NOLAN CREEK

Characterizing Water Quality within Nolan Creek/South Nolan Creek

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For more information about this document or any other document TIAER produces, send email to info@tiaer.tarleton.edu. More information about the Nolan Creek/South Nolan Creek project can be accessed from the project website at: http://www.killeentexas.gov/nolancreekwatershed.

Cover photograph is South Nolan Creek at Levi Crossing (station 11908) taken on August 6, 2013.

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SECTION 1

Introduction

Nolan/South Nolan Creek Watershed

The Nolan Creek/South Nolan Creek watershed comprises 72,800 acres and is located almost completely within Bell County with a small portion extending into Coryell County (Figure 1-1). Municipalities within the watershed include most of Killeen, all of Nolanville and large portions of Harker Heights and Belton. The Fort Hood Military Reservation also covers much of the northern portion of the watershed. Throughout the watershed, there are small lakes and reservoirs, although none directly along the mainstem of the Nolan Creek/South Nolan Creek.

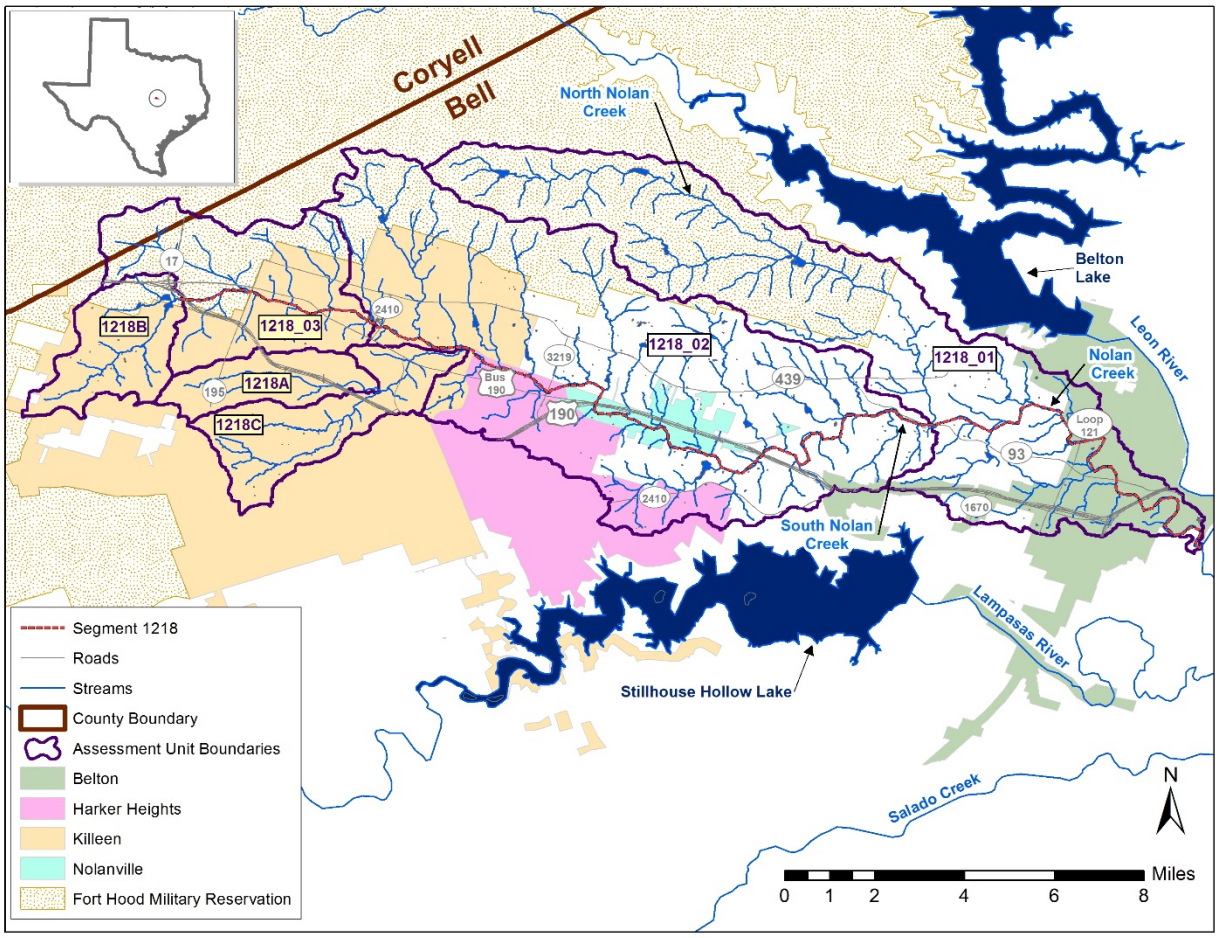

Figure 1-1 Watershed and assessment units associated with Segment 1218, Nolan Creek/South Nolan Creek. Inset shows watershed location within the State of Texas.

Nolan Creek/South Nolan Creek is defined as Segment 1218 by the Texas Commission on Environmental Quality (TCEQ) and extends from its confluence with the Leon River in Bell County to a point 100 meters upstream to the most upstream crossing of US 190 and Loop 172 in Bell County. For assessment purposes, Segment 1218 has been divided into three assessment units (AUs). In addition, three water bodies representing tributaries flowing into Segment 1218 noted as 1218A, 1218B, and 1218C are now assessed. Descriptions of these AUs are as follows:

- 1218_01: Portion of Nolan Creek from the confluence with the Leon River upstream to confluence with North Nolan/South Nolan Creek fork in Bell County.
- 1218_02: Portion of South Nolan Creek from confluence with North Nolan/Nolan Creek fork upstream to confluence with Liberty Ditch in city of Killeen in Bell County.
- 1218_03: Portion of South Nolan Creek from confluence with Liberty Ditch in Killeen upstream to a point 100 meters upstream of the most upstream crossing of US 190 near the intersection of US 190 and Loop 172 in Bell County.
- 1218A: Unnamed Tributary to Little Nolan Creek - from the confluence with Little Nolan Creek upstream to headwaters in the city of Killeen, Bell County.
- 1218B: South Nolan Creek - from 100 meters upstream of the most upstream crossing of US 190 near the intersection of US 190 and Loop 172 upstream to headwaters in the city of Killeen, Bell County.
- 1218C: Little Nolan Creek - from the confluence with Nolan Creek/South Nolan Creek upstream to headwaters in the city of Killeen, Bell County.

Water Quality Concerns and Impairments

Based on the 2012 Texas 303(d) List, assessment units 1218_02 and 1218C are listed as impaired for bacteria (TCEQ, 2013). The Draft 2014 Texas 303(d) list released on June 3, 2015 continues to note these same impairments. Segment 1218_02 was first listed in 1996, while Segment 1218C was not listed until 2010 for bacteria. These AUs have been assigned to Category 5b with regard to bacteria indicating that a review of the water quality standards for this water body will be conducted before a Total Maximum Daily Load (TMDL) is scheduled.

In addition to the bacteria impairment, concerns for nitrate, total phosphorus, and orthophosphorus are noted for AU 1281_02 in the 2012 Texas Water Quality Integrated Report for Clean Water Act Sections 305(b) and 303(d) (TCEQ, 2013). These same concerns are noted in the Draft 2014 Texas Water Quality Integrated Report (TCEQ, 2015).

Monitoring Goals and Objectives

This project for the Nolan Creek/South Nolan Creek watershed builds upon a FY04 Clean Water Act 319(h) grant project conducted by the City of Killeen, *Assessment and Targeting of Bacterial Sources in the South Nolan Creek Watershed*, which assessed water quality conditions and impairments within the upper 6.9 miles of Segment 1218 as encompassed within or on the edge of the municipal boundary of Killeen (Nett and Flowers, 2008). Monitoring in this previous

project was conducted at stations within AU 1218A, 1218B, 1218C, 1218_03 and the upper most portion of 1218_02. Within this previous 319(h) project, monitoring results found low bacteria levels for South Nolan Creek above 38th Street and confirmed a bacteria impairment downstream between Twin Creek Drive and Ann Boulevard within the City of Killeen. Elevated bacteria concentrations were also noted along Long Branch and Little Nolan Creek. These findings led to the partitioning of Nolan Creek/South Nolan Creek into three main AUs, and three additional water bodies for assessment purposes (Figure 1-1). The study indicated that bacteria were not a problem in much of the headwaters as defined by AU 1218_03 allowing future efforts to focus on the impaired areas now defined by AUs 1218_02 and 1218C.

The goal of monitoring within the current 319(h) project was to include sampling throughout Segment 1218 focusing on AUs 1218_02 and 1218C to target sources and loadings of bacteria and evaluate concentrations of nutrients of concern under base and elevated flow conditions.

Data quality objectives (DQOs) for this project were:

- To provide baseline information to aid in determining the spatial distribution of existing non-point and point source contributions of bacteria and nutrients to better assess the bacterial impairments and nutrient concerns currently noted in the 2012 Texas Water Quality Inventory.

- To provide monitoring data to allow a spatial characterization of potential sources of bacteria and nutrients in conjunction with a comprehensive data inventory (see McFarland and Adams, 2015a) and modeling activities using load duration curves (LDCs) and Spatially Explicit Load Enrichment Calculation Tool (SELECT; see McFarland and Adams, 2015b).

By meeting these DQOs, stakeholders within the watershed should be in a position to determine how best to address these impairments and concerns. Monitoring was initiated in May 2013 with approval of the project monitoring Quality Assurance Project Plan and continued into June 2015.

SECTION 2

Watershed Characteristics and Station Descriptions

Nolan Creek has two main forks, South Nolan Creek and North Nolan Creek, which converge about two miles northwest of the City of Belton (Figure 1-1). North Nolan Creek extends nearly 14 river miles through primarily range and forest land with the Fort Hood Military Reservation occupying large portions of its watershed area. South Nolan Creek flows about 20 river miles primarily in an eastward direction with its headwaters extending around the City of Killeen and including portions of the Fort Hood Military Reservation (Figure 1-1). After South Nolan Creek and North Nolan Creek merge, Nolan Creek continues for about 10 more river miles through the City of Belton prior to converging with the Leon River.

Land Use/Land Cover

Historically much of the watershed was grassland and woodland, but now it is largely urbanized, particularly along the western portion of South Nolan Creek (Figure 2-1). The watershed is comprised of about 40 percent developed land, 27 percent grassland, and 23 percent forest (Table 2-1). South Nolan Creek flows through cities of Killeen (136,438 [population estimates from Texas State Data Center, 2013]), Harker Heights (27,960), and Nolanville (4,540). After South and North Nolan Creeks converge, Nolan Creek flows through the City of Belton (19,098) to merge with the Leon River.

Table 2-1 Land use/land cover associated with the Nolan Creek/South Nolan Creek watershed. Source: 2011 National Land Cover Database (USGS, 2014).

Category	Acres	Percent
Open Water	360	0.5%
Developed, Open Space	9,288	12.8%
Developed, Low Intensity	9,839	13.5%
Developed, Medium Intensity	7,214	9.9%
Developed, High Intensity	2,855	3.9%
Barren Land	590	0.8%
Forest	16,708	22.9%
Shrub/Scrub	3,040	4.2%
Grassland/Herbaceous	19,517	26.8%
Pasture/Hay	1,072	1.5%
Cultivated Crops	991	1.4%
Wetlands	1,337	1.8%
Totals	72,811	100.0%

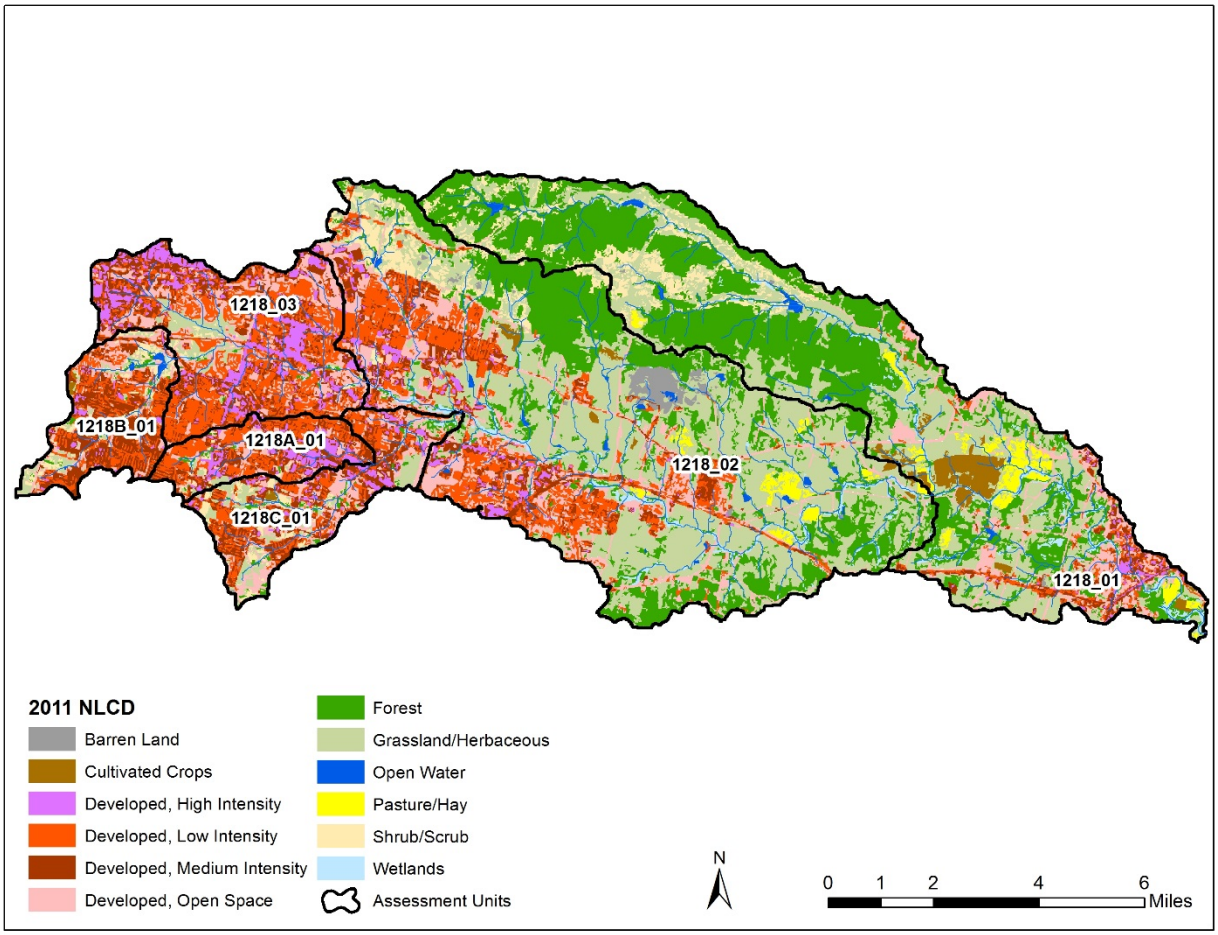

Figure 2-1 Land use/land cover for the Nolan Creek/South Nolan Creek watershed. Source: 2011 National Land Cover Database (USGS, 2014).

Regulated Sources

Within the Nolan Creek/South Nolan Creek watershed, regulated sources include wastewater treatment facilities (WWTFs) and regulated stormwater permitted through the municipal separate storm sewer system (MS4) program. As much of the watershed is urbanized or developed, about 43 percent of the watershed is covered under MS4 permitting (Figure 2-2). There are also eight permitted WWTFs within the watershed (Figure 2-3). Specific information regarding WWTF and MS4 permits are provided in McFarland and Adams (2015a). Permitted discharges from WWTFs ranged from 0.03 to 18 million gallons per day (MGD), but during the study period, averaged 0 to 11.5 MDG (Table 2-2).

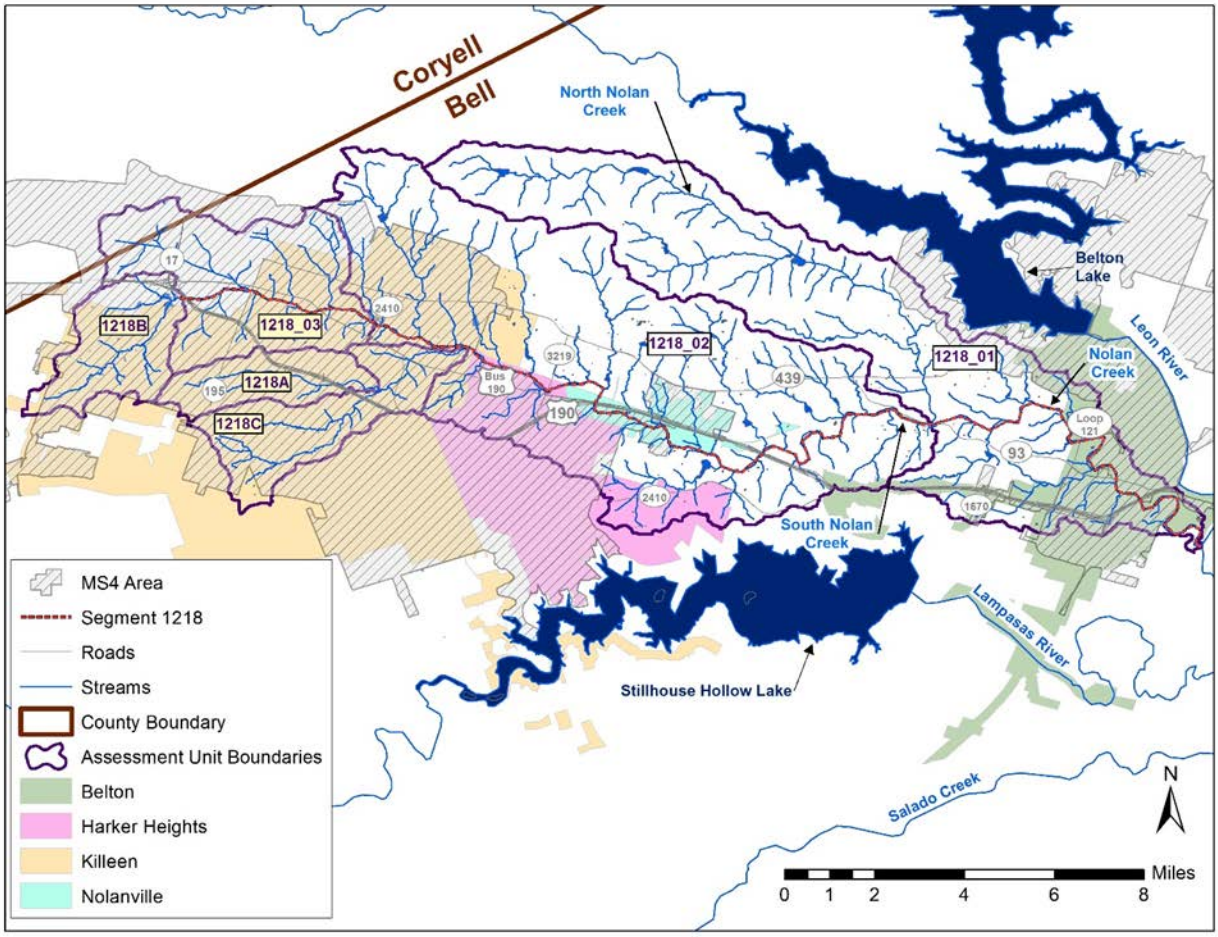

Figure 2-2 Location of MS4 areas within the Nolan Creek/South Nolan Creek watershed. Source: 2010 Census Data of urbanized areas.

Reported *E. coli* concentrations from the WWTFs were generally below permit limits (Table 2-2). For daily average values, the permit limit for WWTFs is the same as the stream criterion for primary contact recreation (PCR) of 126 MPN/100 mL. Only in August and September 2013 at the Bell County WCID1 Main Plant were any values reported above the daily average limit (Figure 2-4). The maximum daily *E. coli* limit for WWTFs is currently 399 MPN/100 mL. The daily maximum was reported as exceeded at the Harker Heights WWTF in December 2014 and May 2015 (Figure 2-5).

Table 2-2 Permitted and reported discharges and summary of reported *E. coli* concentrations from WWTFs. Source: EPA Enforcement and Compliance History Online (ECHO; 2015).

Facility Name	TCEQ Permit #	Permitted Discharge (MGD)	Reported Discharge (MGD) May 2013-Jun2015	Average of Average Reported *E. coli* (MPN/100 mL) May 2013 - Jun2015	Maximum of Maximum Reported *E. coli* (MPN/100 mL) May 2013 - Jun2015	Number of *E. coli* Obs.
Universal Services Ft Hood WWTF	WQ0013358001	0.09	0.05	1	2	7
Bell County WCID No. 1 (Plant 2)	WQ0010351003	6	0	No data	No data	0
Bell County WCID No. 1 WWTF (Main Plant)	WQ0010351002	18	11.5	55	342	26
City of Harker Heights WWTF	WQ0010155001	3	1.93	11	770	26
Bell County WCID No. 1 (Plant 3, South Plant)	WQ0014387001	6	3.01	3	250	26
Bell County WCID No. 3 WWTF	WQ0010797001	0.675	0.25	6	49	7
Blora WWTF	WQ0014994001	0.03	0.01	1	3	8
Temple Belton Regional WWTF	WQ0011318001	10	6.47	2	142	26

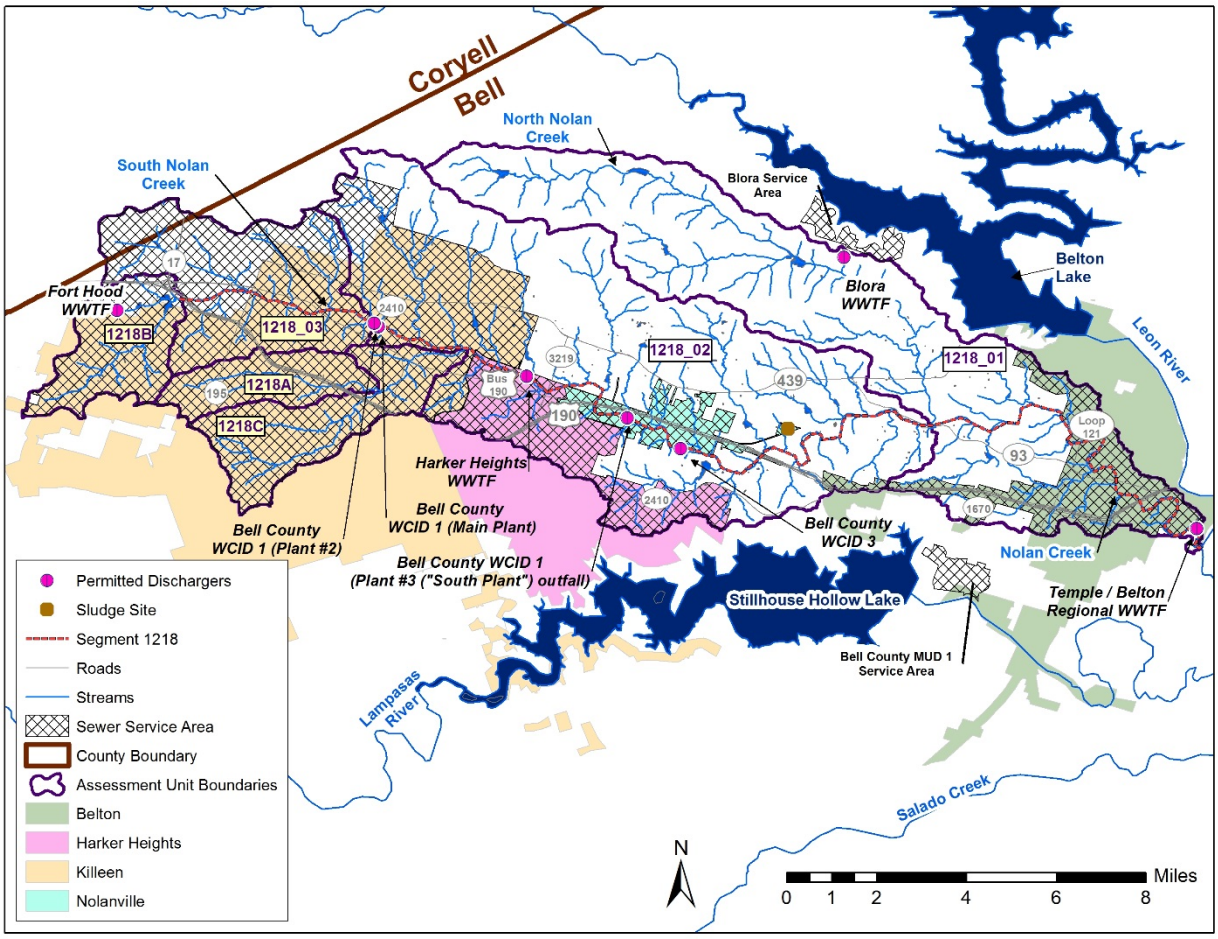

Figure 2-3 Location of WWTF discharges and service area for wastewater collection within the Nolan Creek/South Nolan Creek watershed. Note: Service areas based on Certificates of Convenience and Necessity (CCN) and municipal boundaries. The service area for some WWTFs extends outside the watershed boundaries, largely following municipal boundaries for the cities of Killeen and Harker Heights. Location of WWTF discharges were obtained from TCEQ GIS layer of permitted wastewater outfalls, publication date March 12, 2014.

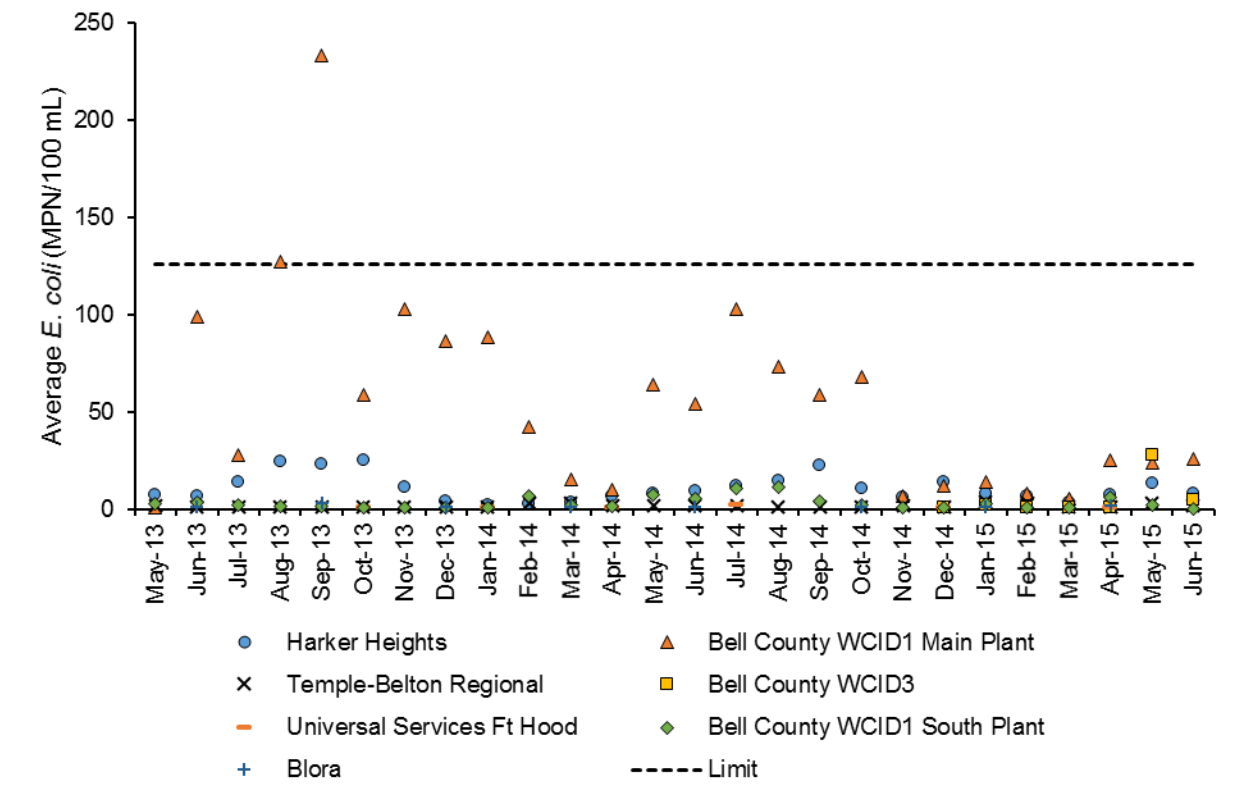

Figure 2-4 Reported daily average *E. coli* by month for WWTFs. Source: EPA ECHO (2015).

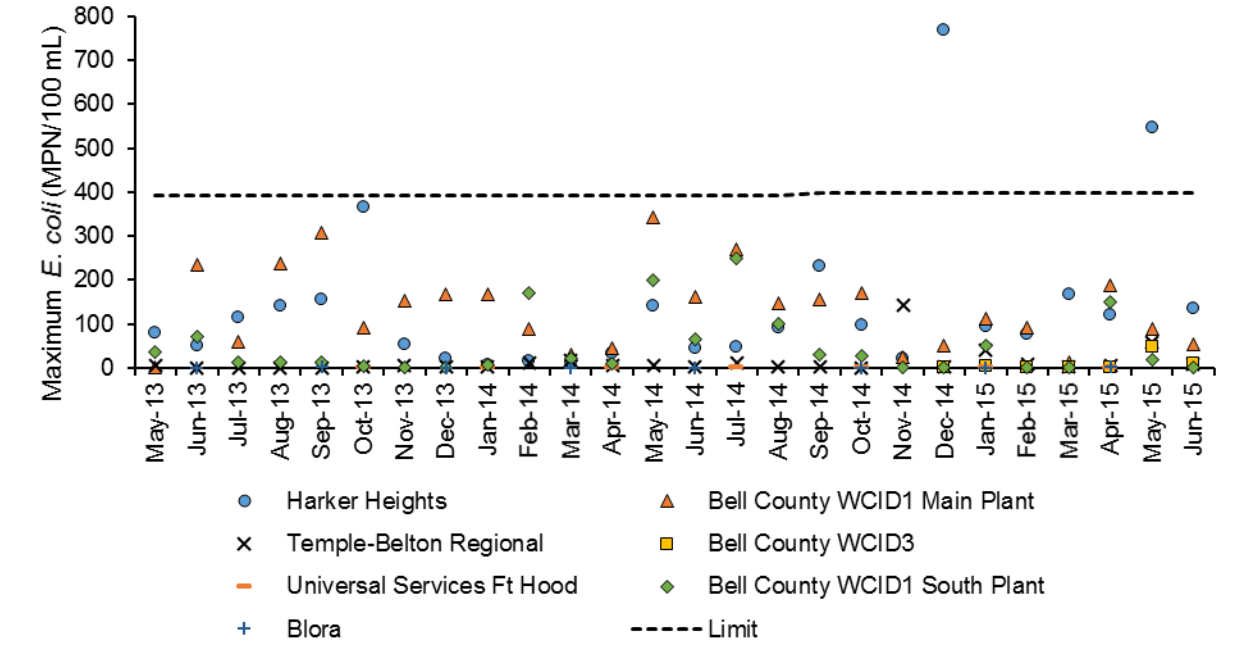

Figure 2-5 Reported daily maximum *E. coli* by month for WWTFs. Source: EPA ECHO (2015).

Unauthorized Discharges

Information on unauthorized discharges was obtained from TCEQ, and also directly from the City of Killeen (see Appendix A). The information on unauthorized discharges is known to be incomplete for the pertinent timeframe (May 2013-June 2015) due to delays in updates to the TCEQ database, but the available information provides an indication of on-going issues with sanitary sewer overflows (SSOs) most notably within the cities of Harker Heights and Killeen (Figure 2-6). Over 100 SSOs events were reported. For the most part, these SSOs were relatively small with most discharges representing less than 200 gallons, and according to municipalities, all SSO events were cleaned and sanitized to mitigate the effect of each spill.

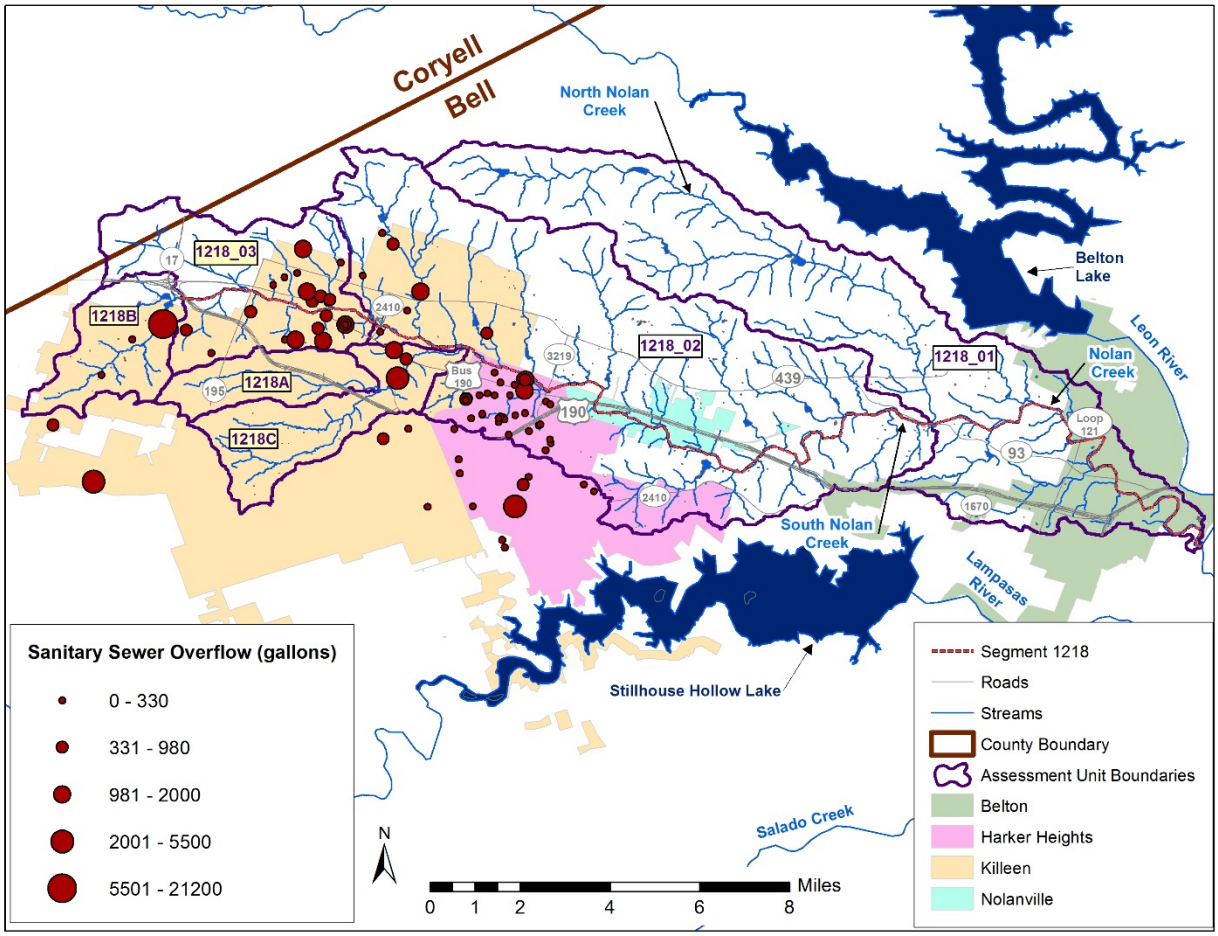

Figure 2-6 Location of reported unauthorized discharges within the Nolan Creek/South Nolan Creek watershed for the study period May 2013 through June 2015. Source: TCEQ and City of Killeen. Circles represent the relative size of reported unauthorized discharges.

Fish kills were related to a few major spills during the project monitoring period. Between May 2013 and June 2015, eight fish kill events were reported to Texas Department of Parks and Wildlife (TDPW) with the number of fish killed ranging from 44 to over 5,000 (Table 2-3 and Figure 2-7). Spills on three occasions involved chlorinated water, which would be expected to lower instream bacteria concentrations, while four other occasions, sewage was discharged from leaking lines, which would be expected to potentially increase bacteria concentrations. One other spill involved industrial resin products along Little Nolan Creek. In all cases, cleanup efforts were taken to try and mitigate these unauthorized discharges.

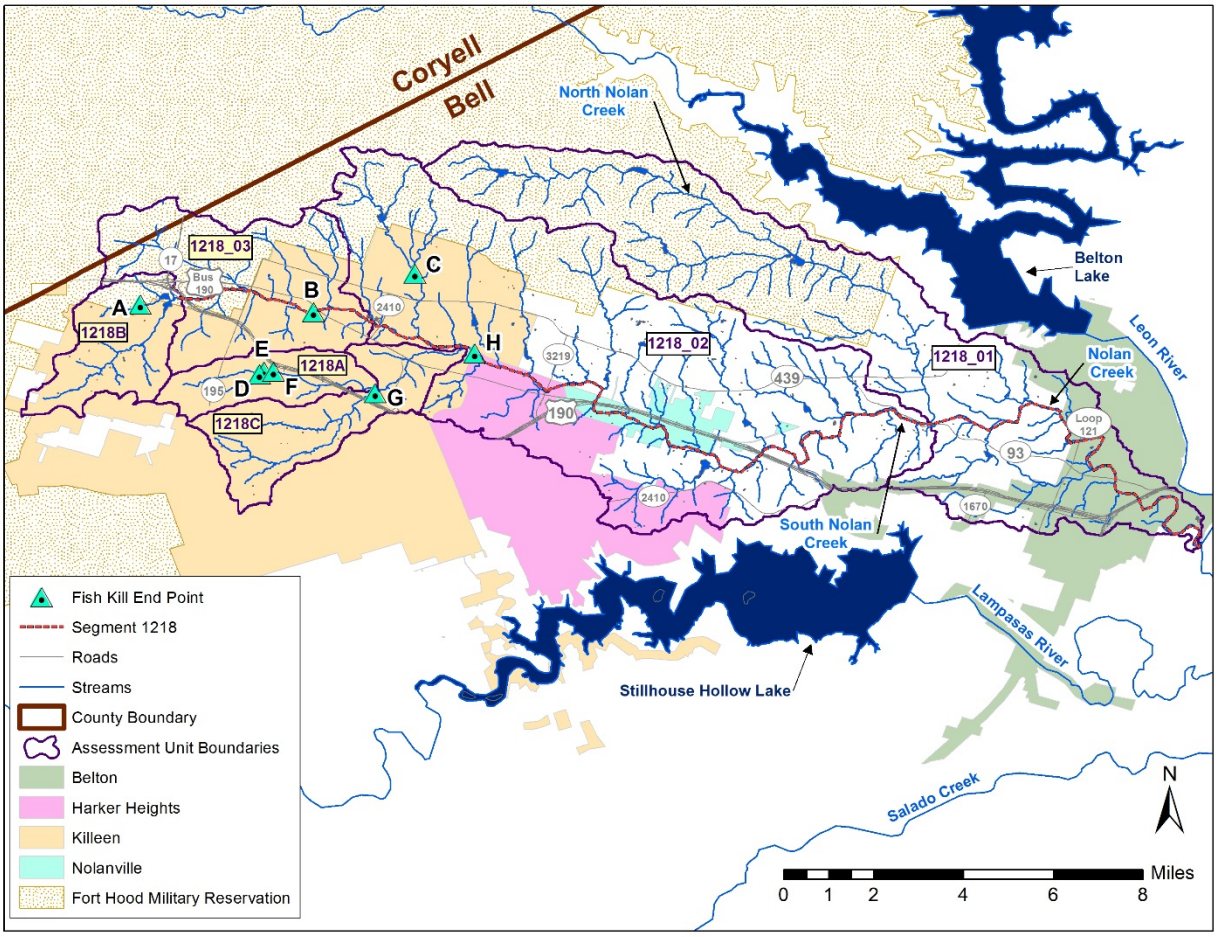

Figure 2-7 Location of reported fish kills within the Nolan Creek/South Nolan Creek watershed for the study period May 2013 through June 2015. Letters correspond to events noted in Table 2-3. Source: TDPW.

Table 2-3 Summary of unpermitted discharges reported to TDPW as fish kills. Source: TDPW data request.

Event ID[a]	Location	Start Date	Est. Total Killed	Specific Source	Specific Cause	Source Action	Other Information
20131A10794 (C)	Long Branch Creek at 2019 Dickens Dr. in Killeen	5/3/2013	76	Sewer Lines (Confirmed)	Sewage (Confirmed)	Unpermitted Discharge (Confirmed)	Sewage line backup caused by root ball, a mop head, and grease in sewer line. Unclogged and vacuum truck used to remove sewage.
20131A10862 (B)	Nolan Creek between South Gray Street and 10th Street	7/2/2013	2412	Sewer Lines (Confirmed)	Sewage (Confirmed)	Unpermitted Discharge (Confirmed) - City of Killeen reported sewage line backed up causing overflow at a lift station. Estimated 40-50,000 gallons of sewage released into the creek.	
20131A10838 (E)	Florence and Trimmier Ditches, tributaries of Nolan Creek near 202 Cobble Stone Drive	7/23/2013	76	Unknown (Suspected)	Chlorine (Suspected) - Chlorine levels were elevated above normal levels in the creek, as determined by chlorine presence/absence test strips (used by city).	Unknown (Suspected)	Suspected release of chlorinated water, possibly from a residential swimming pool.

Event ID[a]	Location	Start Date	Est. Total Killed	Specific Source	Specific Cause	Source Action	Other Information
20131A10951 (D)	Little Nolan Creek (Trimmer Ditch)	10/1/2013	591	Sewer Lines (Confirmed)	Sewage (Confirmed)	Unpermitted Discharge (Confirmed)	Sewage leak from lift station. Pipe lodged inside sewer main caused backup. Unknown amount of sewage released into creek.
20141A11021 (G)	Little Nolan Creek	11/13/2013	771	Construction/Building Trades (Confirmed)	Other (Confirmed) - An incomplete resin curing process resulted in a release of resin products along with process water. An unknown volume of styrene was discharged.	Unpermitted Discharge (Confirmed)	City of Killeen deployed several booms to collect floating material and placed earthen dam to prevent spread downstream.
20141B11136 (F)	Lowe's Ditch, tributary to South Nolan Creek, at 117 Turtle Bend in Killeen	6/17/2014	112	Sewer Lines (Confirmed)	Sewage (Confirmed)	Unregulated Discharge (Confirmed)	About 1,000 gallons of sewage spilled due to grease and root in sewage line. Killeen City staff flushed area with freshwater and disinfected the area.

Event ID[a]	Location	Start Date	Est. Total Killed	Specific Source	Specific Cause	Source Action	Other Information
20141B11172 (A)	Rainforest Ditch into Nolan Creek. Line break at 2201 Water Crest Rd., Killeen, TX	11/9/2014	44	Water Lines (Confirmed)	Chlorine (Confirmed)	Unpermitted Discharge (Confirmed)	About 270,000 (rough estimate) gallons of chlorinated water released due to break in a domestic water line. Staff impounded area downstream of break.
20151B11179 (H)	South Nolan Creek - extended about 6 miles from upstream of US 190 Business and Farm-to-Market 439 on a tributary of South Nolan Creek down to Roy Reynolds Rd and South Nolan Creek	1/5/2015	5305	Hyperchlorinated water released from a holding tank while replacing a valve at Bell County WCID No. 1	Chlorine (Confirmed)	Unpermitted Discharge (Confirmed)	Bell County WCID No 1 discharged about 5 million gallons chlorinated water Jan. 5-6, 2015 and about 2 million gallons Jan. 7-8, 2015

a. Letters in parentheses under Event ID correspond with locations shown in Figure 2-7.

Non-Regulated Sources

Non-regulated sources of bacteria include livestock, domestic pets, wildlife, feral hogs, and on-site sewage facilities (OSSFs). Within the watershed there are an estimated 2,600 cattle, 1,600 sheep and goats, and 280 horses (including ponies, mules, burros and donkeys) based on adjusted Bell County livestock statistics (see McFarland and Adams, 2015a). For domestic pets, assuming about 1 dog per household, there are about 54,000 dogs within the watershed. A deer density of 12.3 deer per 1,000 acres is noted by Texas Parks and Wildlife for the Cross Timber Ecoregion in which Nolan Creek/South Nolan Creek resides (TPWD, 2012). About 1,300 feral hogs are estimated in the watershed assuming 0.03 hogs/acre. Feral hogs have been noted by stakeholders primarily in the area around North Nolan Creek, which is largely forested. For OSSFs (often referred to as septic systems), 2010 US Census data indicates an estimated 2,180 households within the rural area of the watershed are not serviced by WWTFs. The City of Killeen noted that 273 households within its municipal boundaries were still on OSSFs (Figure 2-8), although efforts are on-going to connect these households to sewer lines through the Septic Tank Elimination Program (STEP). Of the estimated 53,973 households in the watershed, only 4.5 percent are not serviced by WWTFs and using OSSFs.

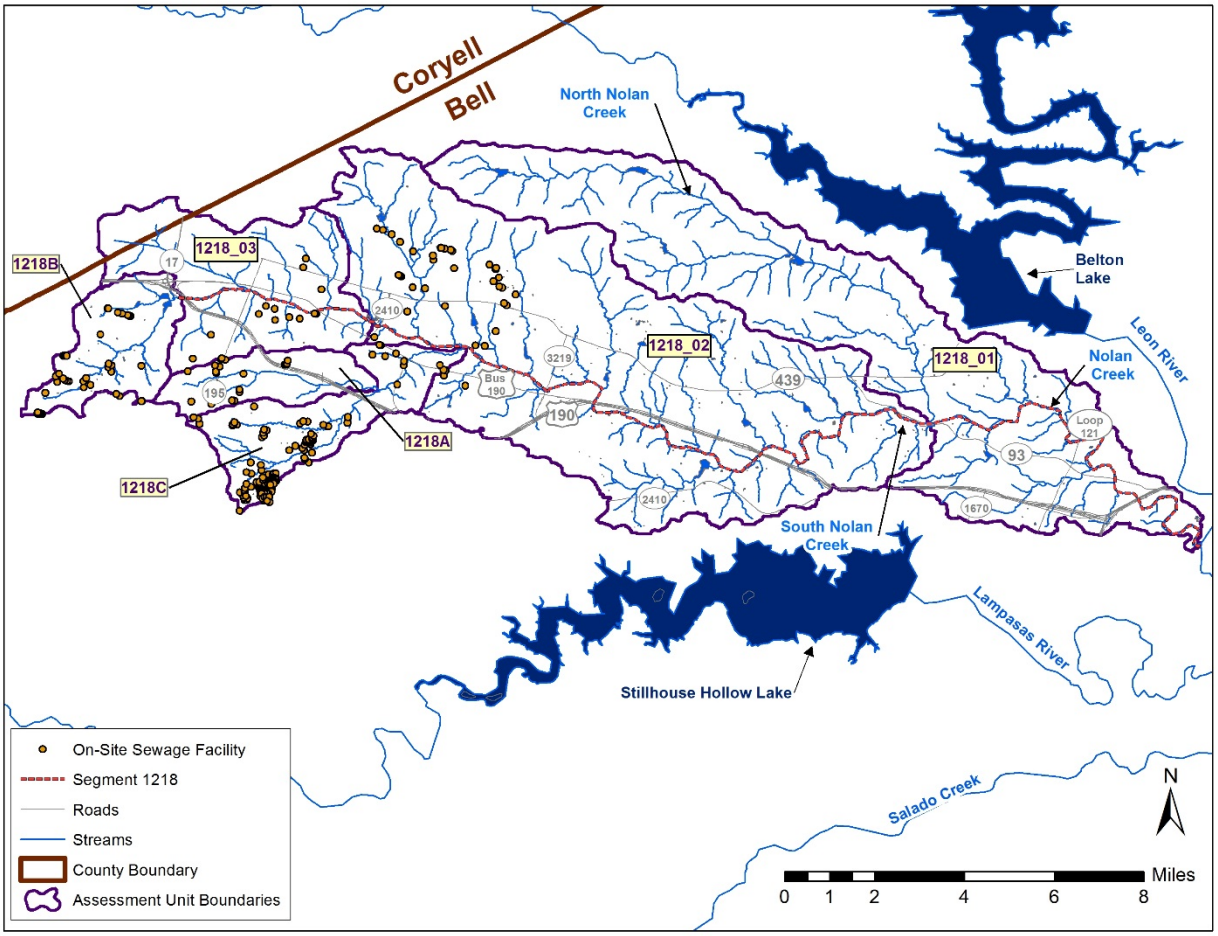

Figure 2-8 Location of OSSFs within the City of Killeen municipal boundaries. Source: City of Killeen, information provided September 2014.

Climatic Conditions

The climate of the watershed is humid subtropical with hot summers and winters that are generally mild, although daily temperatures in the winter can be quite variable with Polar air surges often causing sudden drops (Orton, 1977). Precipitation averages 33.1 inches per year varying 1.8 to 4.2 inches per month (Figure 2-9). The wettest months are generally May and June with over 4 inches of precipitation on average and the driest months are July and August with less than 2 inches on average. Maximum average temperatures occur in July and August corresponding with the driest months of the year. The coolest months of the year are generally December and January. Snowfall is very unusual for the watershed area, but can occur on rare occasions. Freezing temperatures (below 32ºF) as nighttime lows commonly occur between late November and early March. The prevailing winds are southerly with the strongest winds generally associated with spring thunderstorms (Orton, 1977).

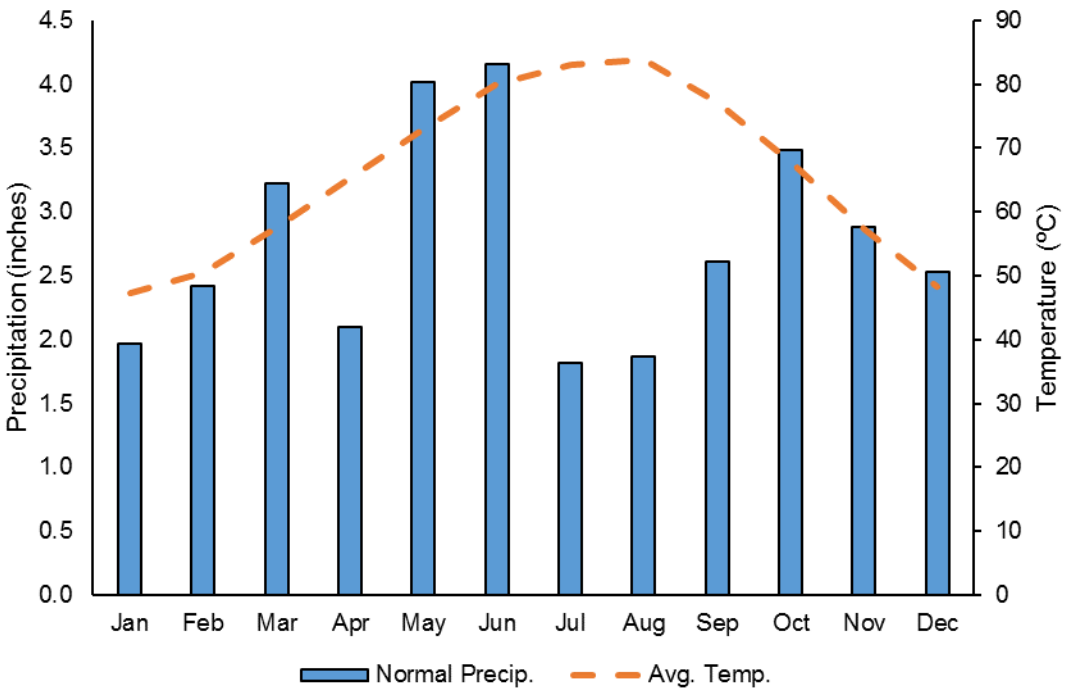

Figure 2-9 Monthly normal precipitation and average temperature for Killeen, Texas. Source: National Climate Data Center, monthly normal 1981-2010 (NCDC, 2015).

During the monitoring period (May 2013 – June 2015), precipitation varied from just a couple of tenths in a given month to a high of over 12 inches in May 2015 (Figure 2-10). Overall more months indicated below normal precipitation than above (Figure 2-11), and if only May 2013 through April 2015 were considered, a precipitation deficit of -7.6 inches occurred indicating drier than normal conditions during most of the study period. Of note, rainfall data were based on values for the City of Killeen (station GHCND:USC00414792), but were estimated based on values for Copperas Cove and Stillhouse Hollow Dam when missing daily values occurred.

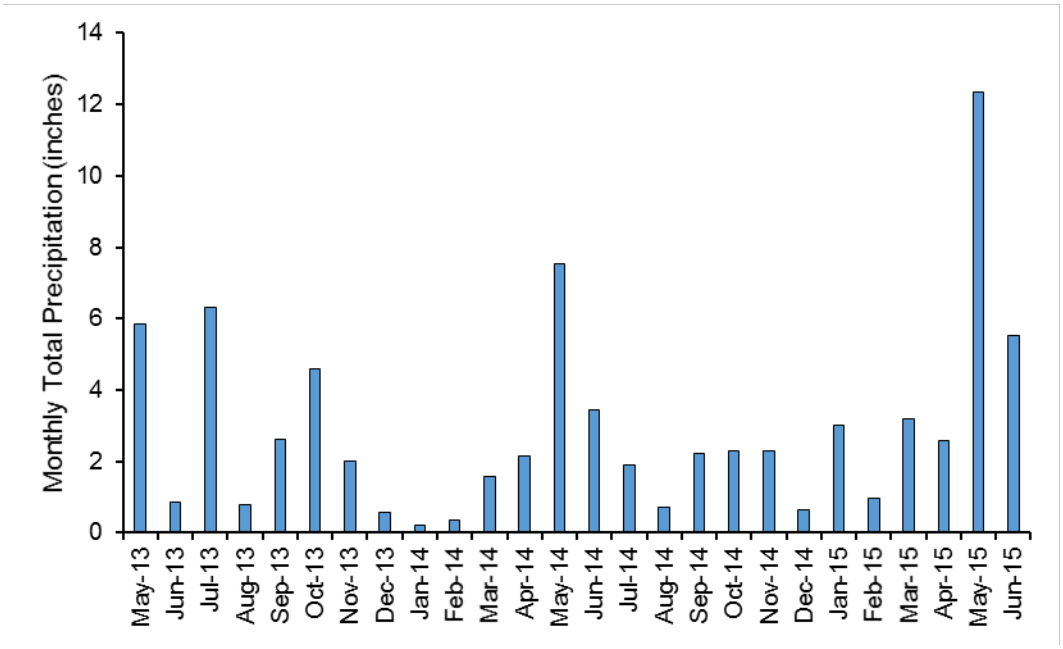

Figure 2-10 Monthly precipitation totals during the monitoring period for Killeen, Texas. Source: NCDC (2015).

On a daily basis from May through June 2015, 160 days were considered “wet” with daily precipitation of 0.01 inches or greater and 631 days were considered “dry” with trace or no precipitation for the City of Killeen. Average rainfall on “wet” days was 0.38 inches per day during the monitoring period. Only 18 days indicated rainfall greater than 1 inch and of these only 4 days indicated daily rainfall greater than 2 inches (Figure 2-12).

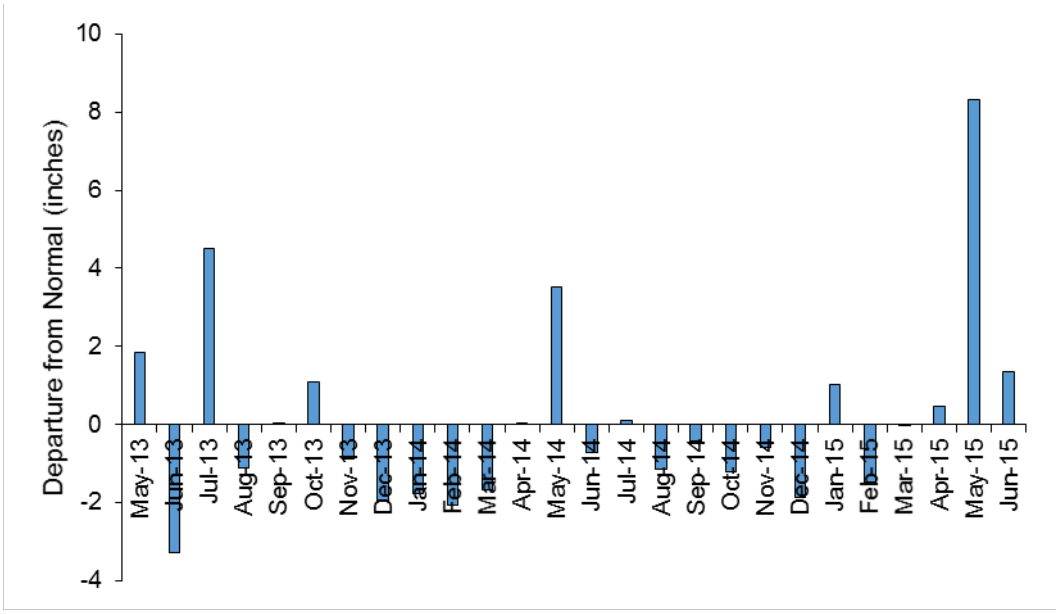

Figure 2-11 Monthly precipitation departures from normal during the monitoring period for Killeen, Texas. Source: NCDC (2015).

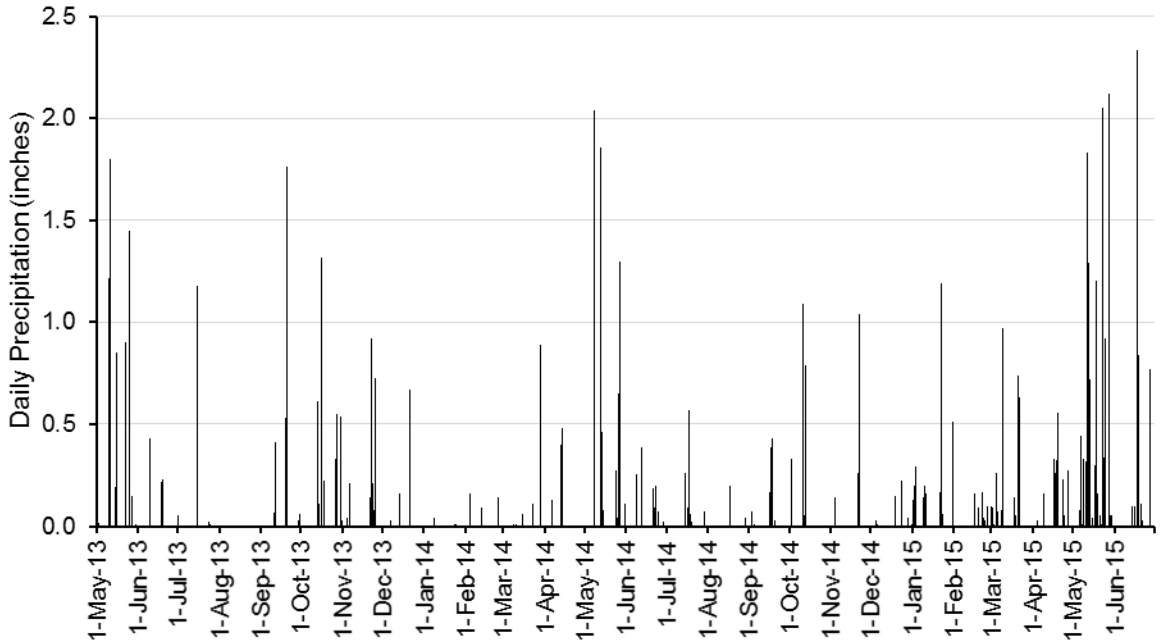

Figure 2-12 Daily precipitation during the monitoring period for Killeen, Texas. Source: NCDC (2015).

SECTION 3

Sampling Stations and Procedures

Station Descriptions

Monitoring included eight stations along the mainstem of South Nolan Creek within AU 1218_02, one on Nolan Creek within AU 1218_01, and two on tributaries to South Nolan Creek (Figure 3-1). The two tributary stations were located on Little Nolan Creek, which represents AU 1218C, and Long Branch, which feeds into South Nolan Creek at the upper end of AU 1218_02. Four of the 11 stations were selected for storm monitoring. The storm monitoring stations (18828, 11913, 11910, and 11905) were spaced out along AU 1218_02 to evaluate changes in water quality with elevated flows. In selecting these locations, an effort was made to distribute stations all along AU 1218_02, but also to focus on potential sources of bacteria and nutrients by placing stations above and below WWTF discharges and along tributaries indicated as potentially contributing to the water quality impairment (Table 3-1). Land use in the drainage area above each monitoring station reflects the largely urban environment (Tables 3-2 and 3-3).

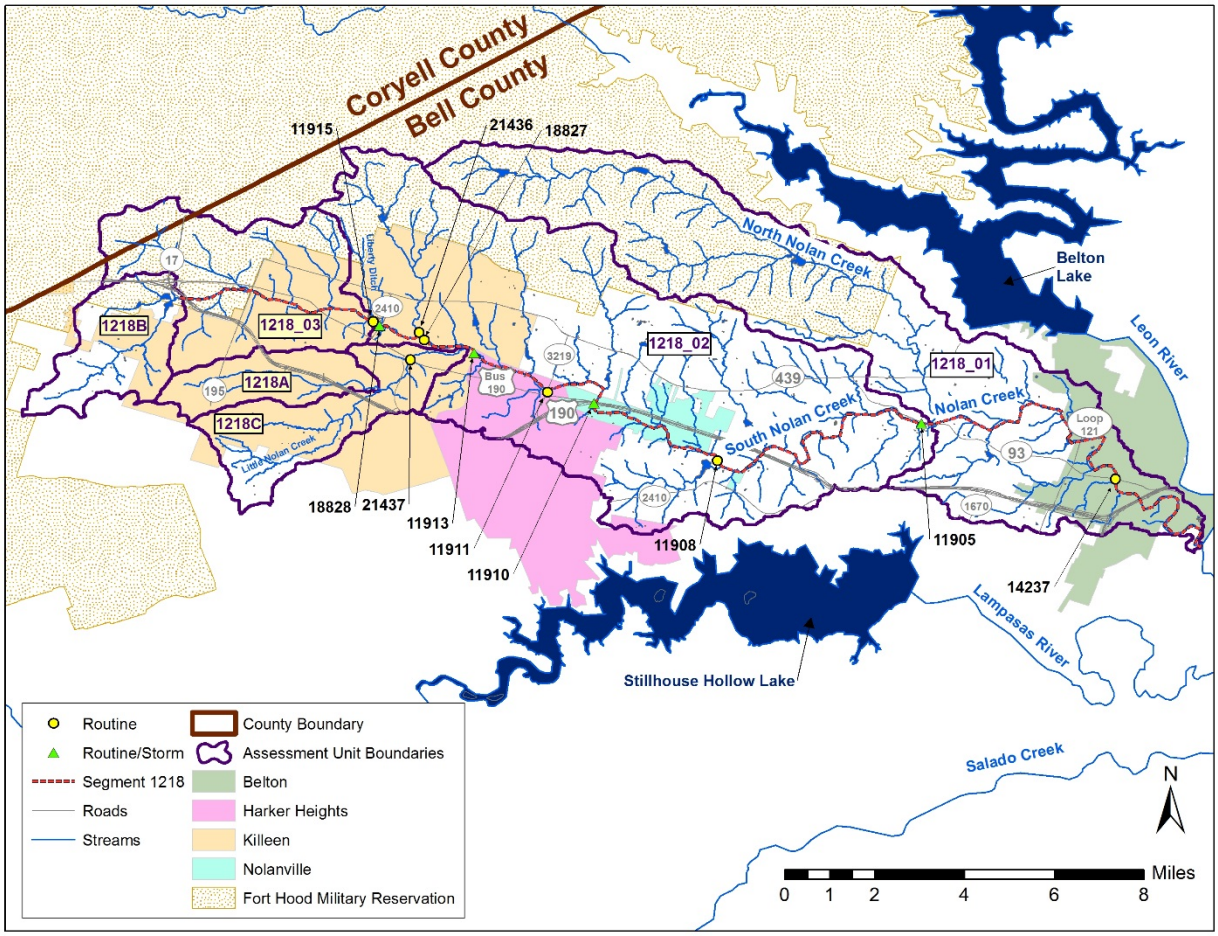

Figure 3-1 Monitoring stations within the Nolan Creek/South Nolan Creek watershed.

Table 3-1 Monitoring stations within the Nolan Creek/South Nolan Creek watershed. Stations listed upstream to downstream order.

TCEQ Station	Site Description	Rationale for Selection	Sampling Type and Monitoring Frequency	
			Routine (RT)[b]	Storm (BFSI)[c]
11915	South Nolan Creek upstream of Bell County WCID1 Main Plant WWTF outfall	Just upstream of Bell County WCID1 Main Plant WWTF discharge and most downstream location on AU 1218_03	Monthly	
18828	South Nolan Creek at 38th St in Killeen	Just below Bell County WCID1 Main Plant WWTF discharge and most upstream station for AU 1218_02	Monthly	Quarterly
21436	Long Branch just upstream of crossing of South Nolan Creek at Twin Creek Dr in Killeen	Considered a potential contributing source based on previous 319 report indicating an increase in concentrations between stations 18828 and 18827.	Monthly	
18827	South Nolan Creek at Twin Creek Dr in Killeen	Elevated bacteria concentrations indicated at this location in previous 319 report. Located downstream of confluence of Long Branch, a major tributary to South Nolan Creek with a drainage area largely within the City of Killeen.	Monthly	
21437	Little Nolan Creek off US 190 in Killeen	Considered a potential contributing source based on previous 319 report indicating an increase in concentrations between 18827 and 11913. Little Nolan indicated to have elevated bacteria concentrations in 2010 and 2012 Texas Integrated Reports.	Monthly	
11913	South Nolan Creek at Roy Reynolds Road in Killeen	Elevated concentrations indicated at this location in previous 319 report. Located on South Nolan just after confluence of Little Nolan Creek.	Monthly	Quarterly

TCEQ Station	Site Description	Rationale for Selection	Sampling Type and Monitoring Frequency	
			Routine (RT)[b]	Storm (BFSI)[c]
11911	South Nolan Creek at FM 3219 in Harker Heights	Located below WWTF discharge associated with Harker Heights. Initially considered as a storm sampling station, but accessibility during elevated flows would be difficult as the area appears to be prone to flooding. The bridge on FM 3219 is also very tall with narrow shoulders making flow measurements from the bridge dangerous for field staff.	Monthly	
11910	South Nolan Creek at US 190 in Nolanville	Located between WWTF discharges associated with Harker Heights and Bell Count WCID1 South Plant.	Monthly	Quarterly
11908	South Nolan Creek at Nolanville Road (now labeled Levi Crossing on most maps)	Located below WWTF discharge associated with Nolanville (Bell County WCID3).	Monthly	
11905	South Nolan Creek at Backstrom Crossing	Represents the most downstream location on AU 1218_02.	Monthly	Quarterly
14237	Nolan Creek at SH 93 in Belton	Within Yettie Polk Park, a recreational area in Belton. Included to complement quarterly monitoring under the Clean Rivers Program that had been occurring at station 14237 in assessing water quality within AU 1218_01.	Monthly	

a. RT indicates routine stream grab samples.
b. BFSI indicates biased flow or wet-weather stream samples.

Table 3-2 Land use/land cover associated with the drainage area above sampling stations within the Nolan Creek/South Nolan Creek watershed. Stations listed upstream to downstream order. Source: National Land Cover Database (USGS, 2011).

Station	Barren Land	Cultivated Crops	Developed, High Intensity	Forest	Grassland\ Herbaceous	Open Water	Pasture\ Hay	Shrub\ Scrub	Wetlands	Total Acres
11915	0.0%	0.2%	89.4%	0.9%	6.0%	0.4%	0.0%	2.9%	0.2%	11,587
18828	0.0%	0.2%	89.8%	0.8%	5.6%	0.4%	0.0%	2.9%	0.2%	12,388
21436	0.8%	0.0%	51.9%	12.0%	17.2%	0.5%	0.0%	17.3%	0.4%	3,890
18827	0.2%	0.2%	80.8%	3.5%	8.3%	0.4%	0.0%	6.3%	0.4%	16,536
21437	0.2%	0.3%	83.5%	2.4%	8.6%	0.0%	0.0%	4.8%	0.1%	6,497
11913	0.2%	0.2%	81.1%	3.4%	8.7%	0.3%	0.0%	5.6%	0.5%	24,030
11911	0.2%	0.4%	74.9%	6.6%	11.6%	0.3%	0.0%	5.3%	0.7%	30,115
11910	0.3%	0.5%	67.8%	10.2%	15.3%	0.3%	0.0%	4.9%	0.8%	34,072
11908	0.9%	0.5%	65.1%	9.9%	17.5%	0.4%	0.2%	4.4%	1.0%	37,919
11905	1.1%	0.4%	52.8%	14.0%	25.6%	0.4%	0.8%	3.4%	1.4%	49,415
14237	0.8%	1.3%	39.5%	23.2%	27.3%	0.5%	1.4%	4.3%	1.7%	70,967

Table 3-3 Percent developed land by subcategory and total urban land area within the drainage area above sampling stations. Stations listed upstream to downstream order. Source: National Land Cover Database (USGS, 2011).

Station	Developed, High Intensity	Developed, Medium Intensity	Developed, Low Intensity	Developed, Open Space	Total Acres Developed
11915	12.2%	26.2%	31.8%	19.3%	10,355
18828	12.1%	26.0%	31.9%	19.9%	11,129
21436	3.0%	10.4%	21.5%	17.0%	2,020
18827	9.9%	22.2%	29.4%	19.3%	13,362
21437	10.3%	26.6%	27.4%	19.1%	5,424
11913	10.0%	23.1%	28.5%	19.4%	19,488
11911	8.8%	20.4%	26.8%	18.9%	22,555
11910	7.8%	18.4%	24.1%	17.5%	23,095
11908	7.0%	17.3%	23.4%	17.4%	24,693
11905	5.4%	13.5%	18.7%	15.2%	25,440
14237	3.8%	9.8%	13.5%	12.4%	26,079

Routine Monitoring

Routine samples were collected monthly at each of the 11 sampling station starting in May 2013 through June 2015 (Table 3-4). Samples were collected at all 11 stations during each event, except on September 10, 2014, when dry conditions were encountered at station 21436. Monitoring at each station included:

- Measurement of instantaneous stream flow when routine water quality samples were collected and documentation of flow measurement method,
- Instantaneous measurement in situ of dissolved oxygen (DO), specific conductance, water temperature, and pH using multiparameter sondes,
- Collection of a water sample for nutrient and total suspended solids (TSS) analysis in appropriate containers,
- Collection of a sample for *E. coli* analysis in a sterile container,
- Documentation of field conditions included days since last precipitation (DSLP), flow severity, and comments on stream or sampling conditions.

Table 3-4 Dates of monthly sample collection May 2013 through June 2015.

2013	2014	2015
	8-Jan-14	7-Jan-15
	5-Feb-14	4-Feb-15
	19-Mar-14	4-Mar-15
	9-Apr-14	22-Apr-15
8-May-13	7-May-14	21-May-15
4-Jun-13	17-Jun-14	10-Jun-15
10-Jul-13	23-Jul-14	
6-Aug-13	13-Aug-14	
11-Sep-13	10-Sep-14	
8-Oct-13	8-Oct-14	
13-Nov-13	12-Nov-14	
12-Dec-13	10-Dec-14	

Field data and samples were collected following the TCEQ guidance document Surface Water Quality Monitoring Procedures, Volume 1 (TCEQ, 2012d). Eight field parameters were reported (Table 3-5) and each water sample was analyzed for seven different laboratory parameters (Table 3-6). All laboratory analyses were conducted by the TIAER laboratory, which is accredited for these parameters through TCEQ's National Environmental Laboratory Accreditation Program (NELAP).

Table 3-5 Field parameters and methods for routine monthly grab samples.

Parameter	Abbreviation	Units	Method[a]	Parameter Code
pH	pH	pH/ units	EPA 150.1 & TCEQ SOP	00400
Dissolved Oxygen	DO	mg/L	EPA 360.1 & TCEQ SOP	00300
Specific Conductance	Conductivity	µS/cm	EPA 120.1 & TCEQ SOP	00094
Temperature	Temp.	ºC	EPA 170.1 & TCEQ SOP	00010
Flow	Flow	cfs	TCEQ SOP	00061
Flow Measurement Method		1-gage 2-electric 3-mechnical 4-weir/flume 5-doppler	TCEQ SOP	89835
Days Since Last Precipitation	DSLP	days	TCEQ SOP	72053
Flow Severity		1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry	TCEQ SOP	01351

a. EPA refers to *Methods for Chemical Analysis of Water and Wastewater*, Manual #EPA-600/4-79-020 and TCEQ SOP refers to *Surface Water Quality Monitoring Procedures*, Volume 1 (RG-415, revised August 2012).

Table 3-6 Laboratory parameters and analysis methods for routine and storm samples.

Parameter	Abbreviation	Units	Method[a]	Parameter Code
Nitrate/nitrite-N, dissolved	NO_2-N+NO_3-N	mg/L	SM online 4500-NO3-F	00631
Total Phosphorus	TP	mg/L	EPA 365.4, modified	00665
Total Kjeldahl Nitrogen	TKN	mg/L	SM 4500-NH3G, modified	00625
Residue, total nonfiltrable (also referred to as Total Suspended Solids)	TSS	mg/L	SM 2540 D	00530
Orthophosphate-P, dissolved, field filtered	PO_4-P	mg/L	SM online 4500P-E	00671
Orthophosphate-P, dissolved, lab filtered	PO_4-P	mg/L	SM online 4500-P E	70507
E. coli	*E. coli*	MPN/100 mL	IDEXX Colilert ®	31699

a. EPA refers to *Methods for Chemical Analysis of Water and Wastewater*, Manual #EPA-600/4-79-020 and SM refers to *Standard Methods for the Examination of Water and Waste Water*.

Storm Sampling

Nine storm events were sampled between September 2013 and April 2015 (Table 3-7). Storm sampling was done to evaluate nutrient and bacteria contributions during elevated flows. Estimated rainfall associated with each event ranged from 0.14 to 2.29 inches using cumulative wet-days. Of note due to work being conducted on the bridge at Roy Reynolds Road, there was a delay in the installation of the automated sampler at station 11913 until after the September 2013 storm event, thus, only a sample for bacteria was collected at this station during that event.

Table 3-7 Dates of storm sample collection. AF = automated, flow-weighted for nutrients and TSS; BG = bacteria grab sample; and SG = storm grab for nutrients. * indicates no sample for nutrients during the Sep. 2013 storm event at Station 11913. Storm grabs collected at station 11905 twice due to issues with the automated sampler.

Date Collected	18828	11913	11910	11905	Estimated Event Precipitation (inches)
21-Sep-13	AF, BG	*, BG	AF, BG	AF, BG	2.29
15-Oct-13	AF, BG	AF, BG	AF, BG	SG, BG	0.73
27-Feb-14	AF, BG	AF, BG	AF, BG	AF, BG	0.14
29-Mar-14	AF, BG	AF, BG	AF, BG	AF, BG	0.89
16-Jul-14	AF, BG	AF, BG	AF, BG	AF, BG	0.35
19-Sep-14	AF, BG	AF, BG	AF, BG	SG, BG	0.99
23-Jan-15	AF, BG	AF, BG	AF, BG	AF, BG	1.42
21-Mar-15	AF, BG	AF, BG	AF, BG	AF, BG	1.56
19-Apr-15	AF, BG	AF, BG	AF, BG	AF, BG	1.47

A storm sampling station was comprised of an ISCO 3700 or 6712 automated sampler and an ISCO 4230 bubbler-type flow meter with tubing encased in PVC from the sampler location down into the stream channel. The sampler and flow meter were enclosed in a sheet metal shelter that is grounded. Electrical power was provided to the sampler and flow meter by marine deep-cycle batteries recharged by solar panels. A phone modem at each storm station allowed remote contact, so the station to call out and contact field personnel when a sampling event occurred.

Each automated sampler had a carrousel capable of containing 24, 1-L bottles. The automated sampler collected water bottles for nutrient and TSS analysis from storm events. Storm sampling by the automated sampler was set to initiate upon a selected rise in water level (generally 0.25 to 1.0 ft) depending on the size of the anticipated event. The flow meter was set to continuously

record stream water levels at 5-minute intervals. Storm sampling focused on the first flush of each event with the automated sampler set to fill bottles as follows:

- An initial bottle filled on sampler activation,
- The next three bottles filled at one-hour intervals,
- The next four bottles filled at two-hour intervals, and
- All remaining bottled filled at six-hour intervals.

This sampling scheme allowed more bottles to be collected at the initiation of a storm event when more variability in water quality parameters is expected. Sample bottles were generally collected within 36-hours of sampler initiation and transported on ice back to the TIAER laboratory for analysis (Table 3-6). Because the collection of bacteria samples requires use of a sterile container, a storm-grab for *E. coli* was manually collected when samples were retrieved from the automated sampler.

Storm samples were transported on ice back to the TIAER laboratory, where sample bottles collected by the automated sampler were flow-weighted into a single storm sample for laboratory analysis using an estimated rating curve based the cross-sectional area and standard hydrologic equations.

Additional Monitoring Considerations

During routine monthly sampling, general maintenance was conducted at each of the four storm sampling stations to make sure they were functioning properly and in ready condition for sampling. As part of general maintenance, the flow meter was downloaded during each monthly routine visit but also downloaded remotely about two weeks after each monthly visit to make sure communications with the sampler were working and to assess the stream level data for any anomalies.

Rating curves were developed for each storm station based on stage-discharge measurements and the stream cross-sectional area. The cross-section of the stream at each storm station was surveyed soon after each sampler was installed. Stage-discharge measurements were collected during routine and storm sample retrieval at these four stations. Of note, during sample retrieval for the March 2015 storm event, conditions were unsafe for wading flow measurements at stations 11905 and 11910, so flow values were estimated based water height and cross-section information as related to previous flow measurements.

Data Management Procedures

<u>Outliers</u>

Values for each constituent were screened to detect questionable data points. Questionable data were then tracked through the chain of custody sheets and field data sheets and laboratory notebooks, as necessary, to ascertain whether these points represented transcription errors in the database. If a transcription error was found, the error was corrected prior to statistical analysis of the data. If not a transcription error, data were maintained in the database, but noted as outliers if excluded from any of the analyses.

Censored Data

For laboratory analyses, left censored data (values measured below the reporting limit as indicated by the limit of quantification in the project QAPP) were set to one-half the reporting limit, as recommended by Gilliom and Helsel (1986) and Ward et al. (1988), prior to data evaluation. Most laboratory parameters had values well above project reporting limits, except for TSS (Table 3-8). For TSS, almost 68 percent of samples had values below 4 mg/L. While *E. coli* can on occasion have right- as well as left-censored values, no censored values (< or >) were reported for *E. coli*.

Table 3-8 Reporting limits and number of censored values by parameter.

Parameter	Reporting Limit	Number Left Censored	Total Number of Samples
NO_2-N+NO_3-N	0.05 mg/L	12	320
TP	0.06 mg/L	30	320
TKN	0.20 mg/L	51	320
TSS	4 mg/L	216	320
PO_4-P	0.005 mg/L	22	320
E. coli	1 MPN/100 mL	0	321[a]

a. The number of *E. coli* samples is one greater than all other parameters, because nutrients and TSS were not analyzed for the September 2013 storm event at Station 11913 due to bridge work being done at this location.

SECTION 4

Bacteria Monitoring Results

Water quality results for all field and laboratory analyses are presented in Appendix B with field results from routine monitoring in Table B-1, laboratory results from routine monitoring in Table B-2, and laboratory and flow results for storm samples in Table B-3. Exploratory data analysis focused primarily on bacteria results. This included time history plots of individual samples and efforts to identifiy potential sources based on timing of unauthorized discharges and relationships with flow. Comparisons between sites were conducted based on geometric mean values by sample type (routine vs storm) for comparison with the geometric mean assessment criterion. Relationships between geometric mean values by station were also explored in comparison to land use parameters.

To maintain the focus on bacteria as the water quality impairment within the watershed, summary analyses for nutrients of concern (nitrate, othro-P, and total-P) are presented in Appendix C. Time history plots of these nutrients for each station and plots comparing concentrations with flow were developed to check data for patterns and anomolies, but only summar statistics and comparisons with screening levels are presented.

Time History

Time history plots of bacteria data indicated at most stations a few samples with extremely high concentrations that warranted further exploration (stations shown in upstream to downstream order, Figures 4-1 – 4-11). While storm samples were differentiated from routine grabs in the time history plots, plots were also developed of flow versus *E. coli* to help illuminate whether these high concentrations occurred during wet or dry conditions (plots not shown). Wet and dry events were also assessed based on the parameter DSLP (days since last precipitation). If DSLP was less than 4, a routine sampling event was considered to represent wet weather conditions. Of the 26 routine sampling events, only one event (May 21, 2015) was considered “wet-weather” influenced. At a few stations, a slight uptick in *E. coli* concentrations in May 2015 in comparison to most routine “dry-weather” samples (see Figures 4-1, 4-2, 4-4, and 4-9).

For “wet-weather” events, there was an expectation that *E. coli* concentrations would increase with increasing nonpoint source runoff, which is borne out for storm samples in Figures 4-2, 4-6, 4-8, and 4-10. Of the “dry-weather” events with high *E. coli* concentrations, the timing of samples were compared with the timing of unauthorized discharges associated with fish kills (Table 2-3) and SSOs (Appendix A).

On two occassions, there appeared to be a fairly clear connection between unauthorized discharges and elevated bacteria concentrations. The relatively high *E. coli* concentrations noted on July 10, 2013 at stations 18828, 18827, and 11913 (Figures 4-2, 4-4, and 4-6) appeared to be related to a large sewage discharge that occurred upstream of all 11 stations, which was reported on July 2, 2013 (Table 2-3). At stations downstream of 11913, located on South Nolan at Roy Reynolds Road, an elevated bacteria signal was not apparent in July 2013. Interestingly, an elevated bacteria signal was also not apparent at station 11915, the most upstream monitoring

station, for the July 2013 routine sample, although the unauthorized discharge would have had to pass by this location to reach the more downstream stations of 18828, 18827, and 11913. The slug of sewage may have already passed through this location or else clean up efforts may have ameloriated any residual impact at station 11915 by the time it was monitored on July 10, 2013.

The other connection of elevated bacteria with an unauthorized discharge appeared to occur with the July 23, 2014 sampling at station 11911 (Figure 4-7). A sewer main leak was reported in Harker Heights on July 21, 2014 near station 11911 (see Appendix A). While other SSO events may have had an impact on instream water quality, the connection was not readily apparent in visually evaluating the data.

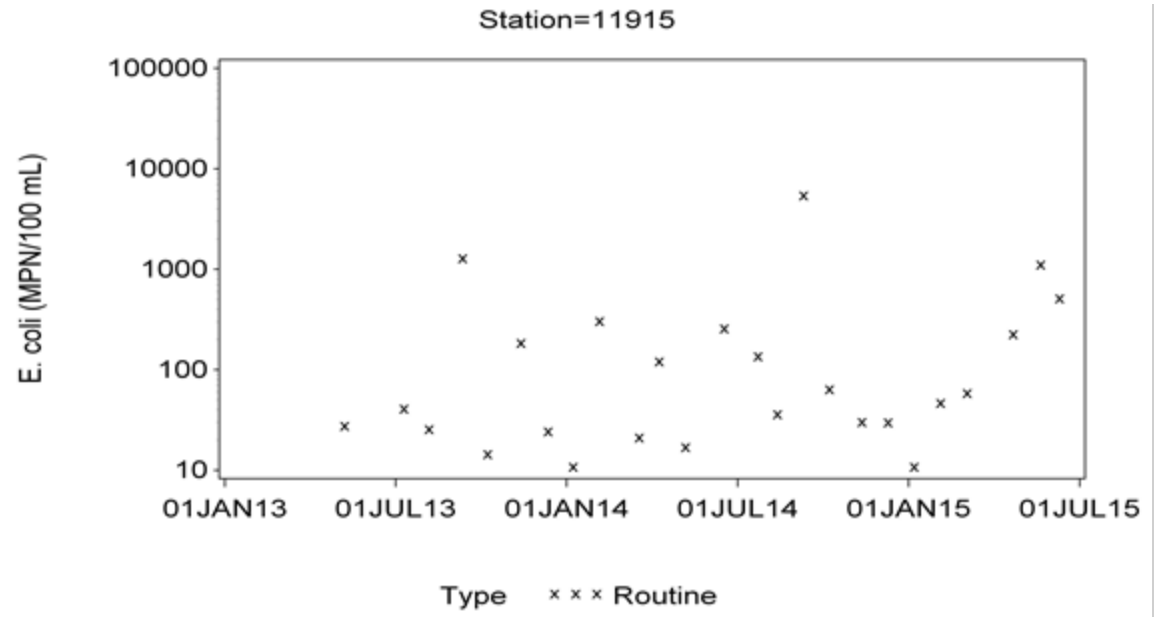

Figure 4-1 Bacteria concentrations at station 11915, South Nolan Creek upstream of Bell County WCID1 Main Plant WWTF outfall.

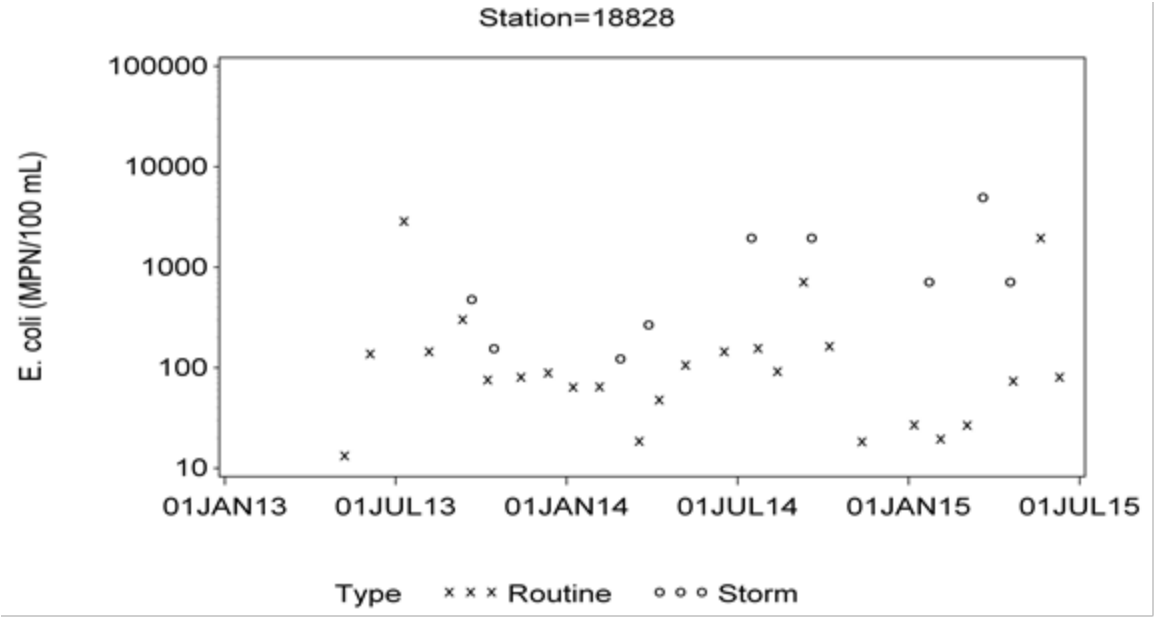

Figure 4-2 Bacteria concentrations at station 18828, South Nolan Creek at 38th St in Killeen.

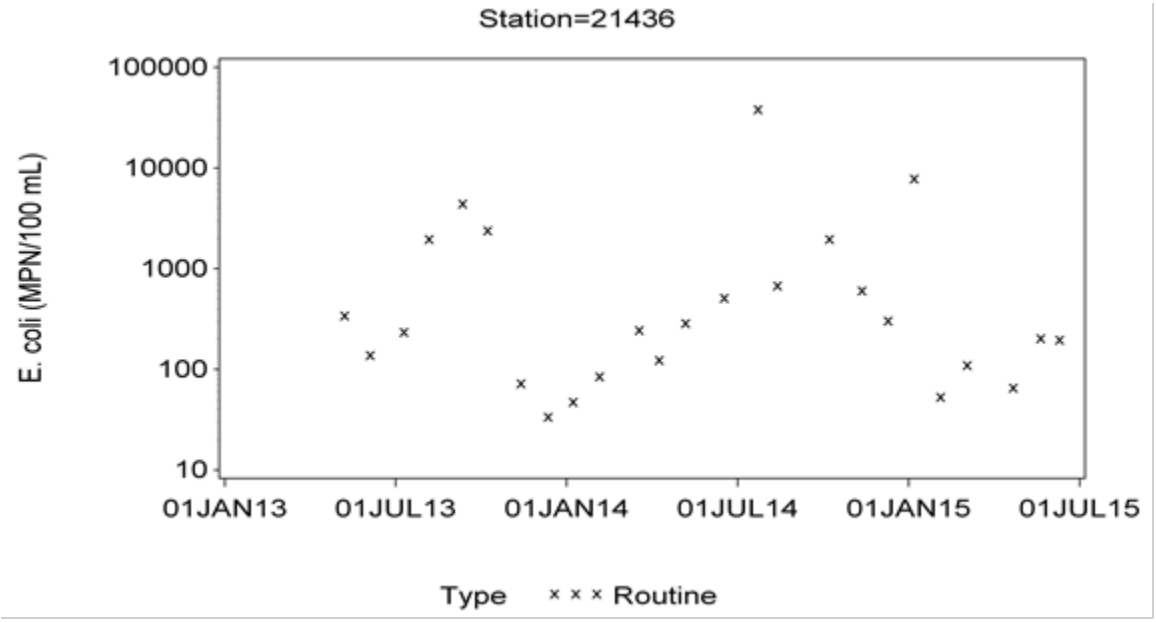

Figure 4-3 Bacteria concentrations at station 21436, Long Branch just upstream of crossing of South Nolan Creek at Twin Creek Dr in Killeen.

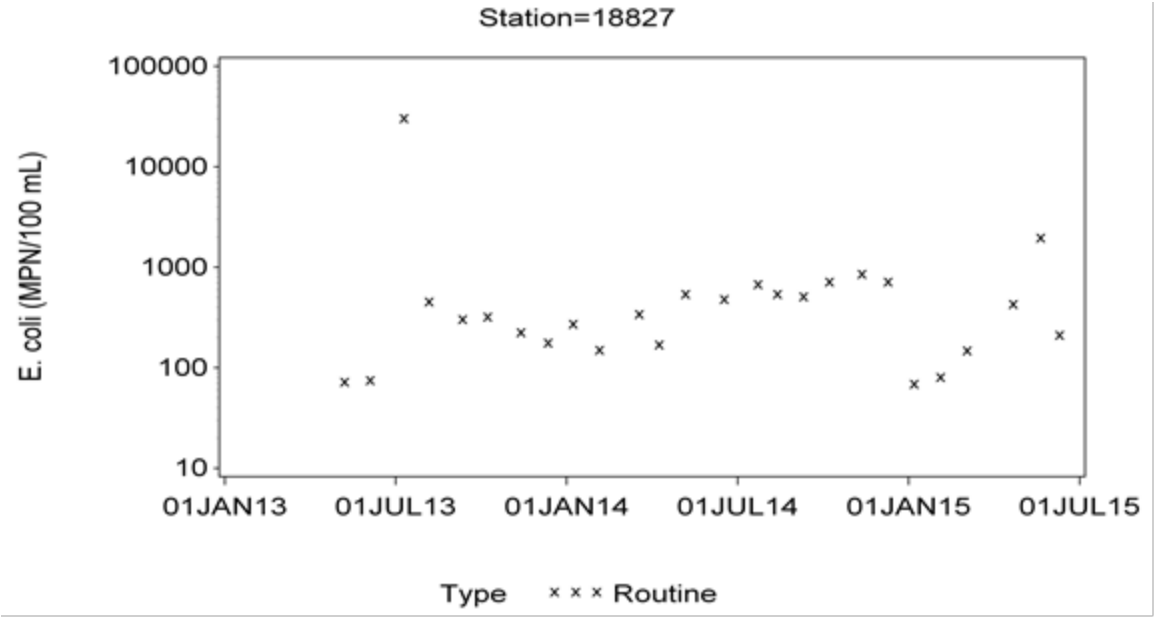

Figure 4-4 Bacteria concentrations at station 18827, South Nolan Creek at Twin Creek Dr in Killeen.

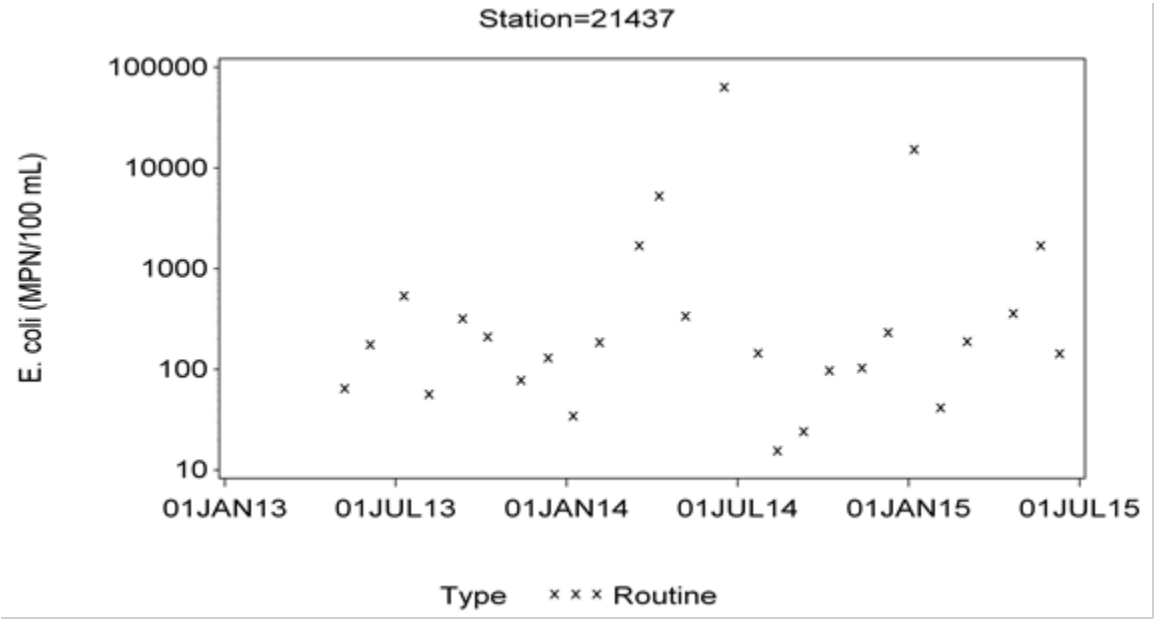

Figure 4-5 Bacteria concentrations at station 21437, Little Nolan Creek off US 190 in Killeen.

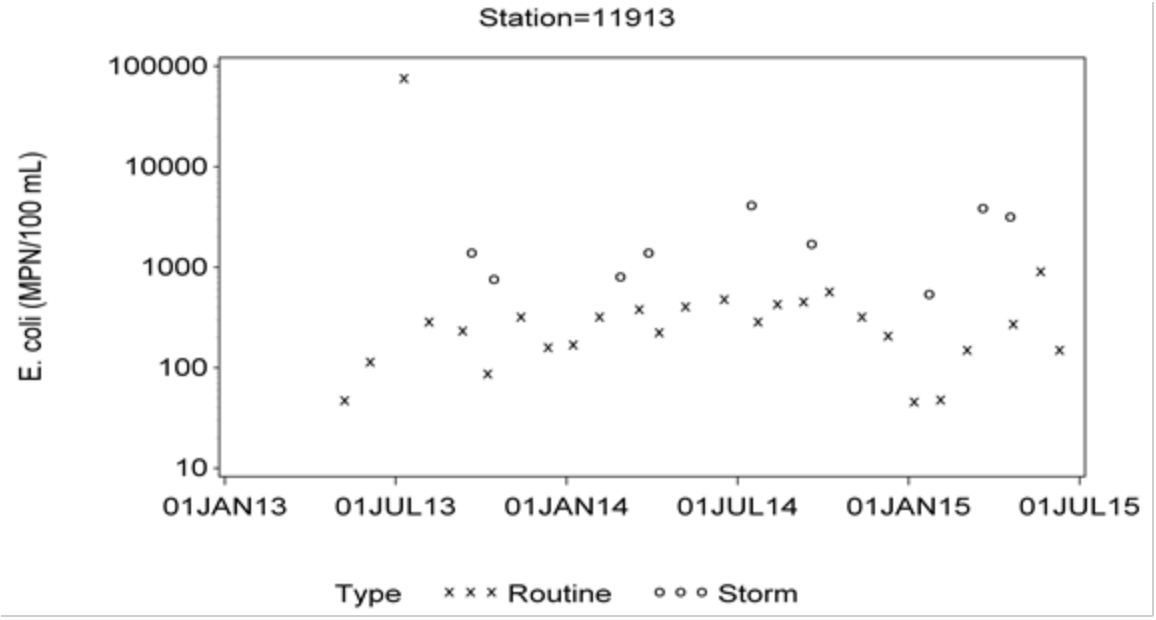

Figure 4-6 Bacteria concentrations at station 11913, South Nolan Creek at Roy Reynolds Road in Killeen.

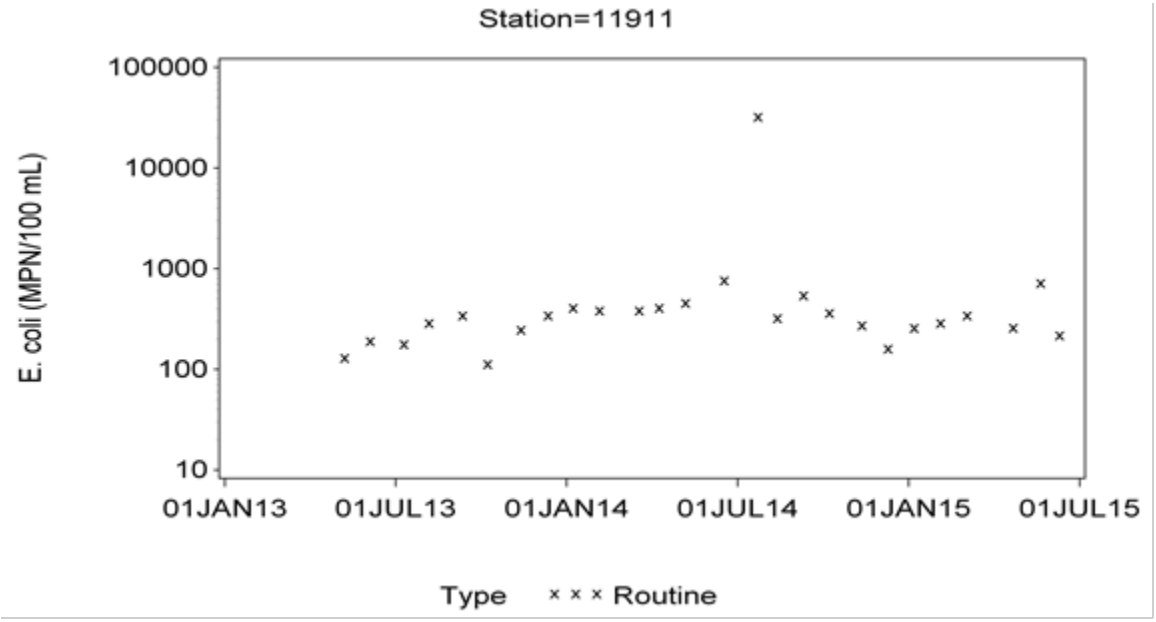

Figure 4-7 Bacteria concentrations at station 11911, South Nolan Creek at FM 3219 in Harker Heights.

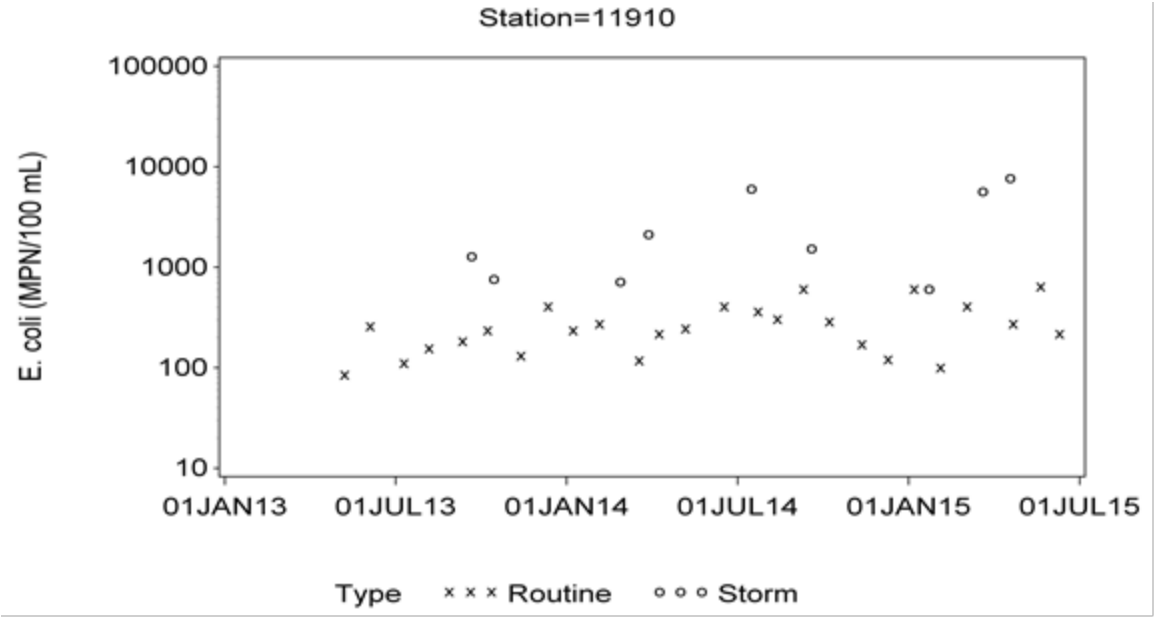

Figure 4-8 Bacteria concentrations at station 11910, South Nolan Creek at US 190 in Nolanville.

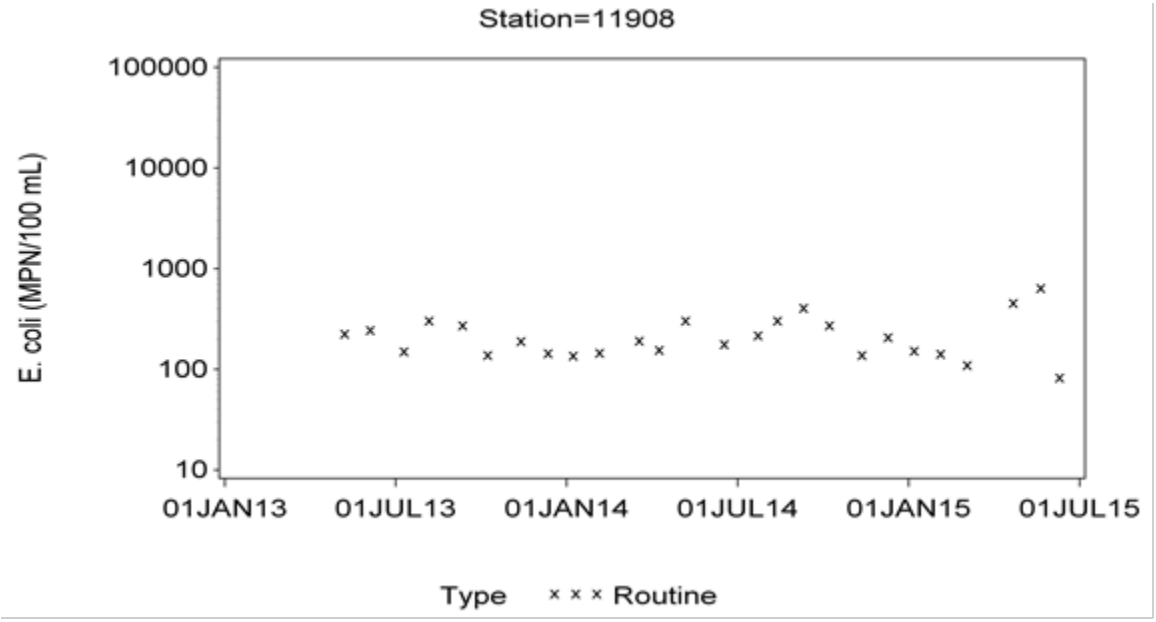

Figure 4-9 Bacteria concentrations at station 11908, South Nolan Creek at Nolanville Road (also known as Levi Crossing).

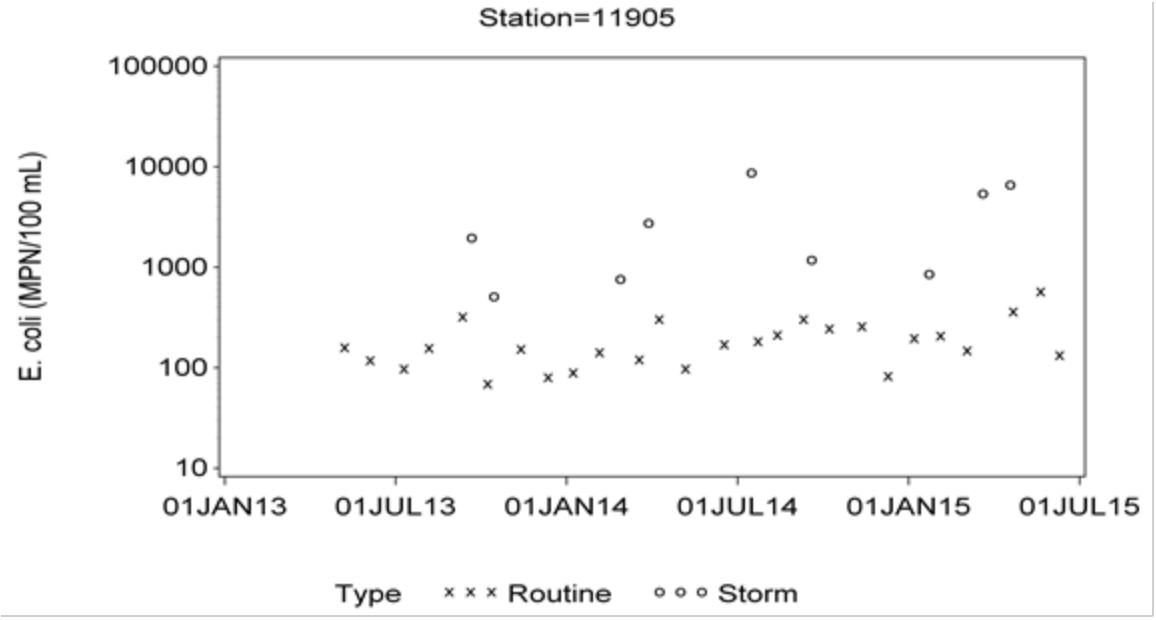

Figure 4-10 Bacteria concentrations at station 11905, South Nolan Creek at Backstrom Crossing.

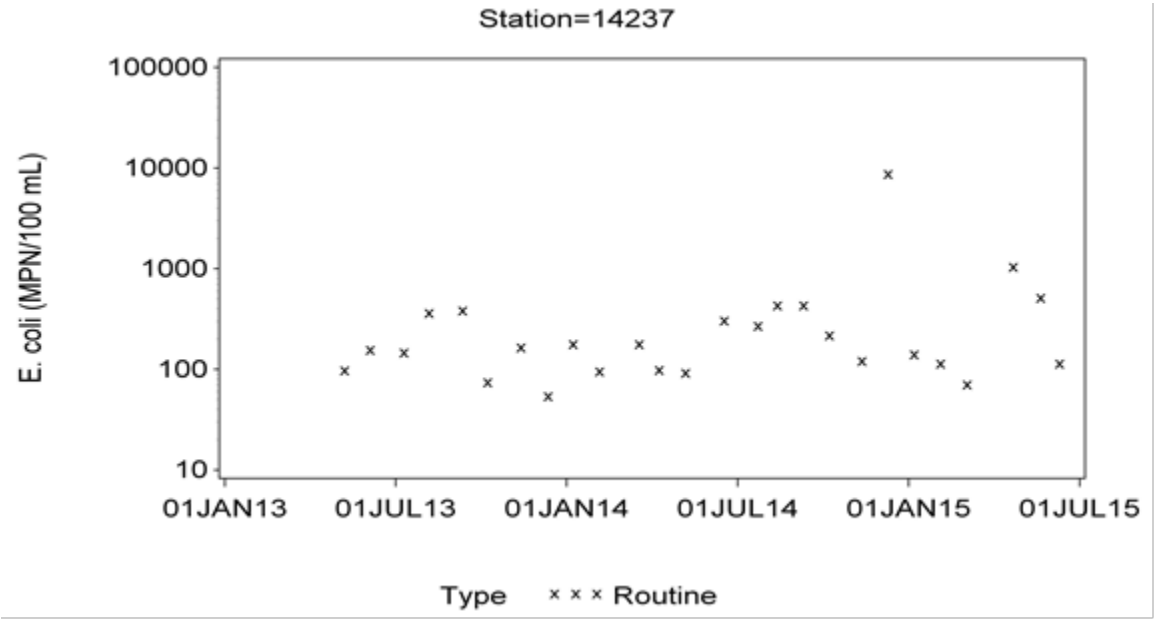

Figure 4-11 Bacteria concentrations at station 14237, Nolan Creek at State Highway 93 in Belton.

Geometric Mean Bacteria Concentrations

Geometric mean concentrations were compared with TCEQ assessment criterion for recreational use. For routine grab samples, only the two most upstream stations indicated concentrations of *E. coli* below assessment levels for primarily contact recreation (PCR, Figure 4-12). All other stations indicated geometric mean concentrations above PCR, but below the criterion of 630 MPN/100 mL set for secondary contract recreation 1 (SCR1). Activities associated with PCR are presumed to involve a high risk of ingesting water, such as swimming and wading by children, while activities associated with SCR1 commonly have more limited body contact with the water, such as fishing, canoeing or kayaking, and, thus, a lower risk of ingesting water.

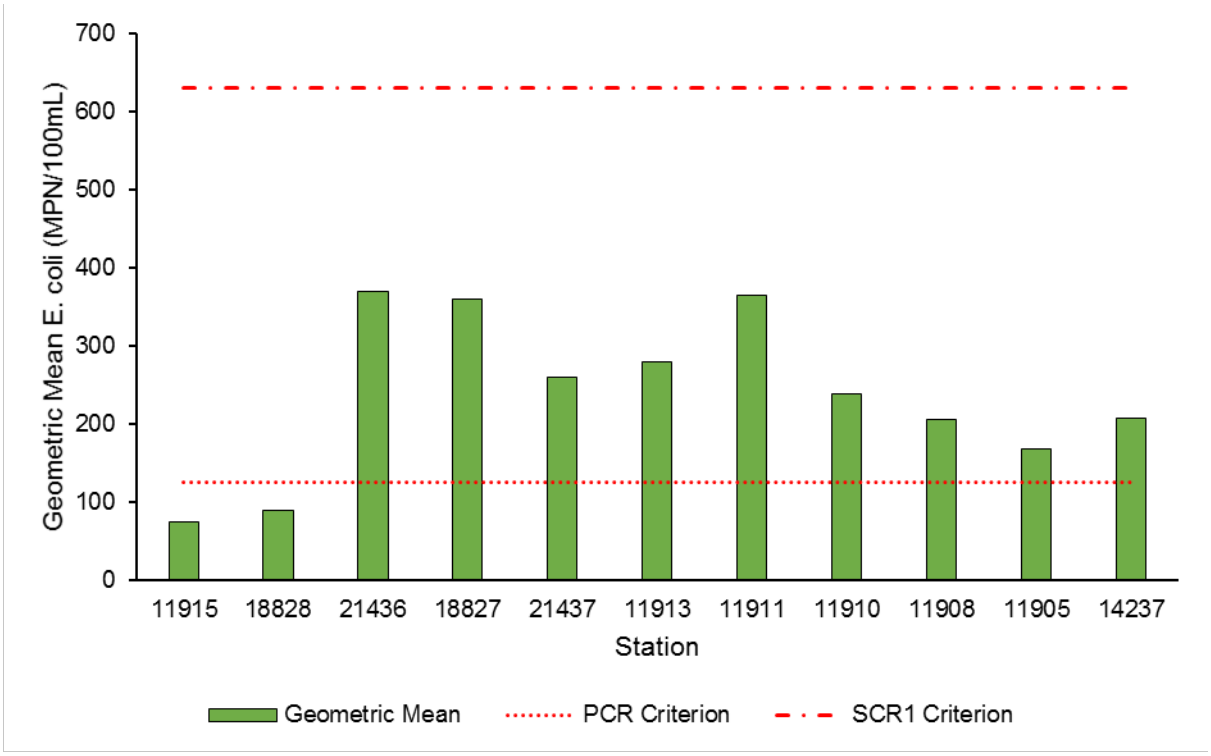

Figure 4-12 Geometric mean *E. coli* concentrations for routine grab samples compared to assessment criteria. PCR = primary contact recreation and SCR1 = secondary contact recreation 1.

While storm samples are not used for water quality assessment purposes, if compared to recreational criterion, the risk of contracting an intestinal disorder from ingestion increases significantly if the water were ingested based on the higher *E. coli* concentrations (Figure 4-13).

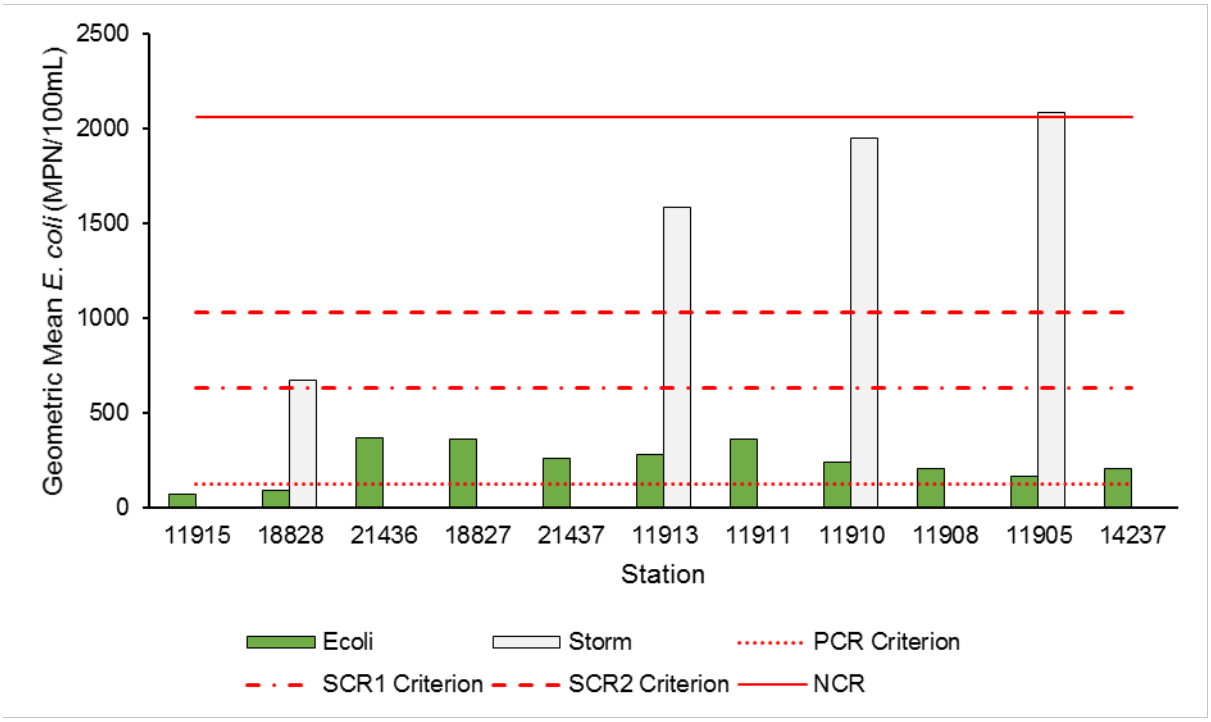

Figure 4-13 Geometric mean *E. coli* concentrations for routine grab and storm samples compared to assessment criteria. PCR = primary contact recreation, SCR1 = secondary contact recreation 1, SCR2 = secondary contract recreation 2, and NCR = noncontact recreation.

Relationships with Flow

Flow is strongly related to bacteria concentrations in this watershed as much higher concentrations occurred during storm events than base flow (Figure 4-13). When geometric mean *E. coli* concentrations were compared between stations by flow, routine grab samples showed no apparent relationship, while the concentration of *E. coli* in storm samples increased notable with increasing flows (Figure 4-14). Flow during storm events, as would be expected, was positively correlated with increasing drainage area, so during wet-weather conditions, as drainage area increased, flow increased as well as *E. coli* concentrations.

During baseflow or routine monitoring, if stations 11915 and 18828 were excluded, a weak but negative correlation was observed between flow and geometric mean *E. coli* concentrations (Figure 4-15).

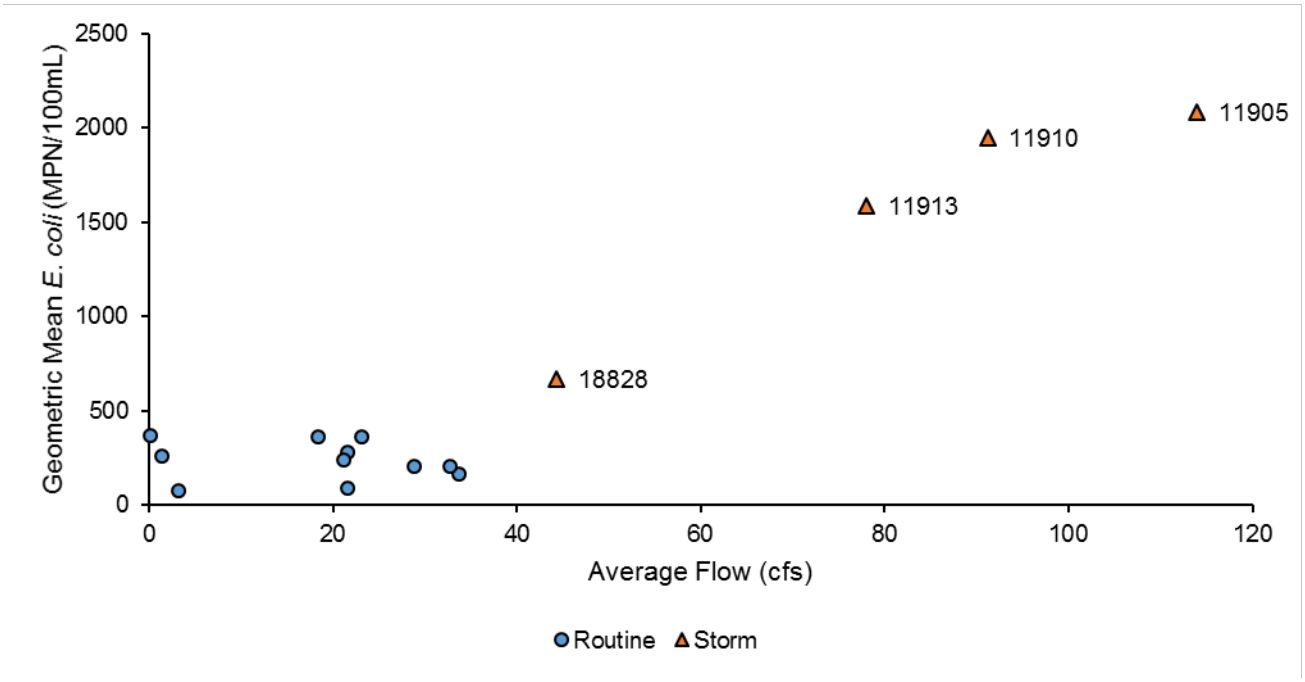

Figure 4-14 Average flow compared to geometric mean *E. coli* concentrations for routine grab and storm samples. Storm stations labeled.

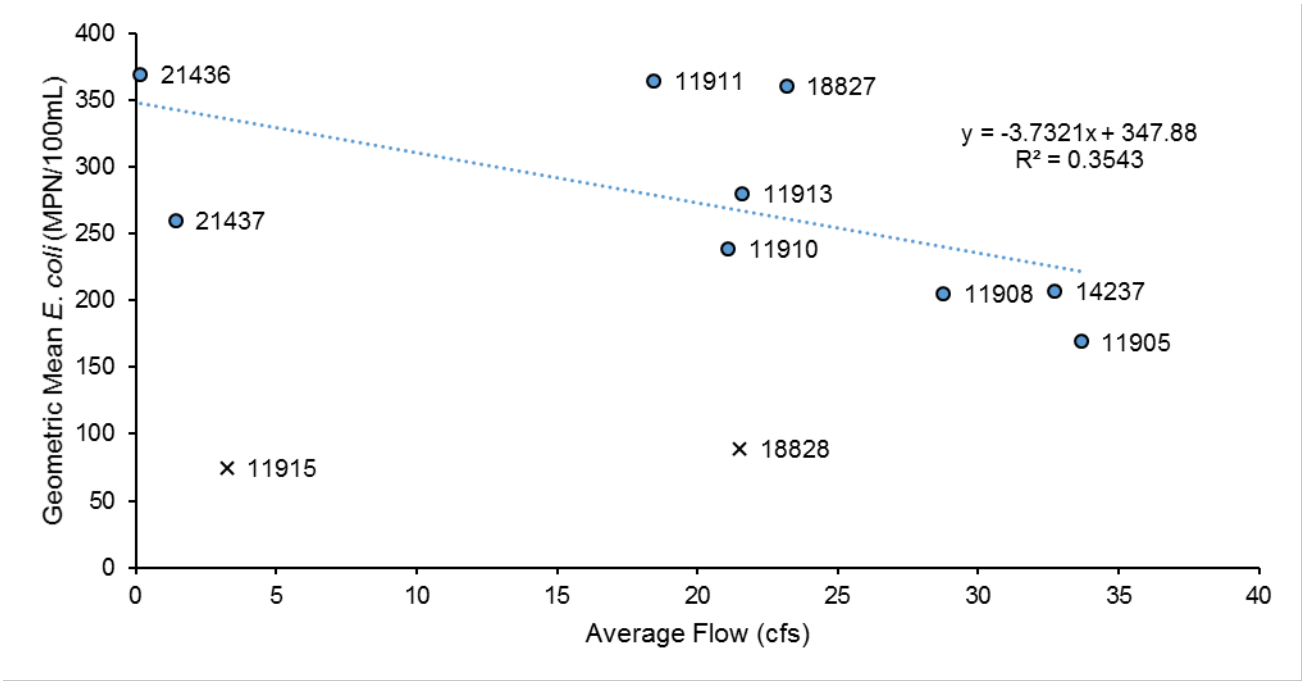

Figure 4-15 Average flow compared to geometric mean *E. coli* concentrations for routine grab samples. Stations 11915 and 18828 shown with “x’s” were not included in the regression relationship.

For the four stations with both routine and storm monitoring, a significant positive correlation occurred with increasing bacteria concentrations with increasing flows. At the two more upstream stations (18828 and 11913), this positive correlation was fairly weak accounting for only about 20 percent of the variability in the data (Figures 4-15 and 4-16). The regression relationship between flow and bacteria concentrations was stronger at the two more downstream stations (11910 and 11905), accounting for about 50 percent of the variability. Data were transformed on a natural log scale. The "x's" in Figures 4-17 and 4-18 represent outliers that were removed from the regression analysis. These outliers represented a routine grab sample collected on July 10, 2013 at station 11913 and a storm sampled collected on July 16, 2014 at station 11905.

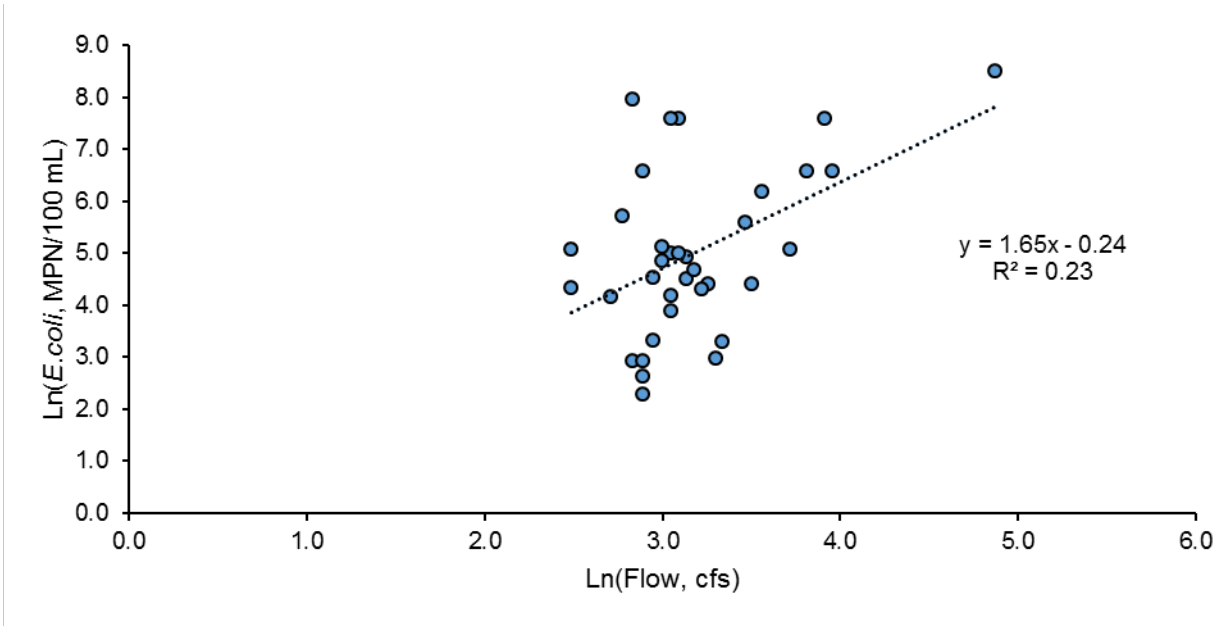

Figure 4-15 Relationship of flow with bacteria concentrations at station 18828, South Nolan Creek at 38th St in Killeen.

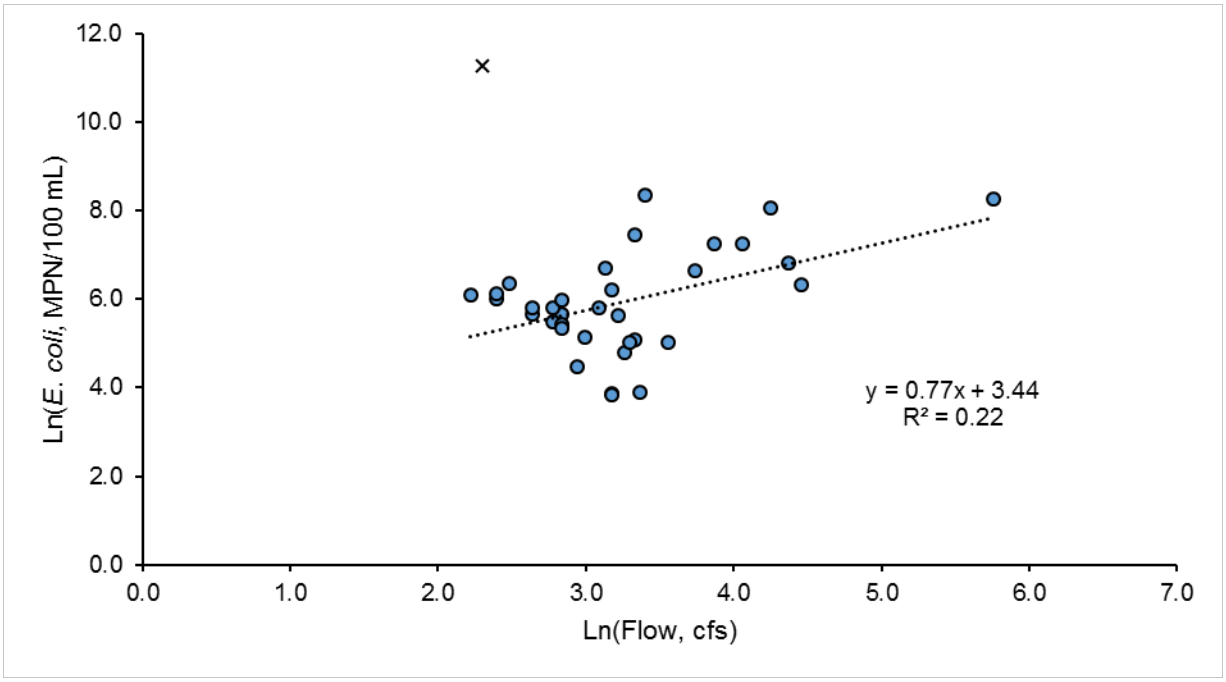

Figure 4-16 Relationship of flow with bacteria concentrations at station 11913, South Nolan Creek at Roy Reynolds Road in Killeen. A routine grab sample collected on July 10, 2013 at station 11913 shown with an "x" was not included in the regression analysis.

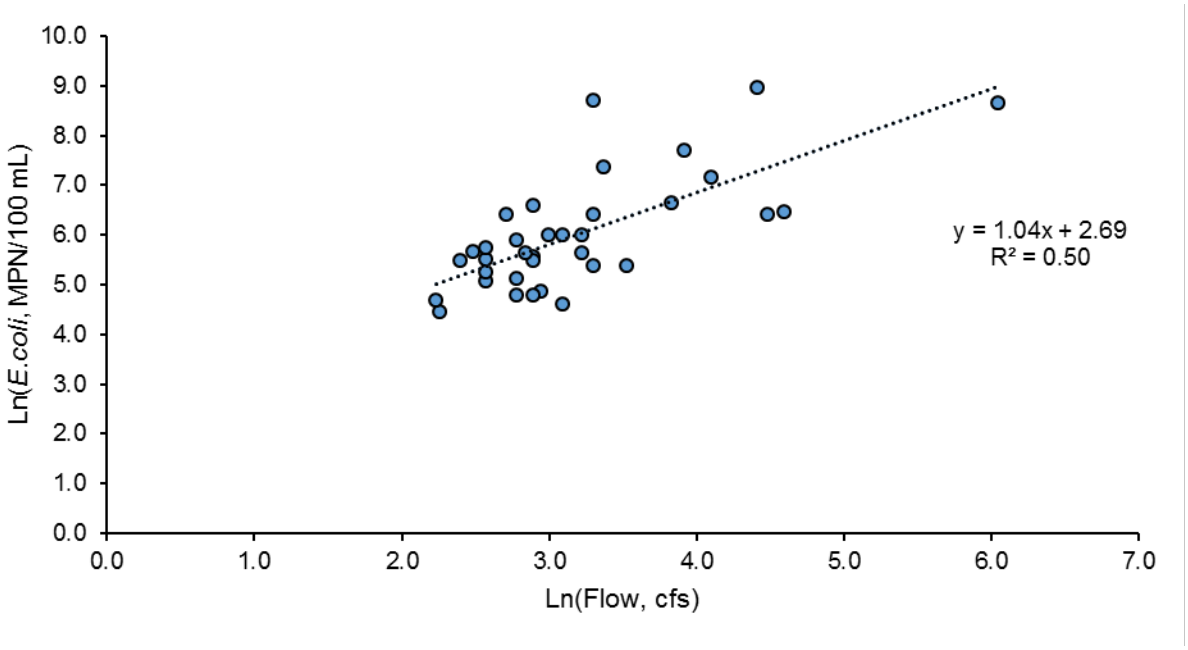

Figure 4-17 Relationship of flow with bacteria concentrations at station 11910, South Nolan Creek at US 190 in Nolanville.

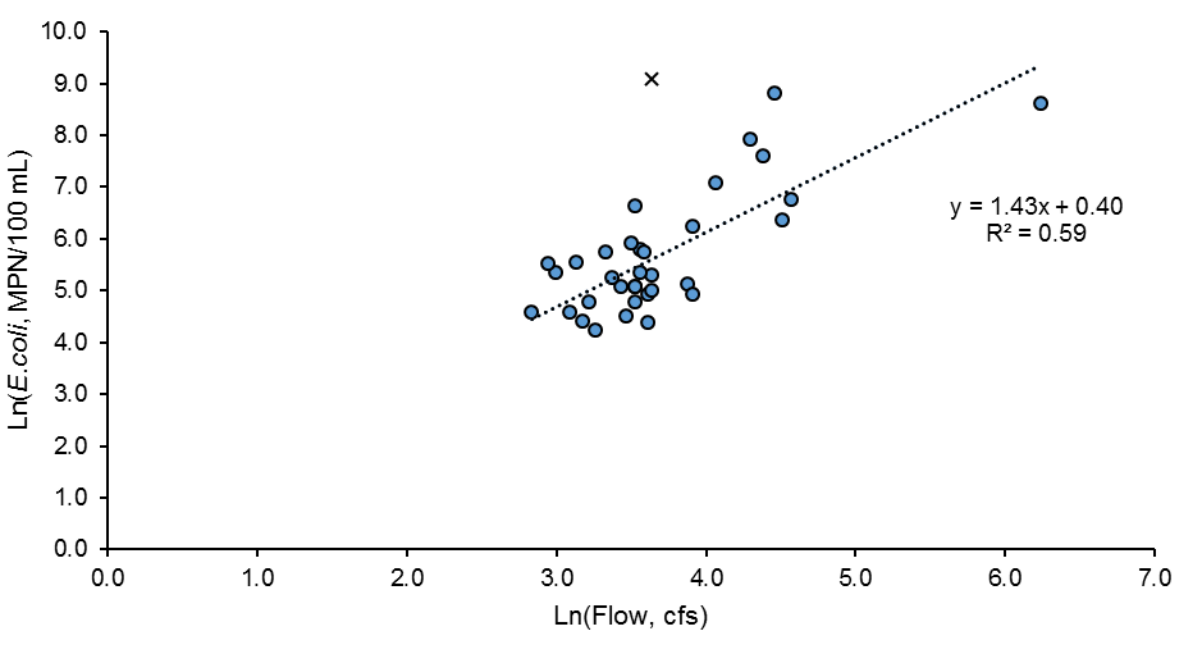

Figure 4-18 Relationship of flow with bacteria concentrations at station 11905, South Nolan Creek at Backstrom Crossing. A storm sampled collected on July 16, 2014 at station 11905 shown with an "x" was not included in the regression analysis.

Comparisons with Drainage Area Characteristics

Besides flow, potential relationships were explored between drainage area characteristics, such as land use and drainage area, and the geometric mean *E. coli* concentrations for each station. In contrast to storm samples, which indicated increasing flow with drainage area, and thus, increasing bacteria concentrations; bacteria concentrations appeared to decrease for routine grab samples with increasing drainage area (Figure 4-19). This decrease in bacteria concentrations with increasing drainage area was only apparent if the two most upstream stations, 11915 an18828, were excluded.

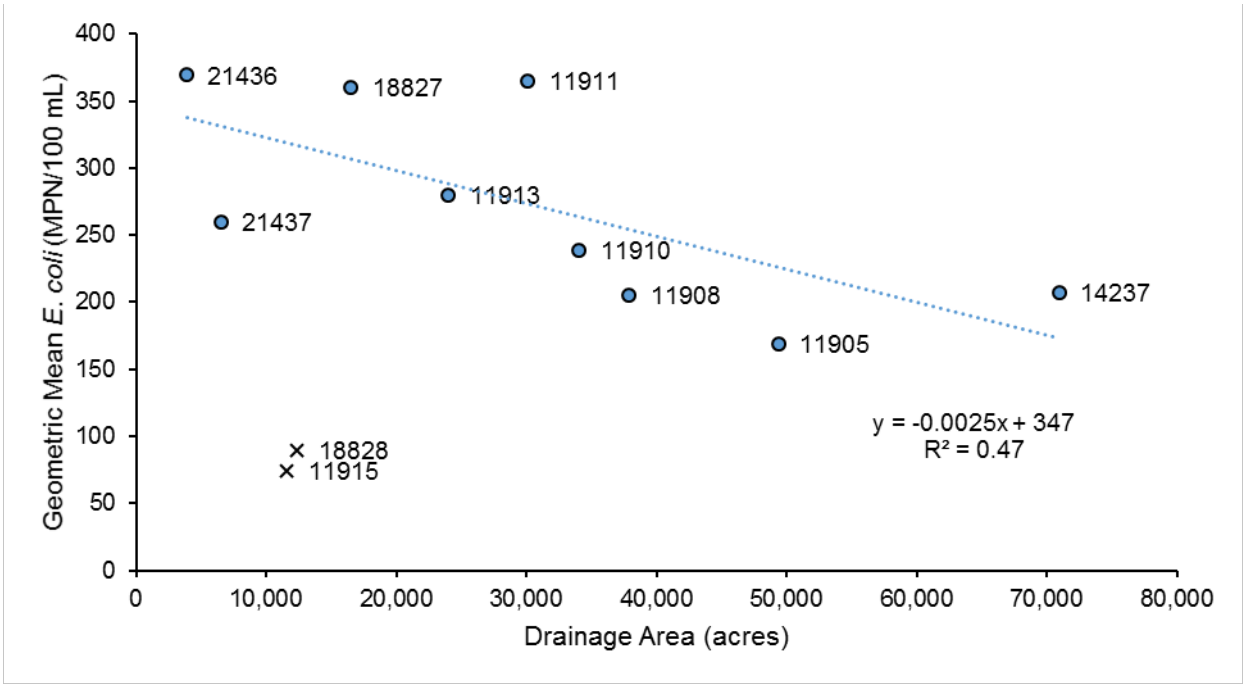

Figure 4-19 Relationship of drainage area size with geometric mean bacteria concentrations for routine grabs. Values are labeled by station. Values for stations 18828 and 11915 were not included in regression analysis and are noted with "x's".

No significant correlations were indicated when geometric mean bacteria concentrations were related to percent land use (see Tables 3-2 and 3-3 for land use/land cover information). This included correlation analyses conducted with and without stations 18828 and 11915, as these two stations appeared to respond differently than the other stations monitored with regard to their bacteria levels. While land use/land cover within the watershed is predominately urban, a significant correlation with the percent urban land area (whether by subcategory or combined) did not occur (Figure 4-20).

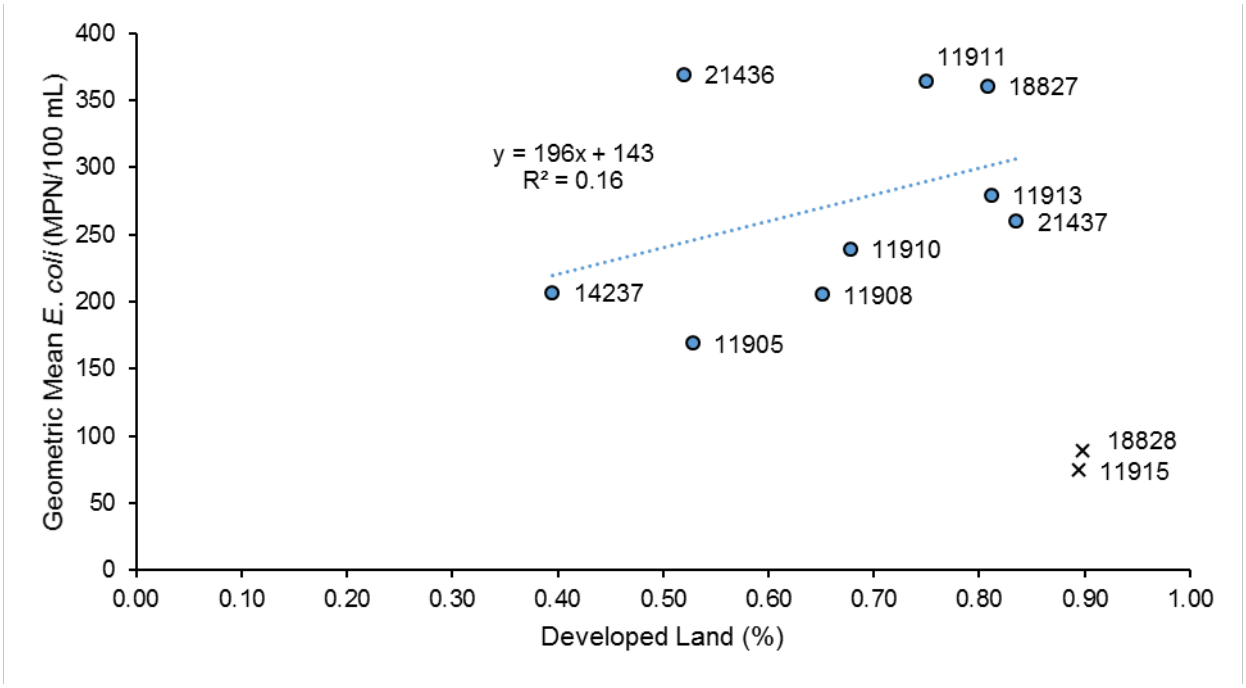

Figure 4-20 Relationship of percent developed land in the drainage area above stations with geometric mean bacteria concentrations for routine grabs. Values are labeled by station. Values for stations 18828 and 11915 were not included in regression analysis and are noted with “x’s”.

SECTION 5

Summary and Discussion

Controlling bacteria concentrations during dry-weather conditions or baseflow can be challenging, as the source in many areas may not be readily apparent. Within the Nolan Creek/South Nolan Creek watershed, the lowest bacteria concentrations for routine grabs consistently occurred at the two most upstream stations (see Figure 4-12), 11915 (just upstream of the discharge from the Bell County WCID1 Main Plant WWTF discharge) and 18828 (located at 38th St in Killeen, just below the WCID1 Main Plant WWTF discharge). Only stations 11915 and 18828 indicated geometric mean *E. coli* concentrations for routine grab samples below the criterion level of 126 MPN/100 mL for primary contact recreation (Figure 4-12). It was unclear why bacteria concentrations were so low at these two stations and higher at other monitored stations with similar land uses. One possibility is that the water near station 18828 is largely spring fed. Springs are often associated with lower bacteria concentrations as the water is filtered through the ground. More elevated concentrations of bacteria at station 18828 in stormwater runoff were indicated during wet-weather conditions reflecting higher bacteria contributions with surface runoff. The bacteria concentrations at station 18828 were slightly higher than those at station 11915 and did appear to correspond with average daily concentrations reported by the Bell County WCID1 Main Plant for *E. coli* reflecting then this contribution in conjunction with upstream contributions. The average daily concentrations from the Bell County WCID1 Main Plant were also below the 126 MPN/100 mL criterion except on a couple of occasions in August and September 2013 (see Figure 2-4).

From station 18828 at 38th St in Killeen to station 18827 at Twin Creek Dr in Killeen, a very notable increase in *E. coli* concentrations occurred for routine grab samples (Figure 4-12). This increase in concentration appeared to be related to inflows from Long Branch, station 21436. Geometric mean *E. coli* concentrations for stations 18828 and 21436 were very similar. It is not clear what is the contributing source along Long Branch, although SSOs are suspected (Figure 2-6) as well as OSSFs (Figure 2-8).

Between stations 18827 at Twin Creek Dr and station 11913 at Roy Reynolds Road, there is an apparent decrease in concentrations of *E. coli* (Figure 4-12). Little Nolan Creek, which flows into South Nolan Creek just prior to station 11913 shows very similar geometric mean concentrations of *E. coli* to station 11913. Within Little Nolan Creek, as with Long Branch, SSOs and OSSFs are suspected as the major contributing sources, although this connection cannot be clearly made. Within the Little Nolan Creek watershed, only a few SSOs have been reported (see Figure 2-6), although one did lead to a fish kill in October 2013 (Table 2-3). Little Nolan Creek does have the highest density of OSSFs within the city limits of Killeen and seepage from these OSSFs may also be contributing to some of the higher *E. coli* concentrations along Little Nolan Creek, and, thus, to South Nolan Creek (Figure 2-8).

From station 11913 at Roy Reynolds Road in Killeen to station 11911 at US 190 in Harker Heights, there is a notable increase in *E. coli* concentrations. This indicates some contributing bacteria source between these two locations. Of the available information, the high frequency of

SSO events within Harker Heights appear to be a likely source for this increase in bacteria loading (Figure 2-6).

From station 11911 to station 11905 at Backstrom Crossing near the end of AU 1218_02 (Figure 2-13), the geometric mean *E. coli* concentrations appear to generally decrease with increasing flows. There are still contributing sources between these stations, but largely dilution with increasing drainage area appears to explain largely the decreasing in *E. coli* concentrations observed.

At station 14237 in Belton, there is a slight increase seen in *E. coli* concentrations compared to station 11905 at Backstorm Crossing. At station 14237, which is located within the Yettie Polk Park, birds were noted as nesting near the bridge at this location and ducks and geese were often seen when sampling. While water quality samples were located upstream of the bridge at this location, studies have shown that bridge nesting by birds can have a localized impact of increasing bacteria concentrations (Pendergrass et al., 2015).

While sources of elevated bacteria concentrations cannot be clearly defined, it appears that during dry-weather conditions or baseflow that SSOs and OSSFs may be notable sources, particularly along Long Branch and Little Nolan Creek and the area near station 11911 within Harker Heights. It is speculated that unseen sewage seepage, whether from OSSFs or leaking sewer lines, may be somethings to consider if seen sources above ground do not appear to be the apparent cause. During wet-weather conditions, bacteria concentrations increase quite notably with rainfall runoff. Contributing sources of bacteria to the land surface, thus, need to be a focus for controlling bacteria concentrations during wet-weather conditions.

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Appendix A: Unauthorized Discharges

Table A-1 Unauthorized discharges within the Nolan Creek/South Nolan Creek. Information provided by TCEQ from open records request and by the City of Killeen.

Customer Name	Date	Volume (gallons)	Incident Source Name	Location
Bell County WCID 1	20-May-13	135	Manhole	1406 E Ave G
City of Harker Heights	21-May-13	250	Manhole	515 Clore
City of Harker Heights	27-Jun-13	200	Cleanout	1101 Bluebird
City of Harker Heights	15-Jul-13	500	Cleanout	809 Roy Reynolds
City of Harker Heights	15-Jul-13	500	Cleanout	811 Roy Reynolds
City of Harker Heights	16-Jul-13	300	Cleanout	811 Roy Reynolds
City of Harker Heights	22-Jul-13	40	Manhole	234 East Cardinal
City of Harker Heights	6-Aug-13	5	Air Relief Valve	Vintage Way Cul-de-Sac
City of Harker Heights	16-Sep-13	10	Cleanout	1103 and 1105 Bluebird
City of Harker Heights	21-Sep-13	80	Manhole	202 Pomo Trail
City of Harker Heights	12-Nov-13	10	Manhole	400 Randy
City of Harker Heights	26-Nov-13	50	Manhole	1001 Old Oak
City of Harker Heights	14-Dec-13	75	Manhole	Dale Earnhardt
City of Killeen	16-Dec-13	1230	Manhole	
City of Killeen	16-Dec-13	1125	Manhole	2400 EVMB
City of Killeen	18-Dec-13	1490	Manhole	2400 EVMB
City of Killeen	28-Dec-13	275	Manhole	Conder & VMB
City of Killeen	30-Dec-13	900	Manhole	2400 EVMB
City of Killeen	10-Jan-14	440	Manhole	2204 Corona Dr

Customer Name	Date	Volume (gallons)	Incident Source Name	Location
City of Killeen	11-Jan-14	2800	Manhole	4011 Madison Dr
City of Harker Heights	12-Jan-14	150	Manhole	226 East Cardinal
City of Harker Heights	20-Jan-14	100	Manhole	224 East Cardinal
City of Harker Heights	31-Jan-14	150	Cleanout	108 East Stacie
City of Harker Heights	31-Jan-14	150	Cleanout	108 West Stacie
City of Harker Heights	18-Feb-14	300	Cleanout	1751A Verna Lee
City of Harker Heights	20-Feb-14	150	Manhole	226 East Cardinal
City of Harker Heights	19-Mar-14	150	Cleanout	1715B Verna Lee
City of Harker Heights	19-Mar-14	5500	Air Relief Valve	Field West of Kachina Loop
City of Harker Heights	25-Mar-14	150	Cleanout	2301 Indian Trail
City of Harker Heights	4-Apr-14	50	Manhole	2132 Modoc
City of Harker Heights	8-Apr-14	30	Manhole	cul-de-sac of Vineyard towards Chaparral
Bell County WCID 1	8-May-14		Manhole	1407 Ave G, Killeen, TX
City of Harker Heights	15-May-14	150	Manhole	1220 Preswick Circle
City of Harker Heights	5-Jun-14	70	Cleanout	Pleasant View Mobile Home Park 305 S. Amy Lane
City of Harker Heights	10-Jun-14	2000	WWTP	430 Pecan
City of Harker Heights	18-Jun-14	200	Service Line	218 E Valley
City of Harker Heights	19-Jun-14	150	Manhole	706 Edwards Drive
City of Harker Heights	19-Jun-14	50	Service Line	Drainage ditch on Mountain Lion near Modoc
City of Harker Heights	24-Jun-14	50	Service Line	302 E Elbert
City of Harker Heights	24-Jun-14	50	Service Line	111 Cox Dr
City of Harker Heights	26-Jun-14	35	Manhole	101 Evergreen Dr.
City of Harker Heights	21-Jul-14	10	Sewer Main	777 Indian Trail

Customer Name	Date	Volume (gallons)	Incident Source Name	Location
City of Harker Heights	1-Aug-14	50	Manhole	226 East Cardinal
Bell County WCID 1	5-Aug-14	60	Manhole	Fort Hood, Building 21008
City of Harker Heights	7-Aug-14	100	Manhole	839 Buffalo
City of Harker Heights	20-Aug-14	50	Manhole	710 Edwards
City of Harker Heights	31-Aug-14	150	Manhole	210 Dale Earnhardt
City of Harker Heights	17-Sep-14	2	Private Cleanout	904 B Rebecca
City of Harker Heights	17-Sep-14	100	Manhole	Harley and Dove Lane Intersection
City of Harker Heights	18-Sep-14	100	Manhole	Intersection of Harley and Dove Lane
City of Harker Heights	26-Sep-14	150	Manhole	700 Indian Trail
City of Harker Heights	10-Oct-14	15	Cleanout	2001 Indian Trail Lot #66
City of Harker Heights	13-Oct-14	150	Cleanout	1601 Harley
City of Harker Heights	15-Oct-14	10	Manhole	801 Terra Cotta Ct
City of Harker Heights	15-Oct-14	500	Air Relief Valve	960 FM 2410
City of Harker Heights	17-Oct-14	1500	Manhole	4100 E Veterans Memorial Blvd
City of Harker Heights	20-Oct-14	50	Cleanout	2001 Indian Trail Lot #66
City of Harker Heights	27-Oct-14	50	Cleanout	1101 Bluebird
City of Killeen	5-Nov-14	470	Service Line	817 VMB
City of Killeen	5-Nov-14	470	Service Line	817 VMB
City of Harker Heights	12-Nov-14	300	Service Line	937 Ashwood
City of Harker Heights	12-Nov-14	300	Service Line	937 Ashwood
City of Harker Heights	14-Nov-14	1500	Service Line	521 E Veterans Memorial Blvd
City of Harker Heights	14-Nov-14	700	Service Line	430 Pecan Dr
City of Killeen	18-Nov-14	90	Service Line	3404 Victoria Circle

Customer Name	Date	Volume (gallons)	Incident Source Name	Location
City of Killeen	20-Nov-14	5	Manhole	2400 EVMB
City of Killeen	21-Nov-14	8	Manhole	3702 Frigate
City of Killeen	26-Nov-14	371	Manhole	Tripp Trail and Sherman
City of Killeen	3-Dec-14	120	Manhole	1410 Greenwood
City of Harker Heights	6-Dec-14	200	Service Line	Vicinity of McDonalds & Valero gas station
City of Harker Heights	7-Dec-14	250	Cleanout	805 Roy Reynolds Rd
City of Killeen	15-Dec-14	320	Manhole	1608 Linda
City of Killeen	15-Dec-14	2,000	Manhole	503 E Ave E
City of Killeen	20-Dec-14	450	Manhole	1202 E Ave E
City of Killeen	22-Dec-14	1,200	Manhole	Longbranch Park
City of Killeen	27-Dec-14	90	Manhole	2112 Continental
City of Killeen	28-Dec-14	60	Manhole	307 W Ave B
City of Killeen	28-Dec-14	30	Manhole	5904 Siltstone
City of Killeen	29-Dec-14	30	Manhole	501-B W Ave E
City of Killeen	6-Jan-15	100	Manhole	2nd St/W Green Ave
City of Killeen	8-Jan-15	1,280	Manhole	2209 Sunny Ln
City of Killeen	14-Jan-15	360	Manhole	1408 Greenwood
City of Killeen	27-Jan-15	535	Manhole	903 Santa Rosa
City of Killeen	28-Jan-15	1,200	Manhole	109 W Harrison Ave
City of Killeen	6-Feb-15	1,250	Manhole	100 Yards W of Chapparal Rd
City of Killeen	14-Feb-15	900	Manhole	Spotted Horse & Mesa
City of Killeen	25-Feb-15	310	Manhole	4101 Nadine
City of Killeen	9-Mar-15	750	Manhole	VMB & Conder

Customer Name	Date	Volume (gallons)	Incident Source Name	Location
City of Killeen	11-Mar-15	525	Manhole	815 Conder
City of Killeen	31-Mar-15	410	Manhole	6503 Nyla
City of Killeen	9-Apr-15	190	Manhole	Mockingbird/Mary Jane
City of Killeen	10-Apr-15	330	Manhole	1713 Stewart
City of Killeen	22-Apr-15	21,200	Manhole	2201 Cody Poe
City of Killeen	25-Apr-15	200	Manhole	5206 Daybreak
City of Killeen	14-May-15	1,950	Manhole	1303 Trimmier
City of Killeen	18-May-15	980	Manhole	501 N Roy Reynolds LS #8
City of Killeen	24-May-15	3,000	Manhole	2228 Reece Creek
City of Killeen	27-May-15	400	Manhole	LS #8
City of Killeen	27-May-15	150	Manhole	307 42nd St
City of Killeen	10-Jun-15	150	Manhole	2209 Elkins
City of Killeen	28-Jun-15	750	Manhole	4602 E VMB

Appendix B: Water Quality Data by Sampling Station

Table B-1 Field data from monthly routine grab samples. For sample type, G = routine grab and O = dry conditions. Data are listed by sampling date with stations ordered from most upstream to downstream.

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11915	8-May-13	10:06	G	471	5.9	7.7	20.5	0.8
18828	8-May-13	9:54	G	643	6.8	7.4	23.4	18
21436	8-May-13	9:37	G	505	8.4	7.8	18.8	0.01
18827	8-May-13	9:21	G	634	5.0	7.6	22.2	19
21437	8-May-13	9:06	G	505	7.1	7.9	19.8	1.0
11913	8-May-13	8:52	G	440	4.7	7.7	21.6	24
11911	8-May-13	8:34	G	618	6.4	7.8	21.8	10
11910	8-May-13	8:18	G	618	7.0	7.9	21.2	9.5
11908	8-May-13	8:02	G	653	7.3	7.9	20.9	31
11905	8-May-13	7:41	G	651	7.1	8.0	20.3	34
14237	8-May-13	7:17	G	656	7.0	8.0	19.2	24
11915	4-Jun-13	10:23	G	433	7.9	7.9	26.8	5.7
18828	4-Jun-13	10:11	G	571	7.3	7.7	26.5	23
21436	4-Jun-13	9:43	G	650	7.6	7.9	22.9	0.03
18827	4-Jun-13	9:56	G	617	6.2	7.7	26.0	18
21437	4-Jun-13	9:29	G	561	8.6	7.9	23.7	1.6
11913	4-Jun-13	9:14	G	611	5.8	7.8	25.2	26
11911	4-Jun-13	8:56	G	624	7.0	7.9	25.4	18
11910	4-Jun-13	8:42	G	606	8.1	8.1	25.3	18
11908	4-Jun-13	8:18	G	645	7.0	8.0	24.6	27
11905	4-Jun-13	7:51	G	636	6.6	8.0	25.2	34
14237	4-Jun-13	7:22	G	629	6.9	8.1	24.7	35
11915	10-Jul-13	10:22	G	537	4.0	7.2	28.6	0.1
18828	10-Jul-13	10:11	G	645	6.7	6.9	29.2	17
21436	10-Jul-13	9:55	G	591	4.9	7.6	25.6	0.01
18827	10-Jul-13	9:45	G	645	4.4	7.1	28.0	18
21437	10-Jul-13	9:31	G	463	6.1	7.7	27.8	0.2
11913	10-Jul-13	9:16	G	642	3.3	7.1	27.7	10
11911	10-Jul-13	8:56	G	605	6.1	7.6	28.1	12
11910	10-Jul-13	8:38	G	657	6.8	7.7	27.7	9.3
11908	10-Jul-13	8:20	G	662	6.2	7.7	27.2	17
11905	10-Jul-13	8:03	G	690	5.7	7.7	27.6	17
14237	10-Jul-13	7:38	G	702	6.2	7.9	26.8	17
11915	6-Aug-13	9:32	G	457	3.2	7.4	28.1	0.9
18828	6-Aug-13	9:20	G	642	6.6	7.1	29.5	21
21436	6-Aug-13	8:53	G	623	6.2	7.7	25.8	0.01
18827	6-Aug-13	8:40	G	640	4.9	7.3	28.3	21
21437	6-Aug-13	8:26	G	518	5.7	7.9	26.3	0.4
11913	6-Aug-13	8:14	G	641	5.0	7.4	27.9	17

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11911	6-Aug-13	7:56	G	631	5.5	7.7	28.1	14
11910	6-Aug-13	7:42	G	629	5.9	7.7	27.8	13
11908	6-Aug-13	7:26	G	678	6.0	7.7	27.7	28
11905	6-Aug-13	7:05	G	659	6.0	7.9	28.1	31
14237	6-Aug-13	6:42	G	671	5.8	7.9	27.5	26
11915	11-Sep-13	9:38	G	307	1.1	7.5	27.4	0.5
18828	11-Sep-13	9:28	G	630	6.1	7.1	29.8	16
21436	11-Sep-13	9:13	G	255	5.6	7.9	23.9	0.01
18827	11-Sep-13	9:02	G	625	5.1	7.5	28.2	21
21437	11-Sep-13	8:50	G	475	5.3	7.8	24.5	0.3
11913	11-Sep-13	8:34	G	621	4.9	7.6	27.0	16
11911	11-Sep-13	8:18	G	554	5.7	7.8	26.6	12
11910	11-Sep-13	8:05	G	491	6.1	7.7	26.2	13
11908	11-Sep-13	7:50	G	643	6.3	7.7	25.9	18
11905	11-Sep-13	7:33	G	648	6.2	7.8	25.9	35
14237	11-Sep-13	7:12	G	685	6.4	7.9	25.7	37
11915	8-Oct-13	9:36	G	448	5.8	7.6	19.5	0.2
18828	8-Oct-13	9:27	G	637	7.3	7.3	27.2	12
21436	8-Oct-13	9:08	G	670	9.1	7.7	15.1	0.01
18827	8-Oct-13	8:59	G	636	6.9	7.6	23.7	21
21437	8-Oct-13	8:43	G	501	8.6	7.8	15.7	0.2
11913	8-Oct-13	8:31	G	636	6.9	7.7	21.5	19
11911	8-Oct-13	8:15	G	633	7.0	7.7	20.8	11
11910	8-Oct-13	8:03	G	644	7.7	7.7	19.3	11
11908	8-Oct-13	7:47	G	679	8.1	7.8	19.1	23
11905	8-Oct-13	7:32	G	679	8.3	7.8	17.8	26
14237	8-Oct-13	7:11	G	677	8.4	7.9	17.1	19
11915	13-Nov-13	10:05	G	459	9.6	7.8	11.0	4.2
18828	13-Nov-13	9:55	G	614	8.0	7.4	21.7	26
21436	13-Nov-13	9:41	G	685	10.0	7.8	9.2	0.14
18827	13-Nov-13	9:30	G	600	8.1	7.7	18.0	27
21437	13-Nov-13	7:58	G	553	11.4	8.0	7.8	2.1
11913	13-Nov-13	9:04	G	612	7.9	7.8	16.7	22
11911	13-Nov-13	8:46	G	614	8.3	7.9	15.8	18
11910	13-Nov-13	8:33	G	605	9.1	7.9	14.4	19
11908	13-Nov-13	8:16	G	615	9.3	7.9	13.3	25
11905	13-Nov-13	7:58	G	625	9.3	7.9	13.1	34
14237	13-Nov-13	7:37	G	642	9.8	8.0	12.4	32
11915	12-Dec-13	10:20	G	540	11.6	7.8	5.4	3.1
18828	12-Dec-13	10:10	G	627	8.5	7.4	18.9	23
21436	12-Dec-13	9:53	G	595	12.0	7.8	6.3	0.08
18827	12-Dec-13	9:39	G	630	8.6	7.7	15.3	33
21437	12-Dec-13	9:28	G	623	12.8	8.0	4.1	1.1
11913	12-Dec-13	9:13	G	633	8.7	7.8	13.3	28
11911	12-Dec-13	8:54	G	634	9.3	7.8	12.6	14

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11910	12-Dec-13	8:40	G	625	9.7	7.8	11.0	22
11908	12-Dec-13	8:23	G	643	10.0	7.8	9.6	28
11905	12-Dec-13	8:05	G	644	10.7	7.9	8.0	37
14237	12-Dec-13	7:36	G	646	11.4	8.1	6.8	45
11915	8-Jan-14	10:23	G	541	12.7	7.7	5.0	2.6
18828	8-Jan-14	10:11	G	623	9.1	7.6	16.7	15
21436	8-Jan-14	9:56	G	715	12.2	7.7	6.9	0.04
18827	8-Jan-14	9:45	G	621	9.0	7.6	13.8	22
21437	8-Jan-14	9:29	G	599	12.8	7.8	5.0	1.0
11913	8-Jan-14	9:15	G	620	9.0	7.6	12.6	20
11911	8-Jan-14	8:57	G	619	9.5	7.7	11.6	16
11910	8-Jan-14	8:44	G	620	9.8	7.7	10.4	18
11908	8-Jan-14	8:26	G	640	10.5	7.8	9.0	21
11905	8-Jan-14	8:08	G	654	10.9	7.8	7.4	32
14237	8-Jan-14	7:47	G	660	11.6	7.9	6.2	39
11915	5-Feb-14	10:43	G	489	10.7	7.9	7.7	1.7
18828	5-Feb-14	10:32	G	622	8.8	7.0	17.5	21
21436	5-Feb-14	10:17	G	511	11.2	7.9	6.7	0.1
18827	5-Feb-14	10:02	G	617	9.0	7.5	14.0	21
21437	5-Feb-14	9:50	G	562	11.7	8.0	5.9	0.7
11913	5-Feb-14	9:36	G	608	8.7	7.6	12.5	16
11911	5-Feb-14	9:21	G	612	9.8	7.8	11.9	17
11910	5-Feb-14	9:08	G	608	10.2	7.9	10.8	17
11908	5-Feb-14	8:53	G	644	9.5	7.8	11.1	29
11905	5-Feb-14	8:35	G	656	9.7	8.0	10.1	37
14237	5-Feb-14	8:12	G	662	10.3	8.1	8.7	32
11915	19-Mar-14	9:28	G	460	8.0	7.7	14.6	1.6
18828	19-Mar-14	9:15	G	617	9.1	7.1	19.1	17
21436	19-Mar-14	9:02	G	661	9.6	7.9	12.7	0.03
18827	19-Mar-14	8:53	G	623	8.2	7.4	17.1	19
21437	19-Mar-14	8:40	G	520	9.5	7.9	13.5	1.0
11913	19-Mar-14	8:28	G	604	7.8	7.5	16.7	17
11911	19-Mar-14	8:13	G	623	7.5	7.6	16.8	13
11910	19-Mar-14	8:01	G	618	7.8	7.7	16.0	18
11908	19-Mar-14	7:43	G	629	8.2	7.7	15.7	19
11905	19-Mar-14	7:25	G	637	7.4	7.8	15.6	25
14237	19-Mar-14	7:02	G	631	7.6	7.9	14.8	28
11915	9-Apr-14	9:42	G	1120	7.9	7.5	16.2	1.7
18828	9-Apr-14	9:31	G	1120	8.4	7.0	20.8	21
21436	9-Apr-14	9:17	G	1120	9.7	7.6	13.2	0.1
18827	9-Apr-14	9:07	G	1120	7.8	7.3	18.5	21
21437	9-Apr-14	8:56	G	1120	8.4	7.7	13.2	0.6
11913	9-Apr-14	8:44	G	1120	7.5	7.4	17.2	17
11911	9-Apr-14	8:25	G	1120	7.9	7.6	17.1	15
11910	9-Apr-14	8:10	G	1120	8.0	7.6	16.2	27

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11908	9-Apr-14	7:50	G	1120	8.5	7.6	15.9	16
11905	9-Apr-14	7:31	G	1120	8.3	7.7	15.7	36
14237	9-Apr-14	7:10	G	1120	8.2	7.7	15.3	29
11915	7-May-14	9:23	G	491	4.5	7.7	22.3	0.7
18828	7-May-14	9:12	G	652	7.6	7.1	23.9	24
21436	7-May-14	8:56	G	683	6.4	7.9	20.7	0.01
18827	7-May-14	8:47	G	655	6.8	7.4	23.0	19
21437	7-May-14	8:35	G	397	7.6	8.0	21.8	0.3
11913	7-May-14	8:23	G	650	6.2	7.5	22.6	11
11911	7-May-14	8:07	G	650	6.8	7.8	22.9	14
11910	7-May-14	7:52	G	660	6.9	7.8	22.3	13
11908	7-May-14	7:36	G	665	7.1	7.8	22.0	18
11905	7-May-14	7:18	G	686	6.6	7.9	21.9	22
14237	7-May-14	6:58	G	696	6.6	7.9	21.5	18
11915	17-Jun-14	9:50	G	403	7.3	7.7	26.8	4.9
18828	17-Jun-14	9:39	G	583	7.3	7.4	26.7	22
21436	17-Jun-14	9:21	G	592	7.1	7.7	24.8	0.01
18827	17-Jun-14	9:10	G	586	7.2	7.6	26.4	28
21437	17-Jun-14	8:58	G	512	8.8	7.8	25.1	1.1
11913	17-Jun-14	8:41	G	596	6.8	7.6	26.0	24
11911	17-Jun-14	8:18	G	608	7.0	7.7	26.2	27
11910	17-Jun-14	7:56	G	595	7.5	7.9	26.4	20
11908	17-Jun-14	7:38	G	621	6.8	7.8	26.1	35
11905	17-Jun-14	7:15	G	599	6.6	7.9	26.7	48
14237	17-Jun-14	6:55	G	599	6.8	8.0	26.6	44
11915	23-Jul-14	10:07	G	367	7.1	7.8	29.5	1.9
18828	23-Jul-14	9:54	G	565	7.3	7.3	29.0	12
21436	23-Jul-14	9:36	G	584	6.2	7.8	26.1	0.01
18827	23-Jul-14	9:24	G	588	7.8	7.6	28.6	17
21437	23-Jul-14	9:09	G	441	6.5	7.9	27.1	0.4
11913	23-Jul-14	8:53	G	615	6.6	7.7	27.8	14
11911	23-Jul-14	8:31	G	609	6.7	7.8	28.0	14
11910	23-Jul-14	8:15	G	602	7.6	8.0	28.1	16
11908	23-Jul-14	7:53	G	633	6.7	7.8	27.7	24
11905	23-Jul-14	7:32	G	608	6.7	8.0	28.0	29
14237	23-Jul-14	7:08	G	597	7.0	8.1	27.7	30
11915	13-Aug-14	9:28	G	472	5.6	7.7	27.8	0.2
18828	13-Aug-14	9:19	G	640	8.1	7.2	28.8	19
21436	13-Aug-14	9:05	G	629	6.4	7.8	24.0	0.01
18827	13-Aug-14	8:55	G	659	6.6	7.6	26.5	10
21437	13-Aug-14	8:43	G	436	6.7	8.1	24.4	0.5
11913	13-Aug-14	8:28	G	658	6.7	7.8	26.1	9.2
11911	13-Aug-14	8:11	G	658	7.4	8.0	26.2	13
11910	13-Aug-14	7:57	G	667	8.0	8.0	25.5	13
11908	13-Aug-14	7:41	G	679	7.4	7.8	25.2	24

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11905	13-Aug-14	7:21	G	678	7.4	7.8	24.9	20
14237	13-Aug-14	7:03	G	682	7.0	7.8	24.4	16
11915	10-Sep-14	9:13	G	347	2.5	7.4	27.5	0.01
18828	10-Sep-14	9:03	G	627	6.6	7.1	29.2	18
21436	10-Sep-14	8:56	O					0
18827	10-Sep-14	8:45	G	644	4.9	7.3	28.0	22
21437	10-Sep-14	8:31	G	389	6.1	7.9	26.5	0.2
11913	10-Sep-14	8:18	G	642	5.0	7.5	27.5	11
11911	10-Sep-14	8:00	G	634	5.7	7.7	27.7	12
11910	10-Sep-14	7:48	G	643	6.4	7.7	27.1	15
11908	10-Sep-14	7:32	G	670	6.5	7.7	27.0	32
11905	10-Sep-14	7:15	G	650	6.4	7.8	26.8	28
14237	10-Sep-14	6:56	G	616	6.3	7.9	26.2	23
11915	8-Oct-14	9:22	G	449	4.1	7.7	24.6	0.1
18828	8-Oct-14	9:12	G	773	7.5	7.0	28.2	20
21436	8-Oct-14	8:57	G	746	6.3	8.0	22.5	0.01
18827	8-Oct-14	8:44	G	779	6.4	7.4	26.7	18
21437	8-Oct-14	8:34	G	522	6.5	8.0	23.7	0.2
11913	8-Oct-14	8:22	G	777	5.7	7.5	26.1	12
11911	8-Oct-14	8:06	G	772	6.5	7.9	25.7	11
11910	8-Oct-14	7:54	G	781	6.9	7.8	25.1	12
11908	8-Oct-14	7:39	G	788	7.0	7.9	24.6	29
11905	8-Oct-14	7:22	G	807	6.9	7.9	24.2	19
14237	8-Oct-14	7:03	G	814	6.8	7.9	23.8	20
11915	12-Nov-14	10:39	G	387	10.1	7.9	10.2	1.6
18828	12-Nov-14	10:27	G	602	8.0	7.2	22.1	18
21436	12-Nov-14	10:08	G	647	11.0	8.0	8.0	0.1
18827	12-Nov-14	9:59	G	590	8.3	7.5	17.6	19
21437	12-Nov-14	9:47	G	488	11.5	8.1	7.5	0.1
11913	12-Nov-14	9:34	G	601	7.7	7.7	16.1	14
11911	12-Nov-14	9:18	G	603	8.7	7.9	15.1	14
11910	12-Nov-14	9:05	G	601	9.8	8.0	13.4	16
11908	12-Nov-14	8:49	G	603	9.9	8.0	12.2	29
11905	12-Nov-14	8:31	G	614	9.8	8.0	11.9	23
14237	12-Nov-14	8:14	G	610	10.5	8.1	11.0	25
11915	10-Dec-14	10:26	G	490	9.3	7.8	12.1	1.1
18828	10-Dec-14	10:13	G	636	7.8	7.2	20.8	18
21436	10-Dec-14	9:57	G	754	10.3	7.9	10.1	0.01
18827	10-Dec-14	9:49	G	643	5.9	7.4	18.4	21
21437	10-Dec-14	9:38	G	579	10.1	7.9	10.5	0.5
11913	10-Dec-14	9:25	G	640	6.1	7.6	16.5	17
11911	10-Dec-14	9:09	G	630	8.2	7.7	15.9	13
11910	10-Dec-14	8:57	G	635	9.2	7.8	14.7	16
11908	10-Dec-14	8:42	G	649	9.1	7.8	13.3	24
11905	10-Dec-14	8:25	G	669	9.1	7.8	12.6	24

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
14237	10-Dec-14	8:06	G	661	9.8	8.0	11.6	26
11915	7-Jan-15	10:13	G	433	10.9	7.7	7.9	2.5
18828	7-Jan-15	10:03	G	589	8.5	7.2	17.2	19
21436	7-Jan-15	9:49	G	510	12.3	7.7	6.7	0.1
18827	7-Jan-15	9:40	G	589	6.8	7.3	15.0	23
21437	7-Jan-15	9:30	G	501	12.3	7.9	6.7	0.9
11913	7-Jan-15	9:17	G	562	7.2	7.5	13.7	24
11911	7-Jan-15	9:02	G	589	8.7	7.6	13.0	25
11910	7-Jan-15	8:49	G	574	9.7	7.7	11.7	27
11908	7-Jan-15	8:33	G	574	10.3	7.7	10.2	27
11905	7-Jan-15	8:18	G	561	10.7	7.8	9.4	38
14237	7-Jan-15	7:59	G	568	11.3	7.8	8.2	30
11915	4-Feb-15	10:20	G	450	12.1	7.8	8.7	4.1
18828	4-Feb-15	10:10	G	590	8.7	7.2	17.0	27
21436	4-Feb-15	9:55	G	466	12.1	7.8	9.6	0.4
18827	4-Feb-15	9:45	G	572	9.1	7.4	14.7	24
21437	4-Feb-15	9:34	G	514	12.2	7.9	8.0	1.4
11913	4-Feb-15	9:22	G	579	8.4	7.6	13.6	29
11911	4-Feb-15	9:07	G	584	9.3	7.6	13.3	20
11910	4-Feb-15	8:55	G	570	10.1	7.7	12.2	22
11908	4-Feb-15	8:38	G	577	10.1	7.7	11.2	26
11905	4-Feb-15	8:17	G	577	10.4	7.8	10.5	35
14237	4-Feb-15	7:55	G	541	10.6	7.8	9.4	30
11915	4-Mar-15	10:04	G	451	10.1	8.0	11.3	3.8
18828	4-Mar-15	9:55	G	549	9.0	7.8	16.1	28
21436	4-Mar-15	9:41	G	433	9.9	8.0	11.4	1.0
18827	4-Mar-15	9:32	G	563	8.1	7.8	16.1	30
21437	4-Mar-15	9:22	G	536	9.9	8.1	12.2	6.1
11913	4-Mar-15	9:12	G	570	7.6	7.9	15.5	27
11911	4-Mar-15	8:58	G	577	8.1	7.9	15.4	23
11910	4-Mar-15	8:47	G	556	8.5	7.9	14.7	25
11908	4-Mar-15	8:31	G	562	8.5	7.9	14.2	33
11905	4-Mar-15	8:14	G	566	8.7	8.0	13.1	38
14237	4-Mar-15	7:57	G	522	10.0	8.0	11.1	42
11915	22-Apr-15	9:28	G	423	8.2	7.9	20.9	5.6
18828	22-Apr-15	9:19	G	613	7.4	7.6	22.5	25
21436	22-Apr-15	9:04	G	465	8.0	7.9	19.3	0.4
18827	22-Apr-15	8:56	G	582	7.3	7.8	21.6	26
21437	22-Apr-15	8:46	G	488	8.7	8.0	19.4	1.7
11913	22-Apr-15	8:34	G	592	6.9	7.9	21.2	25
11911	22-Apr-15	8:20	G	609	7.1	7.9	21.3	21
11910	22-Apr-15	8:05	G	594	7.4	7.9	21.1	25
11908	22-Apr-15	7:49	G	600	7.4	7.9	20.4	31
11905	22-Apr-15	7:33	G	600	7.4	7.9	20.4	33
14237	22-Apr-15	7:05	G	529	7.7	7.8	19.9	34

Station	End Date	End Time	Sample Type	Conductivity (µmhos/cm)	DO (mg/L)	pH (std units)	Water Temp (ºC)	Flow (cfs)
11915	21-May-15	9:49	G	391	8.6	8.0	22.5	28
18828	21-May-15	9:39	G	446	8.4	7.9	22.7	50
21436	21-May-15	9:24	G	549	8.1	7.9	21.5	1.0
18827	21-May-15	9:13	G	505	8.2	7.9	22.8	54
21437	21-May-15	9:02	G	561	10.1	8.0	21.1	11
11913	21-May-15	8:49	G	494	8.2	8.0	22.8	79
11911	21-May-15	8:33	G	524	7.3	8.0	23.2	78
11910	21-May-15	8:20	G	537	7.7	8.0	23.3	99
11908	21-May-15	8:03	G	562	7.5	8.0	23.4	87
11905	21-May-15	7:47	G	541	7.1	8.0	23.6	91
14237	21-May-15	7:29	G	510	7.5	8.1	23.8	90
11915	10-Jun-15	9:07	G	494	7.3	7.5	27.1	6.5
18828	10-Jun-15	8:59	G	624	7.4	7.4	26.1	33
21436	10-Jun-15	8:46	G	655	7.5	7.6	23.6	0.1
18827	10-Jun-15	8:38	G	622	7.3	7.5	25.8	30
21437	10-Jun-15	8:29	G	602	8.4	7.6	24.6	2.6
11913	10-Jun-15	8:15	G	624	6.9	7.5	25.6	35
11911	10-Jun-15	8:01	G	649	7.1	7.6	25.8	26
11910	10-Jun-15	7:49	G	641	7.5	7.6	25.8	34
11908	10-Jun-15	7:35	G	663	7.3	7.6	25.8	43
11905	10-Jun-15	7:19	G	666	7.1	7.7	26.3	50
14237	10-Jun-15	7:00	G	613	7.5	7.7	25.9	58

Table B-2 Laboratory data for monthly routine grab samples. For sample type, G = routine grab and O = dry conditions. Data are listed by sampling date with stations ordered from most upstream to downstream.

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11915	8-May-13	10:06	0.219		0.0118		0.10	< 0.2	0.03	< 0.06	28	2	< 4
18828	8-May-13	9:54	13.4		2.55		2.36		2.77		14	2	< 4
21436	8-May-13	9:37	0.268		0.0618		0.56		0.09		350	14	
18827	8-May-13	9:21	14.4		2.43		1.57		2.63		73	2	< 4
21437	8-May-13	9:06	0.025	< 0.05	0.0025	< 0.005	0.10	< 0.2	0.06		66	2	< 4
11913	8-May-13	8:52	14.6		2.03		0.86		2.21		48	2	< 4
11911	8-May-13	8:34	11.8		1.78		0.38		1.81		130	2	< 4
11910	8-May-13	8:18	11.8		1.92		0.66		2.03		86	2	< 4
11908	8-May-13	8:02	9.88		2.04		0.58		2.14		230	5	
11905	8-May-13	7:41	9.61		1.92		0.10	< 0.2	1.79		160	2	< 4
14237	8-May-13	7:17	9.72		1.84		0.50		1.90		99	2	< 4
11915	4-Jun-13	10:23	0.245		0.0025	< 0.005	0.28		0.03	< 0.06	7	5	
18828	4-Jun-13	10:11	6.76		1.09		1.40		1.15		140	2	< 4
21436	4-Jun-13	9:43	0.168		0.0025	< 0.005	0.10	< 0.2	0.03	< 0.06	140	2	< 4
18827	4-Jun-13	9:56	9.54		1.76		2.40		1.89		76	2	< 4
21437	4-Jun-13	9:29	0.055		0.0025	< 0.005	0.10	< 0.2	0.03	< 0.06	180	14	
11913	4-Jun-13	9:14	10.0		1.59		0.60		1.68		120	2	< 4
11911	4-Jun-13	8:56	8.48		1.36		0.10	< 0.2	1.41		190	2	< 4
11910	4-Jun-13	8:42	7.81		1.35		1.07		1.41		260	2	< 4
11908	4-Jun-13	8:18	7.54		2.00		0.45		2.10		250	2	< 4
11905	4-Jun-13	7:51	7.61		1.46		0.10	< 0.2	1.53		120	2	< 4
14237	4-Jun-13	7:22	7.28		1.14		0.51		1.17		160	2	< 4
11915	10-Jul-13	10:22	0.238		0.0153		0.25		0.03	< 0.06	41	15	
18828	10-Jul-13	10:11	14.3		2.97		2.35		3.32		2900	2	< 4
21436	10-Jul-13	9:55	0.139		0.0185		0.27		0.03	< 0.06	340	7	
18827	10-Jul-13	9:45	14.0		3.19		4.28		3.65		31000	2	< 4
21437	10-Jul-13	9:31	0.052		0.0067		0.10	< 0.2	0.03	< 0.06	550	2	< 4
11913	10-Jul-13	9:16	15.4		2.93		1.22		3.20		77000	2	< 4
11911	10-Jul-13	8:56	11.7		2.65		0.57		2.77		180	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11910	10-Jul-13	8:38	12.8		2.90		0.86		3.07		110	4	
11908	10-Jul-13	8:20	10.9		2.71		0.66		2.88		150	7	
11905	10-Jul-13	8:03	10.6		2.63		0.27		2.78		99	2	< 4
14237	10-Jul-13	7:38	9.57		2.47		0.10	< 0.2	2.56		150	2	< 4
11915	6-Aug-13	9:32	0.186		0.0069		0.30		0.06		26	2	< 4
18828	6-Aug-13	9:20	13.0		2.14		1.45		2.48		150	2	< 4
21436	6-Aug-13	8:53	0.083		0.0078		0.40		0.08		2000	2	< 4
18827	6-Aug-13	8:40	13.7		2.35		2.22		2.70		460	5	
21437	6-Aug-13	8:26	0.025	< 0.05	0.0065		0.36		0.06		58	2	< 4
11913	6-Aug-13	8:14	14.9		2.27		0.63		2.53		290	5	
11911	6-Aug-13	7:56	12.2		1.98		0.41		2.10		290	2	< 4
11910	6-Aug-13	7:42	11.5		2.11		0.56		2.34		160	2	< 4
11908	6-Aug-13	7:26	12.5		2.89		0.67		3.29		310	7	
11905	6-Aug-13	7:05	11.9		1.89		0.89		2.11		160	2	< 4
14237	6-Aug-13	6:42	9.90		1.83		0.40		1.99		370	2	< 4
11915	11-Sep-13	9:38	0.025	< 0.05	0.0087		1.63		0.09		1300	2	< 4
18828	11-Sep-13	9:28	12.5		2.97		3.31		3.28		310	2	< 4
21436	11-Sep-13	9:13	0.095		0.0062		1.09		0.08		4500	2	< 4
18827	11-Sep-13	9:02	14.8		3.08		2.15		3.45		310	4	
21437	11-Sep-13	8:50	0.025	< 0.05	0.0025	< 0.005	0.86		0.03	< 0.06	330	2	< 4
11913	11-Sep-13	8:34	15.9		3.08		0.97		3.33		240	8	
11911	11-Sep-13	8:18	9.83		2.13		0.95		2.31		350	12	
11910	11-Sep-13	8:05	7.02		1.76		1.24		1.88		190	5	
11908	11-Sep-13	7:50	12.1		3.17		1.01		3.39		280	8	
11905	11-Sep-13	7:33	11.9		2.86		0.68		3.09		330	6	
14237	11-Sep-13	7:12	12.8		3.10		0.57		3.31		370	2	< 4
11915	8-Oct-13	9:36	0.113		0.0065		0.94		0.10		15	2	< 4
18828	8-Oct-13	9:27	16.9		2.73		1.96		2.99		77	2	< 4
21436	8-Oct-13	9:08	0.025	< 0.05	0.0025	< 0.005	0.37		0.03	< 0.06	2400	5	
18827	8-Oct-13	8:59	16.9		2.94		1.76		3.18		330	2	< 4
21437	8-Oct-13	8:43	0.025	< 0.05	0.0025	< 0.005	0.34		0.03	< 0.06	210	6	
11913	8-Oct-13	8:31	15.6		3.00		1.28		3.27		88	7	

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11911	8-Oct-13	8:15	12.8		2.61		1.40		2.84		110	2	< 4
11910	8-Oct-13	8:03	13.5		2.85		1.35		3.05		240	2	< 4
11908	8-Oct-13	7:47	14.8		3.28		1.34		3.54		140	2	< 4
11905	8-Oct-13	7:32	14.2		3.02		0.65		3.13		70	2	< 4
14237	8-Oct-13	7:11	14.0		2.78		1.10		2.90		75	2	< 4
11915	13-Nov-13	10:05	0.353		0.0071		1.03		0.10		190	35	
18828	13-Nov-13	9:55	13.6		1.86		3.01		1.85		82	4	
21436	13-Nov-13	9:41	0.403		0.0025	< 0.005	0.95		0.10		73	2	< 4
18827	13-Nov-13	9:30	13.0		1.66		0.55		1.76		230	2	< 4
21437	13-Nov-13	7:58	0.064		0.0060		0.25		0.03	< 0.06	79	9	
11913	13-Nov-13	9:04	14.0		1.82		0.55		1.90		330	2	< 4
11911	13-Nov-13	8:46	12.2		1.77		0.71		1.81		250	2	< 4
11910	13-Nov-13	8:33	9.99		1.59		1.27		1.61		130	2	< 4
11908	13-Nov-13	8:16	11.0		1.70		1.39		1.63		190	2	< 4
11905	13-Nov-13	7:58	11.4		1.72		0.69		1.73		160	2	< 4
14237	13-Nov-13	7:37	11.0		1.57		0.63		1.52		170	2	< 4
11915	12-Dec-13	10:20	0.642		0.0113		0.63		0.12		25	2	< 4
18828	12-Dec-13	10:10	15.5		1.89		1.56		1.97		91	2	< 4
21436	12-Dec-13	9:53	0.507		0.0025	< 0.005	0.47		0.11		34	2	< 4
18827	12-Dec-13	9:39	14.8		1.82		0.85		1.86		180	2	< 4
21437	12-Dec-13	9:28	0.313		0.0025	< 0.005	0.10	< 0.2	0.03	< 0.06	130	2	< 4
11913	12-Dec-13	9:13	14.9		1.92		0.61		2.00		160	2	< 4
11911	12-Dec-13	8:54	14.2		1.96		0.76		2.08		350	2	< 4
11910	12-Dec-13	8:40	12.6		1.71		0.74		1.73		410	2	< 4
11908	12-Dec-13	8:23	13.5		1.72		1.00		1.77		150	2	< 4
11905	12-Dec-13	8:05	10.9		1.53		0.77		1.53		81	2	< 4
14237	12-Dec-13	7:36	8.69		1.36		0.38		1.40		55	2	< 4
11915	8-Jan-14	10:23	0.543		0.0056		0.36		0.14		11	2	< 4
18828	8-Jan-14	10:11	13.0		1.84		0.83		2.00		61	2	< 4
21436	8-Jan-14	9:56	0.424		0.0025	< 0.005	0.21		0.09		48	2	< 4
18827	8-Jan-14	9:45	12.3		1.74		0.76		1.85		280	2	< 4
21437	8-Jan-14	9:29	0.107		0.0025	< 0.005	0.23		0.18		35	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11913	8-Jan-14	9:15	13.0		1.85		0.48		1.99		170	2	< 4
11911	8-Jan-14	8:57	12.2		1.78		0.56		1.89		410	5	
11910	8-Jan-14	8:44	10.8		1.61		0.68		1.74		240	2	< 4
11908	8-Jan-14	8:26	11.5		1.67		1.22		1.78		140	2	< 4
11905	8-Jan-14	8:08	9.53		1.48		1.38		1.58		91	2	< 4
14237	8-Jan-14	7:47	9.09		1.41		0.63		1.46		180	2	< 4
11915	5-Feb-14	10:43	0.580		0.0068		0.45		0.15		310	2	< 4
18828	5-Feb-14	10:32	14.9		2.19		1.41		2.40		66	2	< 4
21436	5-Feb-14	10:17	0.599		0.0053		0.77		0.17		86	7	
18827	5-Feb-14	10:02	14.9		2.11		1.32		2.28		150	4	
21437	5-Feb-14	9:50	0.025	< 0.05	0.0025	< 0.005	0.10	< 0.2	0.11		190	2	< 4
11913	5-Feb-14	9:36	14.1		2.03		0.45		2.12		330	2	< 4
11911	5-Feb-14	9:21	11.6		1.85		0.94		1.97		390	2	< 4
11910	5-Feb-14	9:08	10.1		1.57		0.37		1.59		280	2	< 4
11908	5-Feb-14	8:53	10.7		1.66		0.90		1.70		150	2	< 4
11905	5-Feb-14	8:35	10.7		1.84		0.76		1.88		140	2	< 4
14237	5-Feb-14	8:12	10.8		1.84		0.67		1.89		96	2	< 4
11915	19-Mar-14	9:28	0.464		0.0348		0.10	< 0.2	0.10		21	2	< 4
18828	19-Mar-14	9:15	14.8		2.00		0.81		2.33		19	2	< 4
21436	19-Mar-14	9:02	0.364		0.0388		0.10	< 0.2	0.11		250	2	< 4
18827	19-Mar-14	8:53	14.7		2.08		0.77		2.37		350	5	
21437	19-Mar-14	8:40	0.387		0.0428		0.10	< 0.2	0.10		1700	2	< 4
11913	19-Mar-14	8:28	14.6		2.10		0.72		2.32		390	2	< 4
11911	19-Mar-14	8:13	12.0		1.71		0.59		1.87		390	2	< 4
11910	19-Mar-14	8:01	12.4		1.79		0.61		1.93		120	2	< 4
11908	19-Mar-14	7:43	12.3		2.13		1.20		2.38		190	12	
11905	19-Mar-14	7:25	9.79		1.86		0.95		2.02		120	2	< 4
14237	19-Mar-14	7:02	8.36		1.55		0.45		1.68		180	2	< 4
11915	9-Apr-14	9:42	0.110		0.0025	< 0.005	0.10	< 0.2	0.03	< 0.06	120	2	< 4
18828	9-Apr-14	9:31	12.8		1.76		1.01		1.98		49	2	< 4
21436	9-Apr-14	9:17	0.025	< 0.05	0.0025	< 0.005	0.10	< 0.2	0.07		130	2	< 4
18827	9-Apr-14	9:07	12.8		1.69		1.51		1.88		170	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
21437	9-Apr-14	8:56	0.025	< 0.05	0.0050		0.53		0.03	< 0.06	5400	2	< 4
11913	9-Apr-14	8:44	12.8		1.90		0.98		2.11		230	2	< 4
11911	9-Apr-14	8:25	9.27		1.87		1.79		2.10		410	2	< 4
11910	9-Apr-14	8:10	8.16		1.74		1.85		1.88		220	2	< 4
11908	9-Apr-14	7:50	9.26		1.98		1.11		2.12		160	2	< 4
11905	9-Apr-14	7:31	8.16		1.42		0.77		1.61		310	4	
14237	9-Apr-14	7:10	5.61		1.15		0.41		1.29		99	2	< 4
11915	7-May-14	9:23	0.103		0.0075		0.51		0.06		17	2	< 4
18828	7-May-14	9:12	18.6		2.80		0.67		3.82		110	2	< 4
21436	7-May-14	8:56	0.025	< 0.05	0.0066		0.10	< 0.2	0.18		290	2	< 4
18827	7-May-14	8:47	18.8		2.85		1.37		3.27		560	2	< 4
21437	7-May-14	8:35	0.025	< 0.05	0.0090		0.67		0.08		340	2	< 4
11913	7-May-14	8:23	17.8		2.90		0.81		3.51		410	6	
11911	7-May-14	8:07	13.7		2.51		0.70		2.93		460	4	
11910	7-May-14	7:52	14.7		2.44		1.47		2.81		250	6	
11908	7-May-14	7:36	12.3		2.46		2.41		2.34		310	7	
11905	7-May-14	7:18	12.7		2.42		1.99		2.31		99	6	
14237	7-May-14	6:58	12.1		2.35		1.53		2.37		93	2	< 4
11915	17-Jun-14	9:50	0.223		0.0112		0.33		0.03	< 0.06	260	2	< 4
18828	17-Jun-14	9:39	9.57		1.59		0.67		1.69		150	2	< 4
21436	17-Jun-14	9:21	0.113		0.0173		0.28		0.03	< 0.06	520	2	< 4
18827	17-Jun-14	9:10	10.2		1.59		0.77		1.71		490	19	
21437	17-Jun-14	8:58	0.083		0.0246		0.84		0.07		65000	2	< 4
11913	17-Jun-14	8:41	10.8		1.69		0.42		1.82		490	2	< 4
11911	17-Jun-14	8:18	10.1		1.66		0.32		1.80		770	2	< 4
11910	17-Jun-14	7:56	8.52		1.42		0.42		1.52		410	2	< 4
11908	17-Jun-14	7:38	7.98		1.52		0.82		1.57		180	2	< 4
11905	17-Jun-14	7:15	8.27		1.12		0.10	< 0.2	1.20		170	2	< 4
14237	17-Jun-14	6:55	7.02		1.05		0.36		1.07		310	2	< 4
11915	23-Jul-14	10:07	0.103		0.0025	< 0.005	0.42		0.09		140	2	< 4
18828	23-Jul-14	9:54	12.8		2.05		1.31		2.34		160	2	< 4
21436	23-Jul-14	9:36	0.126		0.0179		0.33		0.06		39000	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
18827	23-Jul-14	9:24	14.5		2.22		1.03		2.69		690	2	< 4
21437	23-Jul-14	9:09	0.025	< 0.05	0.0143		0.10	< 0.2	0.03	< 0.06	150	11	
11913	23-Jul-14	8:53	17.2		2.72		0.29		3.01		290	2	< 4
11911	23-Jul-14	8:31	12.7		2.75		0.39		3.00		33000	4	
11910	23-Jul-14	8:15	13.6		2.41		0.22		2.68		370	4	
11908	23-Jul-14	7:53	12.7		3.09		0.61		3.38		220	6	
11905	23-Jul-14	7:32	10.4		1.88		0.27		2.07		190	5	
14237	23-Jul-14	7:08	10.6		1.52		0.27		1.63		270	9	
11915	13-Aug-14	9:28	0.360		0.0427		0.10	< 0.2	0.03	< 0.06	36	2	< 4
18828	13-Aug-14	9:19	19.5		3.15		0.58		3.42		93	2	< 4
21436	13-Aug-14	9:05	16.8		2.79		0.90	c-0075	2.84		690	2	< 4
18827	13-Aug-14	8:55	20.3		3.26		0.69		3.62		550	2	< 4
21437	13-Aug-14	8:43	0.423		0.0632		0.10	< 0.2	0.08		16	2	< 4
11913	13-Aug-14	8:28	20.1		3.44		1.26		3.64		440	5	
11911	13-Aug-14	8:11	17.1		3.00		0.37		3.26		330	2	< 4
11910	13-Aug-14	7:57	18.2		3.15		0.23		3.41		310	5	
11908	13-Aug-14	7:41	16.1		3.57		0.38		3.84		310	10	
11905	13-Aug-14	7:21	14.9		3.23		0.10	< 0.2	3.46		210	4	
14237	13-Aug-14	7:03	15.3		3.06		0.20		3.25		440	5	
11915	10-Sep-14	9:13	0.310		0.0510		0.10	< 0.2	0.09		5500	2	< 4
18828	10-Sep-14	9:03	19.6		3.25		1.59		3.52		730	2	< 4
21436	10-Sep-14	8:56											
18827	10-Sep-14	8:45	21.8		3.48		1.74		3.78		520	9	
21437	10-Sep-14	8:31	0.174		0.0251		0.92		0.11		25	2	< 4
11913	10-Sep-14	8:18	22.0		3.59		2.05		3.88		460	6	
11911	10-Sep-14	8:00	18.6		3.14		1.52		3.32		550	2	< 4
11910	10-Sep-14	7:48	18.9		3.16		1.87		3.38		610	9	
11908	10-Sep-14	7:32	17.1		3.88		1.61		4.15		410	8	
11905	10-Sep-14	7:15	17.5		2.99		1.81		3.23		310	5	
14237	10-Sep-14	6:56	14.6		2.79		0.10	< 0.2	2.98		440	12	
11915	8-Oct-14	9:22	0.213		0.0332		0.44		0.12		64	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
18828	8-Oct-14	9:12	19.1		3.28		2.08		3.56		170	2	< 4
21436	8-Oct-14	8:57	0.191		0.0350		0.45		0.13		2000	2	< 4
18827	8-Oct-14	8:44	20.9		3.36		2.11		3.61		730	2	< 4
21437	8-Oct-14	8:34	0.208		0.0261		0.10	< 0.2	0.07		99	2	< 4
11913	8-Oct-14	8:22	20.6		3.48		0.35		3.78		580	8	
11911	8-Oct-14	8:06	18.6		3.17		0.26		3.35		370	4	
11910	8-Oct-14	7:54	18.7		3.21		0.35		3.34		290	4	
11908	8-Oct-14	7:39	18.0		3.36		0.81		3.46		280	7	
11905	8-Oct-14	7:22	16.5		3.23		0.57		3.40		250	2	< 4
14237	8-Oct-14	7:03	15.8		2.84		0.10	< 0.2	2.97		220	2	< 4
11915	12-Nov-14	10:39	0.515		0.0462		0.78		0.12		31	2	< 4
18828	12-Nov-14	10:27	15.8		2.30		1.95		2.51		19	2	< 4
21436	12-Nov-14	10:08	0.322		0.0239		0.10	< 0.2	0.03	< 0.06	610	2	< 4
18827	12-Nov-14	9:59	16.9		2.39		1.13		2.57		870	2	< 4
21437	12-Nov-14	9:47	0.352		0.0298		0.24		0.09		110	2	< 4
11913	12-Nov-14	9:34	18.1		2.61		0.60		2.70		330	2	< 4
11911	12-Nov-14	9:18	15.1		2.48		0.68		2.53		280	2	< 4
11910	12-Nov-14	9:05	15.8		2.44		1.18		2.52		170	2	< 4
11908	12-Nov-14	8:49	14.6		2.52		0.56		2.56		140	2	< 4
11905	12-Nov-14	8:31	12.8		2.45		0.35		2.55		260	2	< 4
14237	12-Nov-14	8:14	12.0		2.10		0.30		2.22		120	2	< 4
11915	10-Dec-14	10:26	0.090		0.0025	< 0.005	0.57		0.03	< 0.06	30	2	< 4
18828	10-Dec-14	10:13	14.2		2.40		0.73		2.72		10	2	< 4
21436	10-Dec-14	9:57	0.362		0.0434		0.10	< 0.2	0.03	< 0.06	310	2	< 4
18827	10-Dec-14	9:49	14.5		2.35		0.81		2.70		730	2	< 4
21437	10-Dec-14	9:38	0.259		0.0320		0.10	< 0.2	0.03	< 0.06	240	2	< 4
11913	10-Dec-14	9:25	14.5		2.39		0.21		2.70		210	2	< 4
11911	10-Dec-14	9:09	12.7		2.28		0.10	< 0.2	2.52		160	2	< 4
11910	10-Dec-14	8:57	13.0		2.25		0.10	< 0.2	2.44		120	2	< 4
11908	10-Dec-14	8:42	12.9		2.35		0.10	< 0.2	2.56		210	2	< 4
11905	10-Dec-14	8:25	11.3		2.30		0.10	< 0.2	2.47		83	2	< 4
14237	10-Dec-14	8:06	11.7		2.00		0.10	< 0.2	2.21		8800	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11915	7-Jan-15	10:13	0.585		0.0326		1.43		0.16		11	2	< 4
18828	7-Jan-15	10:03	9.41		1.38		3.75		2.44		28	2	< 4
21436	7-Jan-15	9:49	0.296		0.0166		0.62		0.15		7900	2	< 4
18827	7-Jan-15	9:40	12.8		2.01		4.78		2.26		70	2	< 4
21437	7-Jan-15	9:30	0.271		0.0306		0.10	< 0.2	0.08		16000	2	< 4
11913	7-Jan-15	9:17	13.6		2.20		1.23		2.46		47	11	
11911	7-Jan-15	9:02	12.8		2.00		0.61		2.23		260	5	
11910	7-Jan-15	8:49	12.1		1.80		0.10	< 0.2	2.00		610	22	
11908	7-Jan-15	8:33	10.1		1.72		1.00		1.78		150	2	< 4
11905	7-Jan-15	8:18	6.70		1.46		0.62		1.44		200	2	< 4
14237	7-Jan-15	7:59	9.28		1.61		0.71		1.63		140	2	< 4
11915	4-Feb-15	10:20	0.496		0.0165		0.96		0.07		47	2	< 4
18828	4-Feb-15	10:10	15.3		1.86		2.55		2.01		20	2	< 4
21436	4-Feb-15	9:55	0.372		0.0267		0.94		0.03	< 0.06	54	2	< 4
18827	4-Feb-15	9:45	14.4		1.72		2.50		1.80		82	2	< 4
21437	4-Feb-15	9:34	0.090		0.0114		0.79		0.07		42	2	< 4
11913	4-Feb-15	9:22	14.7		1.82		2.42		1.92		49	2	< 4
11911	4-Feb-15	9:07	14.4		1.83		1.17		1.91		290	2	< 4
11910	4-Feb-15	8:55	12.3		1.58		1.32		1.61		100	2	< 4
11908	4-Feb-15	8:38	12.0		1.53		0.85		1.61		140	2	< 4
11905	4-Feb-15	8:17	8.70		1.54		0.45		1.55		210	2	< 4
14237	4-Feb-15	7:55	7.75		1.26		0.38		1.26		120	2	< 4
11915	4-Mar-15	10:04	0.487		0.0025	< 0.005	0.51		0.03	< 0.06	59	2	< 4
18828	4-Mar-15	9:55	10.1		1.33		1.38		1.48		27	2	< 4
21436	4-Mar-15	9:41	0.148		0.0025	< 0.005	0.78		0.09		110	2	< 4
18827	4-Mar-15	9:32	11.2		1.45		1.09		1.60		150	2	< 4
21437	4-Mar-15	9:22	0.286		0.0025	< 0.005	0.32		0.08		190	2	< 4
11913	4-Mar-15	9:12	11.4		1.49		0.96		1.64		150	2	< 4
11911	4-Mar-15	8:58	11.6		1.64		1.71		1.78		250	2	< 4
11910	4-Mar-15	8:47	10.2		1.38		1.57		1.44		410	2	< 4
11908	4-Mar-15	8:31	9.9		1.43		1.31		1.56		110	2	< 4
11905	4-Mar-15	8:14	8.57		1.58		0.58		1.77		150	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
14237	4-Mar-15	7:57	6.60		1.17		0.37		1.21		71	2	< 4
11915	22-Apr-15	9:28	0.261		0.0125		0.10	< 0.2	0.03	< 0.06	230	2	< 4
18828	22-Apr-15	9:19	14.2		2.01		1.20		2.22		75	2	< 4
21436	22-Apr-15	9:04	0.278		0.0147		0.96		0.07		66	2	< 4
18827	22-Apr-15	8:56	11.8		1.67		0.38		1.83		440	2	< 4
21437	22-Apr-15	8:46	0.272		0.0231		0.10	< 0.2	0.03	< 0.06	670	2	< 4
11913	22-Apr-15	8:34	12.7		1.81		0.10	< 0.2	1.97		280	2	< 4
11911	22-Apr-15	8:20	13.0		1.90		0.10	< 0.2	2.06		260	2	< 4
11910	22-Apr-15	8:05	11.5		1.68		0.10	< 0.2	1.85		280	2	< 4
11908	22-Apr-15	7:49	10.0		1.48		0.25		1.55		460	5	
11905	22-Apr-15	7:33	8.00		1.63		0.10	< 0.2	1.78		370	2	< 4
14237	22-Apr-15	7:05	5.58		1.02		0.10	< 0.2	1.11		1100	7	
11915	21-May-15	9:49	0.805		0.0136		0.10	< 0.2	0.08		1100	5	
18828	21-May-15	9:39	2.62		0.272		0.10	< 0.2	0.32		2000	5	
21436	21-May-15	9:24	0.472		0.0118		0.10	< 0.2	0.03	< 0.06	210	2	< 4
18827	21-May-15	9:13	6.02		0.619		0.20		0.71		2000	5	
21437	21-May-15	9:02	0.986		0.0054		0.10	< 0.2	0.03	< 0.06	1700	2	< 4
11913	21-May-15	8:49	4.36		0.427		0.29		0.47		920	7	
11911	21-May-15	8:33	5.54		0.607		0.10	< 0.2	0.67		730	7	
11910	21-May-15	8:20	6.06		0.67		0.10	< 0.2	0.74		650	7	
11908	21-May-15	8:03	6.33		0.871		0.24		0.94		650	7	
11905	21-May-15	7:47	4.93		0.718		0.30		0.74		580	10	
14237	21-May-15	7:29	3.97		0.574		0.10	< 0.2	0.58		520	7	
11915	10-Jun-15	9:07	0.721		0.0025	< 0.005	0.54		0.03	< 0.06	520	2	< 4
18828	10-Jun-15	8:59	10.8		1.56		1.13		1.70		82	2	< 4
21436	10-Jun-15	8:46	0.510		0.0025	< 0.005	0.40		0.03	< 0.06	200	2	< 4
18827	10-Jun-15	8:38	10.0		1.47		1.20		1.57		210	2	< 4
21437	10-Jun-15	8:29	0.987		0.0025	< 0.005	1.17		0.07		150	2	< 4
11913	10-Jun-15	8:15	10.5		1.40		1.33		1.50		150	2	< 4
11911	10-Jun-15	8:01	11.1		1.59		1.60		1.68		220	2	< 4
11910	10-Jun-15	7:49	9.83		1.42		1.77		1.51		220	2	< 4
11908	10-Jun-15	7:35	7.86		1.37		1.41		1.45		84	2	< 4

Site	End Date	End Time	NO_2-N +NO_3-N (mg/L)	NO_2-N +NO_3-N <	PO_4-P (mg/L)	PO_4-P <	TKN (mg/L)	TKN <	TP (mg/L)	TP <	*E. coli* (MPN/100mL)	TSS (mg/L)	TSS <
11905	10-Jun-15	7:19	7.98		1.12		0.94		1.16		140	2	< 4
14237	10-Jun-15	7:00	5.88		0.815		0.79		0.87		120	2	< 4

Table B-3 Laboratory data for nutrients and TSS for storm samples. For sample type, F = flow-weighted automated sample and SG = storm grab. Data are listed by sampling date with stations ordered from most upstream to downstream.

Station	Start Date	Start Time	End Date	End Time	Sample Type	NO_2-N +NO_3-N (mg/L)	PO_4-P (mg/L)	TKN (mg/L)	TKN <	TP (mg/L)	TSS (mg/L)	TSS <
18828	19-Sep-13	17:00	21-Sep-13	9:20	F	0.902	0.114	0.83		0.20	103	
11910	19-Sep-13	20:00	21-Sep-13	8:50	F	2.07	0.409	0.87		0.52	117	
11905	20-Sep-13	10:00	21-Sep-13	8:20	F	1.14	0.347	1.60		0.69	465	
18828	13-Oct-13	0:30	15-Oct-13	8:55	F	0.603	0.0604	0.83		0.26	326	
11913	13-Oct-13	0:00	15-Oct-13	9:40	F	4.15	0.562	0.82		0.67	97	
11910	13-Oct-13	1:55	15-Oct-13	10:05	F	3.59	0.554	0.97		0.81	407	
11905			15-Oct-13	12:26	SG	5.04	0.995	0.10	< 0.2	1.08	2	< 4
18828	25-Feb-14	22:35	26-Feb-14	13:00	F	2.48	0.28	1.33		0.50	241	
11913	25-Feb-14	23:20	26-Feb-14	13:45	F	3.69	0.415	1.65		0.58	146	
11910	26-Feb-14	0:25	26-Feb-14	14:50	F	4.03	0.611	3.84		1.28	502	
11905	26-Feb-14	3:15	26-Feb-14	13:40	F	7.51	0.954	3.94		2.22	492	
18828	28-Mar-14	13:45	29-Mar-14	13:50	F	1.24	0.10	2.97		0.60	675	
11913	28-Mar-14	14:10	29-Mar-14	10:35	F	4.17	0.48	1.48		0.72	126	
11910	28-Mar-14	14:35	29-Mar-14	11:00	F	2.25	0.262	3.24		0.94	1200	
11905	28-Mar-14	17:00	29-Mar-14	11:40	F	2.61	0.464	5.20		1.69	1530	
18828	15-Jul-14	14:50	16-Jul-14	11:15	F	1.77	0.237	1.04		0.53	392	
11913	15-Jul-14	15:30	16-Jul-14	11:55	F	6.54	0.975	0.98		1.19	140	
11910	15-Jul-14	16:25	16-Jul-14	12:50	F	5.88	1.09	1.46		1.62	485	
11905	15-Jul-14	18:50	16-Jul-14	15:15	F	5.49	1.07	1.21		1.65	435	
18828	18-Sep-14	18:10	19-Sep-14	8:35	F	2.09	0.287	0.22		0.38	26	
11913	18-Sep-14	18:20	19-Sep-14	4:45	F	5.43	0.79	0.59		0.86	36	
11910	18-Sep-14	19:35	19-Sep-14	10:00	F	6.80	1.05	0.80		1.19	57	
11905			19-Sep-14	10:00	SG	5.83	1.20	0.30		1.28	13	
18828	22-Jan-15	5:15	23-Jan-15	12:15	F	0.389	0.0284	1.25		0.12	72	
11913	21-Jan-15	20:55	23-Jan-15	11:20	F	4.57	0.562	1.27		0.67	45	
11910	22-Jan-15	6:55	23-Jan-15	9:20	F	1.89	0.242	2.15		0.54	180	
11905	22-Jan-15	9:20	23-Jan-15	10:35	F	3.33	0.523	3.51		0.88	252	
18828	20-Mar-15	14:00	21-Mar-15	4:25	F	0.665	0.058	0.68		0.21	114	

Station	Start Date	Start Time	End Date	End Time	Sample Type	NO_2-N +NO_3-N (mg/L)	PO_4-P (mg/L)	TKN (mg/L)	TKN <	TP (mg/L)	TSS (mg/L)	TSS <
11913	20-Mar-15	14:40	21-Mar-15	5:05	F	3.51	0.53	0.61		0.65	38	
11910	20-Mar-15	15:30	21-Mar-15	5:55	F	2.58	0.458	1.41		0.73	199	
11905	20-Mar-15	18:20	21-Mar-15	8:45	F	3.55	0.74	1.66		1.04	160	
18828	18-Apr-15	18:30	19-Apr-15	8:55	F	0.304	0.0145	0.69		0.21	265	
11913	18-Apr-15	19:10	19-Apr-15	9:35	F	3.75	0.432	0.52		0.56	115	
11910	18-Apr-15	19:30	19-Apr-15	10:30	F	2.34	0.358	1.85		0.77	501	
11905	18-Apr-15	21:55	19-Apr-15	10:00	F	2.26	0.364	2.63		1.08	754	

Table B-4 Laboratory data for *E. coli* and measurements of flow associated with storm events. For sample type, GSG = storm grab for bacteria. Data are listed by sampling date with stations ordered from most upstream to downstream.

Station	End Date	End Time	Sample Type	Flow (cfs)	Flow	*E. coli* (MPN/100mL)
18828	21-Sep-13	10:25	GSG	35		490
11913	21-Sep-13	9:45	GSG	48		1400
11910	21-Sep-13	9:08	GSG	60		1300
11905	21-Sep-13	8:33	GSG	80		2000
18828	15-Oct-13	11:20	GSG	41		160
11913	15-Oct-13	10:50	GSG	42		770
11910	15-Oct-13	10:28	GSG	46		770
11905	15-Oct-13	12:25	GSG	50		520
18828	27-Feb-14	12:33	GSG	20		130
11913	27-Feb-14	12:02	GSG	23		820
11910	27-Feb-14	11:35	GSG	18		730
11905	27-Feb-14	11:00	GSG	34		770
18828	29-Mar-14	14:25	GSG	32		270
11913	29-Mar-14	13:45	GSG	58		1400
11910	29-Mar-14	13:10	GSG	50		2200
11905	29-Mar-14	12:16	GSG	73		2800
18828	16-Jul-14	13:55	GSG	22		2000
11913	16-Jul-14	13:30	GSG	30		4200
11910	16-Jul-14	12:55	GSG	27		6100
11905	16-Jul-14	12:30	GSG	38		8800
18828	19-Sep-14	11:40	GSG	21		2000
11913	19-Sep-14	11:10	GSG	28		1700
11910	19-Sep-14	10:40	GSG	29		1600
11905	19-Sep-14	10:00	GSG	58		1200
18828	23-Jan-15	12:25	GSG	52		730
11913	23-Jan-15	11:55	GSG	86		550
11910	23-Jan-15	11:25	GSG	88		610
11905	23-Jan-15	10:50	GSG	96		870
18828	21-Mar-15	11:15	GSG	130		5000
11913	21-Mar-15	10:45	GSG	317		3900
11910	21-Mar-15	10:25	GSG	420	Estimate	5700
11905	21-Mar-15	11:15	GSG	510	Estimate	5500
18828	19-Apr-15	11:35	GSG	45		730
11913	19-Apr-15	11:05	GSG	70		3200
11910	19-Apr-15	10:40	GSG	82		7800
11905	19-Apr-15	10:00	GSG	86		6700

Appendix C: Comparison of Nutrients to Screening Levels for Assessment

As nitrates (NO_2-N+NO_3-N), orthophosphate-phosphorus (PO_4-P), and total-P are considered nutrients of concern within the watershed, a summary of results are presented in this section. Basic statistics of monitoring data by type (routine or storm) are shown for NO_2-N+NO_3-N in Tables C-1, PO_4-P in Table C-2, and total-P in Table C-3. Comparisons of median values in relation to assessment screening levels are shown for NO_2-N+NO_3-N in Figure C-1, PO_4-P in Figure C-2, and total-P in Figure C-3. Nutrient concentrations were very low at stations 11915, 21436, and 21437, which are not influenced by WWTF discharges. Concentrations of nutrients at all other stations are influenced by WWTF discharges. All four stations monitored for storm events showed notable decreases in nutrients concentrations during storm events compared to routine samples indicating a dilution effect occurring with stormwater runoff.

Table C-1 Basic statistics for NO_2-N+NO_3-N for routine grab and storm samples collected between May 2013 and June 2015. Stations ordered from most upstream to downstream.

Station	Type	Mean (mg/L)	Median (mg/L)	Std Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Obs.
11915	Routine	0.35	0.29	0.22	< 0.05	0.81	26
18828	Routine	13.6	13.9	3.88	2.62	19.6	26
21436	Routine	0.93	0.28	3.31	< 0.06	16.8	25
18827	Routine	14.2	14.4	3.60	6.02	21.8	26
21437	Routine	0.21	0.10	0.26	< 0.05	0.99	26
11913	Routine	14.5	14.6	3.65	4.36	22.0	26
11911	Routine	12.5	12.2	2.86	5.54	18.6	26
11910	Routine	12.0	12.0	3.36	6.06	18.9	26
11908	Routine	11.7	11.8	2.89	6.33	18.0	26
11905	Routine	10.6	10.5	2.96	4.93	17.5	26
14237	Routine	9.81	9.65	3.16	3.97	15.8	26
18828	Storm	1.16	0.90	0.79	< 0.05	2.48	9
11913	Storm	4.48	4.16	1.03	3.51	6.54	8
11910	Storm	3.49	2.58	1.78	1.89	6.80	9
11905	Storm	4.08	3.55	2.02	1.14	7.51	9

Table C-2 Basic statistics for PO_4-P for routine grab and storm samples collected between May 2013 and June 2015. Stations ordered from most upstream to downstream.

Station	Type	Mean (mg/L)	Median (mg/L)	Std Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Obs.
11915	Routine	0.02	0.01	0.01	< 0.005	0.05	26
18828	Routine	2.12	2.03	0.72	0.27	3.28	26
21436	Routine	0.13	0.01	0.56	< 0.005	2.79	25
18827	Routine	2.20	2.10	0.71	0.62	3.48	26
21437	Routine	0.01	0.01	0.02	< 0.005	0.06	26
11913	Routine	2.25	2.07	0.74	0.43	3.59	26
11911	Routine	2.08	1.93	0.58	0.61	3.17	26
11910	Routine	2.00	1.78	0.65	0.67	3.21	26
11908	Routine	2.23	2.02	0.79	0.87	3.88	26
11905	Routine	1.97	1.85	0.69	0.72	3.23	26
14237	Routine	1.78	1.59	0.72	0.57	3.10	26
18828	Storm	0.13	0.10	0.11	0.01	0.29	9
11913	Storm	0.59	0.55	0.19	0.42	0.98	8
11910	Storm	0.56	0.46	0.31	0.24	1.09	9
11905	Storm	0.74	0.74	0.33	0.35	1.20	9

Table C-3 Basic statistics for total-P for routine grab and storm samples collected between May 2013 and June 2015. Stations ordered from most upstream to downstream.

Station	Type	Mean (mg/L)	Median (mg/L)	Std Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Obs.
11915	Routine	0.08	0.07	0.04	< 0.06	0.16	26
18828	Routine	2.40	2.37	0.82	0.32	3.82	26
21436	Routine	0.19	0.08	0.56	< 0.06	2.84	25
18827	Routine	2.43	2.33	0.80	0.71	3.78	26
21437	Routine	0.06	0.07	0.04	< 0.06	0.18	26
11913	Routine	2.45	2.27	0.82	0.47	3.88	26
11911	Routine	2.23	2.09	0.64	0.67	3.35	26
11910	Routine	2.14	1.91	0.71	0.74	3.41	26
11908	Routine	2.36	2.13	0.87	0.94	4.15	26
11905	Routine	2.07	1.84	0.74	0.74	3.46	26
14237	Routine	1.86	1.66	0.77	0.58	3.31	26
18828	Storm	0.33	0.26	0.17	0.12	0.60	9
11913	Storm	0.74	0.67	0.21	0.56	1.19	8
11910	Storm	0.93	0.81	0.37	0.52	1.62	9
11905	Storm	1.29	1.08	0.48	0.69	2.22	9

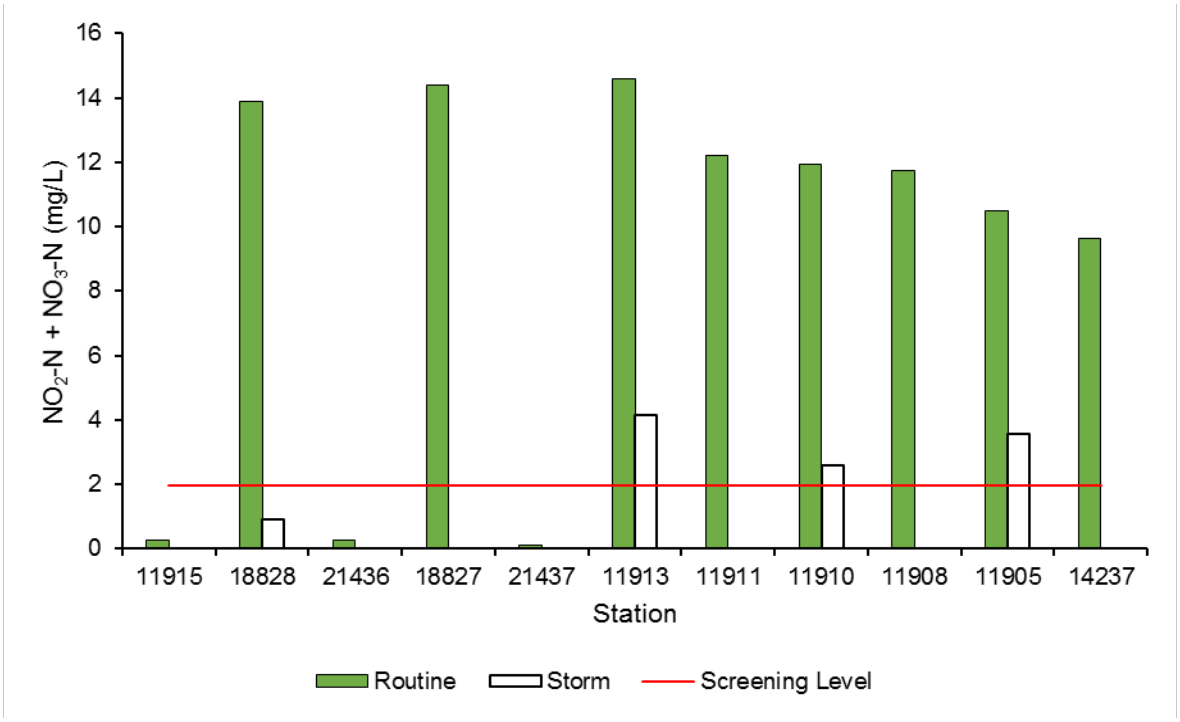

Figure C-1 Median NO_2-N+NO_3-N concentrations from routine grab and storm compared to screening level of 1.95 mg/L. Stations ordered from most upstream to downstream.

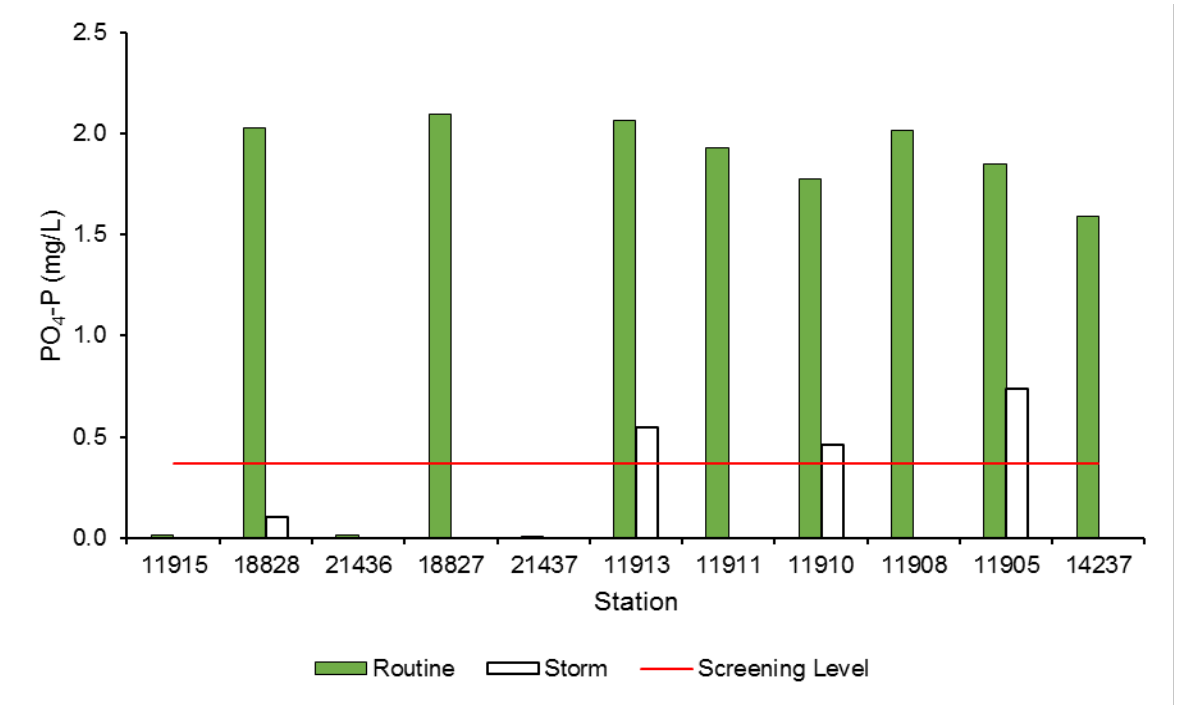

Figure C-2 Median PO_4-P concentrations from routine grab and storm compared to screening level of 0.37 mg/L. Stations ordered from most upstream to downstream.

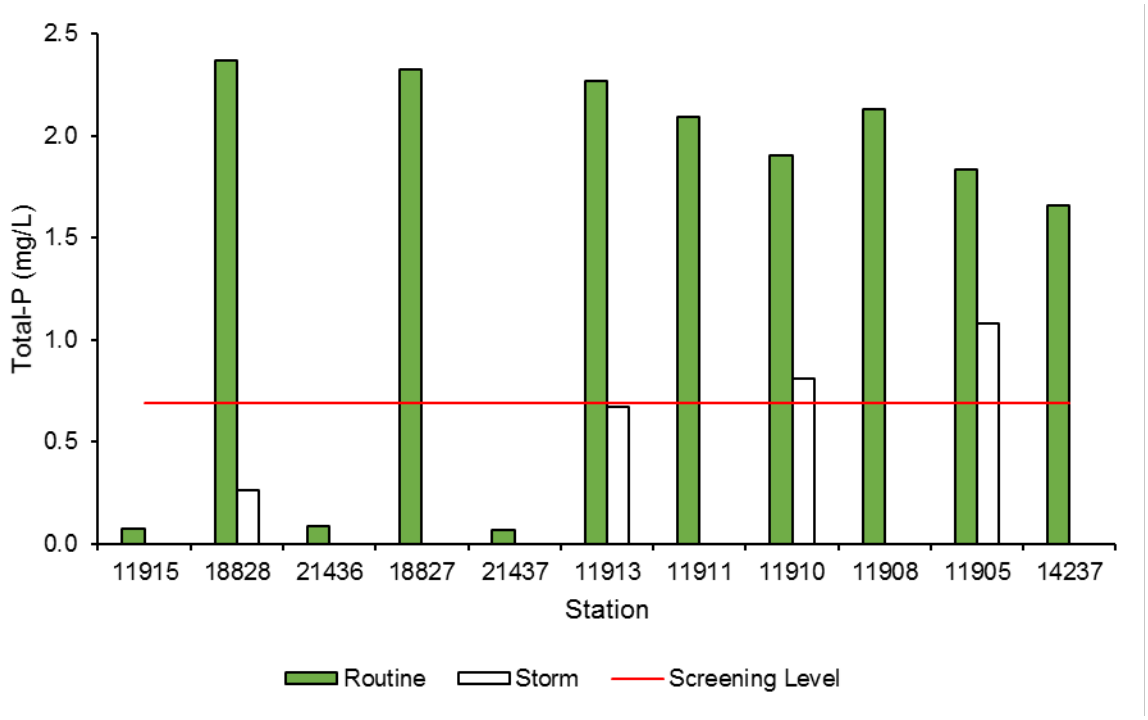

Figure C-3 Median total-P concentrations from routine grab and storm compared to screening level of 0.69 mg/L. Stations ordered from most upstream to downstream.