSGP) authorize the discharge of stormwater derived from industrial activities into local surface water. These MSGPs are differentiated based on their specific facility type and the types of potentially hazardous materials present on-site. Facilities that do not utilize hazardous materials and/or have facilities that prevent interactions with precipitation (e.g. enclosed facilities) are issued MSGP – 'No Exposure' Certifications. Since these facilities do not produce contaminated runoff, they do not have a specified receiving body for effluent and would therefore have a minimal effect on the bacterial loads in the Little River watershed. There were 29 MSGPs issued within the Little River watershed, with Bell County having 10, Milam County having 6, and Williamson County having 2. There was one Pesticide General Permit (TXG870000) and one Wastewater Evaporation Permit (WQG10000) for Williamson and Bell counties, respectively.

Concentrated Animal Feeding Operations

The Hanover Farm is the only CAFO that discharges into the Little River. This CAFO produces beef cattle on 264 acres in Milam County. This farm utilizes retention ponds to exceed their required capacity of 59.26 acres of drainage. Currently, this CAFO is produces an estimated 30660 tons of waste annually. According to the TCEQ regulations for CAFOs, there cannot be direct discharge from wastewater into natural bodies of water. Retention structures are needed to impound wastewater under typical conditions, discharge of CAFO wastewater is only allowed during "catastrophic rainfall events." The TCEQ is mainly concerned with how CAFOs in a watershed may affect the levels of Biochemical oxygen demand, ammonia-nitrogen, phosphorus and fecal coliform bacteria. Each CAFO in the state is required to develop a site-specific Nutrient Management Plan (NMP) that requires self-reported soil and water testing. There is no available information on how the sludge is processed and stored for this specific CAFO.

Wastewater Treatment and Other Direct Discharge Facilities

A review of the TCEQ TPDES point data found 12 facilities that had discharge permits. All of these facilities were permitted to discharge municipal wastewater or domestic wastewater. These NPDES numbers were cross-referenced with the TCEQ Water Quality Permits and Registration Database in order to ensure that these permits were still active and to determine additional facility information. Permit numbers, facility names, descriptions of receiving waters, and permitted flow rates are included in Table 5 and Figure 4.

Table 5. Permitted discharge facilities within the watershed.

TPDES Permit No.	NPDES No.	Permittee	Facility	Receiving Waters	Final Maximum Permitted Discharges (MGD)
WQ0011091001	0020257	BELL COUNTY WCID 2	BELL COUNTY WCID 2 ACADEMY WWTP	To Boggy Creek; thence to Little River Segment No. 1213 of the Brazos River Basin	0.10 MGD
WQ0011090001	0020249	BELL COUNTY WCID 2	LITTLE RIVER WWTP	To an unnamed ditch; thence to Katy Ditch; thence to Boggy Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin	0.16 MGD
WQ0002545000	0089109	BNSF RAILWAY CO	BNSF RAILWAY WWTP	Via outfalls 001 and 002 to unnamed ditches; thence to Knob Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin	Flow: Intermittent and flow variable
WQ0010880001	0027006	CITY OF BARTLETT	CITY OF BARTLETT WWTP	To Town Branch; thence to Indian Creek; thence to Donahoe Creek; thence to the Little River in Segment No. 1213 of the Brazos River Basin	0.325 MGD
WQ0010004001	0053651	CITY OF CAMERON	CAMERON WWTP	To an unnamed tributary; thence to Little River	0.96 MGD
WQ0010897001	0046612	CITY OF HOLLAND	CITY OF HOLLAND WWTP	To a man-made, unnamed tributary of Darrs Creek; thence to Darrs Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin	0.20 MGD

WQ0014594001	0127698	CITY OF JARRELL	CITY OF JARRELL DONAHOE WWTP	To Donahoe Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin.	1.0 MGD
WQ0010804001	0027103	CITY OF ROGERS	CITY OF ROGERS WWTP	To an unnamed tributary; thence to an unnamed pond; thence to an unnamed tributary; thence to Sypert Branch; thence to Dry Hollow; thence to Little River	*
WQ0010470002	0047651	CITY OF TEMPLE	DOSHIER FARM WWTP	To an unnamed tributary; thence to Big Elm Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin.	7.5 MGD
WQ0011263001	0058084	CITY OF TROY	CITY OF TROY WWTP	King's Branch Creek; thence to Big Elm Creek; thence to Little River	0.309 MGD
WQ0014508001	0126497	SOUTHWEST MILAM WATER SUPPLY CORP	MILANO WELL WTP	To a railroad ditch; thence to an unnamed tributary to Sandy Creek; thence to Sandy Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin.	0.13 MGD
WQ0011875001	73008	TOWN OF BUCKHOLTS	TOWN OF BUCKHOLTS WWTP	To a tributary of Lipan Creek; thence to Lipan Creek; thence to Big Elm Creek; thence to Little River in Segment No. 1213 of the Brazos River Basin.	*

* No discharge information was available for the facility

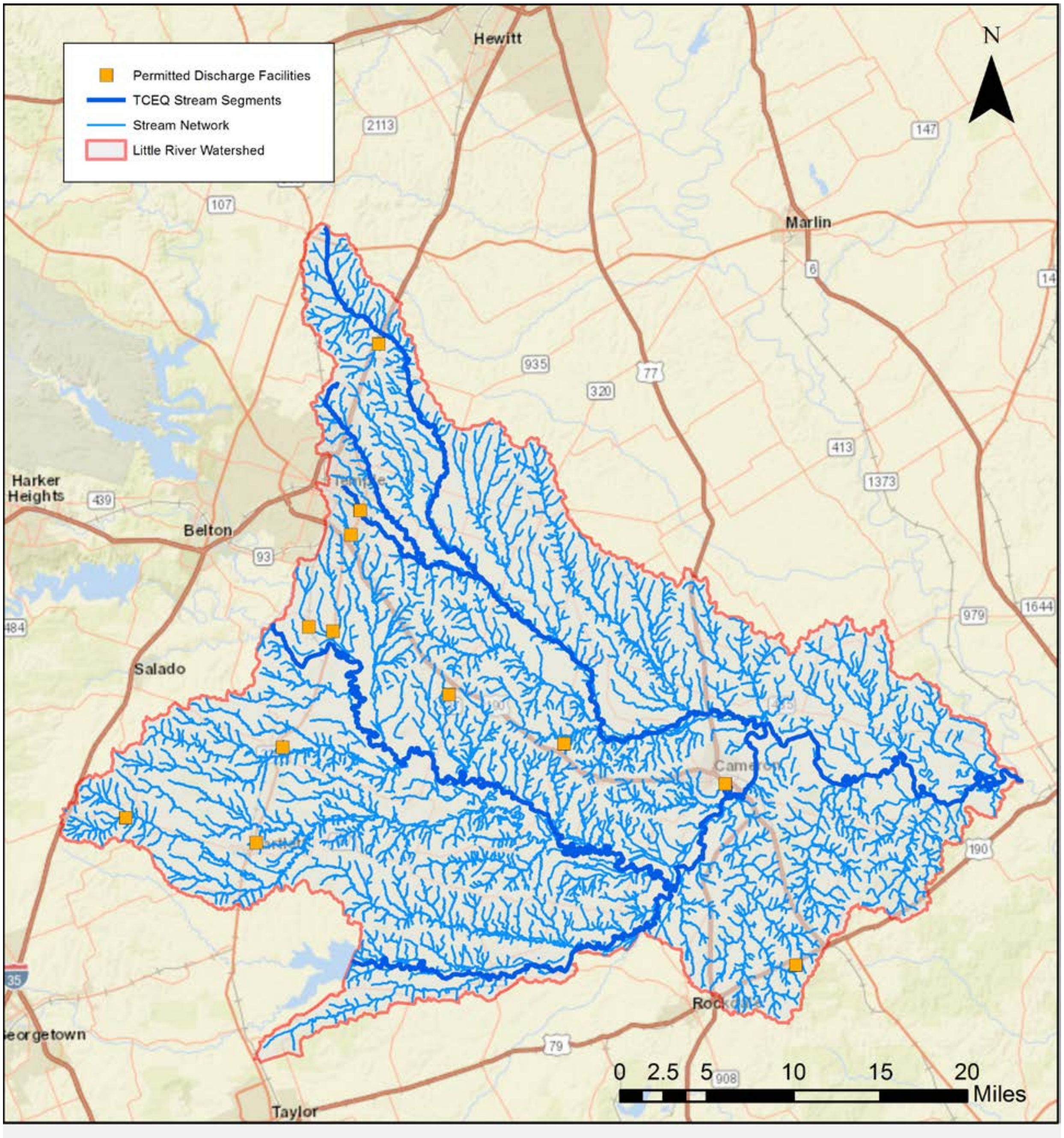

Figure 4. Permitted discharge facilities within the Little River watershed.

Non-permitted Discharges

Non-regulated discharges are diffuse sources of pollution, often referred to as nonpoint sources. Often, voluntary best management practices are used to address non-regulated discharges since they are not rigidly permitted like point source pollution.

Agricultural Activities and Domesticated Animals

Grazing livestock or the use of manure fertilizer can introduce *E. coli* into the surrounding watershed. Although there is the potential of direct deposition of fecal bacteria by domesticated animals, generally this source is minimal. In order to quantify the livestock populations within the watershed, livestock statistics were obtained per county from the USDA NASS (2012) (Table 6). These counties include Bell, Falls, McLennan, Milam, and Williamson, and the data includes population information for cattle, goats, sheep, horses, domestic hogs, laying hens, broilers, and turkeys.

Table 6. Estimated livestock numbers within the watershed.

County	Cattles	Sheep	Goats	Horses	Domestic Hogs	Laying Hens	Broilers	Turkeys
Bell	8,919	1,723	5,155	342	310	4,838	544	0
Falls	3,681	137	260	36	20	142	137	1
McLennan	219	22	39	5	3	0	0	2,931
Milam	17,859	433	1,659	1,144	293	272,971	187,908	398,620
Williamson	2,999	562	1,113	77	19	682	59	13
Total	33,677	2,877	8,226	1,604	645	278,633	188,648	401,565

The bacterial contribution for domestic pets was also estimated for the Little River watershed. Domestic animal wastes can be considered a diffuse source of *E. coli* in a watershed. The American Veterinary Medical Association (AMVA) estimates that there are 0.584 dogs per person per household and that there are 0.638 cats per person per household. These estimates were used to determine an estimate of the total number of domestic pets for the Little River watershed (Table 7).

Number of Households = Human Population / (Average Household Density for watershed)

Number of Dogs = 0.584 X (Total Number of Households)

Number of Cats = 0.638 X (Total Number of Households)

Table 7. Estimated dog and cat populations in the watershed.

County	Population	Average Household Density	Number of Households	Estimated Dog Population	Estimated Cat Population
Bell	119,006	2.65	44,908	26,226	28,651
Falls	459	2.51	183	107	117
McLennan	2,819	2.60	1,084	633	692
Milam	14,401	2.59	5,560	3,247	3,547
Williamson	28,615	2.74	10,444	6,099	6,663
Total	165,301	2.62	62,179	36,313	39,670

Water Quality Management Plans WQMP

The Texas State Soil and Water Conservation Board and the NRCS provide agricultural operators the option of using Water Quality Management Plans (WQMPs) to manage water quality. These plans are created to be site specific and address possible pollution sources while taking the needs of the producer into consideration. These plans are developed with guidance and approved by local soil and water conservation districts. A WQMP is required by law for poultry facilities but can be developed for anyone who has agricultural and silvicultural lands. Within the Little River watershed, there are currently 10 facilities that have WQMPs associated with them in 8 HUC 12 (Table 8). All of the WQMPs within the watershed are associated with poultry operations with 1,362,200 birds covered, with 15,626.6 tons of litter produced annually.

Table 8. WQMP summary within the Little River watershed.

HUC 12	Poultry WQMPs	Max number of birds	Estimated Litter Produced Annually (tons)	Planned Litter Allowable To Be Utilized On-Site (tons)	Excess Litter To Be Utilized Off-Site (tons)
120701010605	1	314,400	1,907	0	1,907
120702040110	1	54,000	1,415	952	463
120702040207	3	264600	3,407	542	2,865
120702040306	1	44,400	723	0	723
120702040307	1	220,000	1,232	0	1,232
120702040308	1	160,800	1,008	0	1,008
120702050406	1	48,000	815	0	815
120702050506	1	256,000	5,119	0	5,119
Total	10	1,362,200	15,627	1,494	14,133

Wildlife and Unmanaged Animal Contributions

E. coli is also present in the waste of wildlife within the watershed. Estimates of wildlife such as raccoons, opossums, and birds are difficult to accurately ascertain. *E. coli* can be introduced into waterways either from direct deposition or from the indirect transfer of fecal material via runoff. Since almost half of the watershed is natural land, wildlife contributions to *E. coli* can be significant in the watershed (Table 8). There are no listed exotic game ranches within the watershed, but TPWD estimates that the Blackland Prairie Ecoregion can support 5 deer/1000 acres or 200 ac/deer. Suitable habitat for deer within the Blackland Prairie Ecoregion include cultivated crops, forest, hay/pasture, herbaceous, shrub/scrub, and woody wetlands with a total of 660,980 acres. The total deer population is estimated to be 3,305.

Feral Hogs

Although feral hogs are not native species, their presence in a watershed contributes to the bacterial loads attributed to wildlife. Despite their ubiquity in Texas' watersheds, there is no reliable data on feral hog population densities. Estimates suggest that the land cover present in the Little River watershed would produce a density of 33.3 ac/hog (Wagner and Moench, 2009). Suitable land use is similar to that of deer, which includes cultivated crops, forest, hay/pasture, herbaceous, shrub/scrub, and woody wetlands. The feral hog population for the Little River is therefore estimated to be 19,849 (Table 8).

Table 9. Deer and feral hog populations within the watershed.

Land Cover Type	Acres	# of Deer	# of Feral Hogs
Cultivated Crops	214,232	1,071	6,433
Forest	76,565	383	2,299
Hay/Pasture	146,760	734	4,407
Herbaceous	145,295	726	4,363
Shrub/Scrub	49,886	249	1,498
Woody Wetlands	28,242	141	848
Total	660,980	3,305	19,849

Failing On-site Sewage Facilities

Since the Little River watershed is rural area, many residents 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 do provide an adequate level of treatment and disinfection. However, failing OSSFs can lead to non-point bacterial contamination within a watershed.

Initial estimates of households were determined by mapping 911 addresses for each county within the watershed. These addresses were then verified using the TNRIS Digital Orthoimagery Quadrangle dataset. This aerial imagery verified which 911 addresses were registered to actual residences, as opposed to those that were support structures such as garages, barns, etc. Any duplicate addresses were then removed. These addresses were used to determine the number of residences that utilize OSSFs.

This was done by locating which households were located outside of the service areas for municipalities' Certificates of Convenience and Necessity. This approximation found 7,395 OSSF facilities within the watershed (Figure 3). These OSSF points were then overlaid over the soil groups within the watershed. This analysis determined that the majority of the watershed had soils with very limited drainage capacity. These poorly drained soils increase the likelihood of an OSSF failing to drain and subsequently contributing *E. coli* to the Little River or its tributaries. This procedure was performed according to the processes laid out by previous OSSF GIS analyses in Gregory et al. 2013.

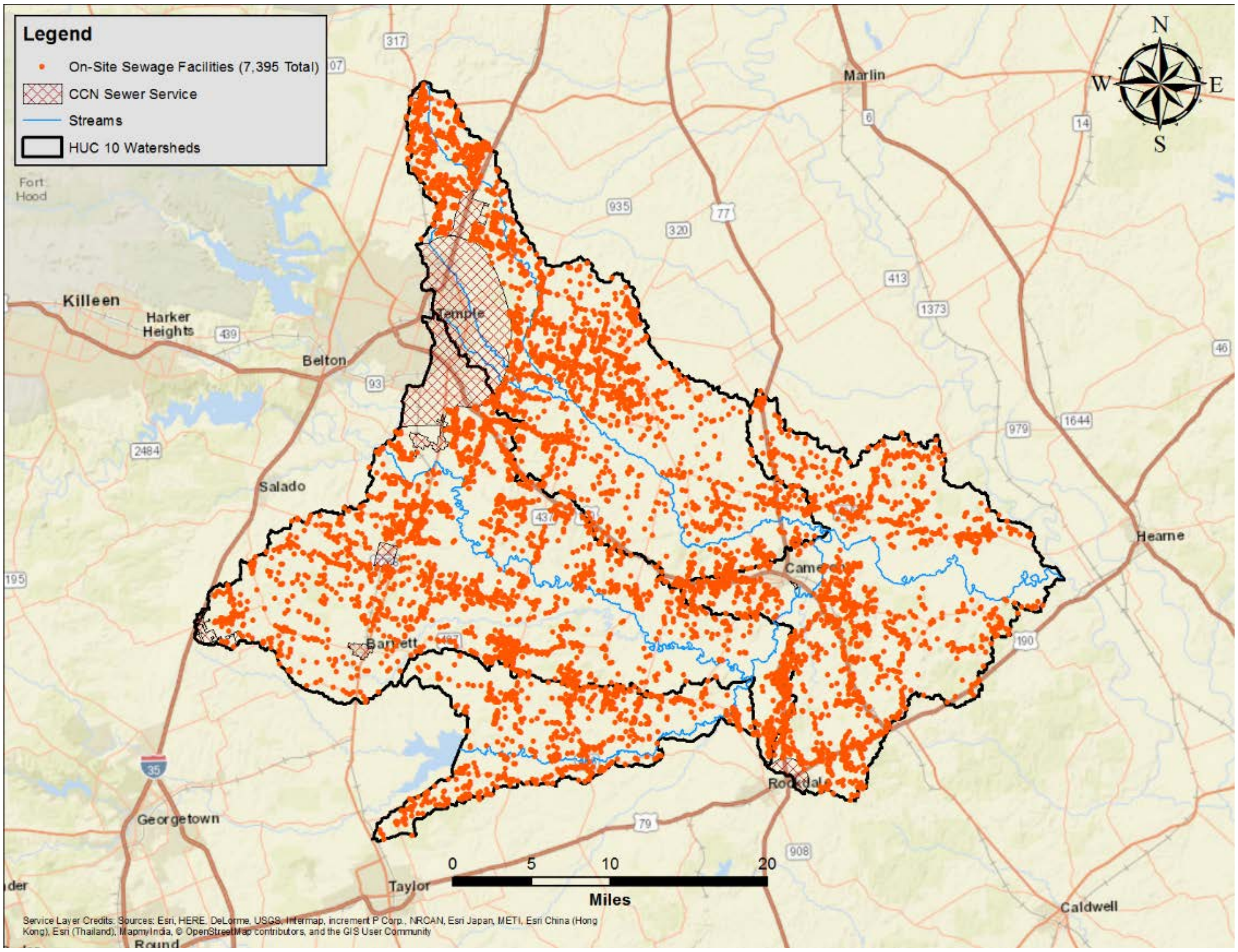

Figure 5. Municipal Service Regions and OSSF locations within the watershed.

References

AVMA. 2012 U.S. Pet Ownership Calculator. American Veterinary Medical Association https://www.avma.org/KB/Resources/Statistics/Pages/US-pet-ownership-calculator.aspx

Gregory L, Blumenthal B, Wagner K, Borel K, Karthikeyan R. 2013. Estimating On-site Sewage Facility Density and Distribution Using Geo-Spatial Analyses. J Nat Environ Sci. 4(1): 14-21.

PRISM (Parameter-elevation Regressions on Independent Slopes Model) Climate Group at Oregon State University. 2012. PRISM Products Matrix. www.prism.oregonstate.edu/

TCEQ. 2012 Texas Water Quality Inventory Water Bodies Evaluated. 2012 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d), www.tceq.texas.gov/assets/public/waterquality/swqm/assess/12twqi/2012_wbevalua ted.pdf

TWDB. 2013. Draft Population and Municipal Water Demand Projections. 2016 Regional and 2017 State Water Plan Projections Data, www.twdb.state.tx.us/waterplanning/data/projections/2017/demandproj.asp

USDA NASS. 2012. Census of Agriculture- County Summary Highlights. http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter _2_County_Level/Texas/st48_2_001_001.pdf

Wagner KL. and Moench E. 2009. Education Program for Improved Water Quality in Copano Bay. Task Two Report. College Station, TX: Texas Water Resources Institute. TR-347.