NOLAN CREEK

Watershed Protection Plan for
Nolan Creek/South Nolan Creek (Segment 1218)

Prepared for the

The Nolan Creek Partnership

By the

Texas Institute for Applied Environmental Research
(TR1802)

With Funding Provided by the

Texas Commission on Environmental Quality
Nonpoint Source Program CWA §319(h)
Contract No. 582-16-60281

PREPARED IN COOPERATION WITH THE TEXAS COMMISSION OF ENVIRONMENTAL QUALITY AND U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was financed through grants from the U.S. Environmental Protection Agency through the Texas Commission on Environmental Quality

ACKNOWLEDGEMENTS

Financial support for development of this Watershed Protection Plan (WPP) was provided through a Texas Commission on Environmental Quality (TCEQ) Nonpoint Source Program Clean Water Act §319(h) grant for the project, *Nolan Creek/South Nolan Creek Watershed Protection Plan* (Contract No. 582-16-60281, U.S. Environmental Protection Agency Federal ID #99614620) to the Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. This WPP was largely prepared by Anne McFarland, senior research scientist, Leah Taylor, senior project director, Elaine Smith, former project coordinator, and Todd Adams, research associate, with TIAER and is based on input from the Nolan Creek Partnership.

Background information characterizing the watershed was developed as part of a previous project, *Assessment of Water Quality and Watershed Based Planning for Nolan Creek/South Nolan Creek* also funded through the Texas Commission on Environmental Quality (TCEQ) Nonpoint Source Program Clean Water Act §319(h) (Contract No. 582-13-30061, U.S. Environmental Protection Agency Federal ID #99614617), which TIAER conducted in partnership with the City of Killeen. Reports associated with this characterization project can be accessed from TIAER's website at: http://tiaer.tarleton.edu/ruaa/nolan-creek-watershed.html.

We would like to thank the guidance provided by those involved with previous Texas WPPs. The WPPs for the Leon River Below Proctor Lake and Above Belton Lake (Parson Water & Infrastructure, Inc. and the Brazos River Authority, 2015) and the Lampasas River (Prcin and Srinivasan, 2013) were particularly important, as the Leon and Lampasas River watersheds directly border the Nolan Creek/South Nolan Creek watershed, thus, providing relevant information from the surrounding area and a continuity in the planning process where various municipal, county, and other stakeholder boundaries stretch across all three watersheds.

For more information about this document or the Nolan Creek/South Nolan Creek WPP, please visit the project website at: http://www.nolancreekwpp.com/.

Cover photograph is Nolan Creek at Levi Crossing (station 11908) taken on July 26, 2017.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Acronyms and Abbreviations

AU	Assessment Unit
AWCL	Agricultural Water Conservation Loan
AVMA	American Veterinary Medical Association
BCHD	Bell County Health Department
BMP	Best Management Practice
BPAC	Bicycle and Pedestrian Advisory Committee
BRA	Brazos River Authority
CAFO	Concentrated Animal Feeding Operation
CCN	Certificates of Convenience and Necessity
CDBG	Community Development Block Grant
cfs	cubic feet per second
cfu	colony forming unit
CIG	Conservation Innovation Grants
CRP	Clean Rivers Program
CSP	Conservation Stewardship Program
CTCOG	Central Texas Council of Governments
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
DAR	Drainage Area Ratio
DFAC	Dining Facilities Administration Center
DSLP	Days since last significant precipitation
E. coli	*Escherichia coli*
ECHO	Enforcement and Compliance History Online
EDAP	Economically Distressed Area Program
EE	Environmental Education
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FDC	flow duration curve
F&RLCP	Farm & Ranch Lands Conservation Program
FOG	fats, oils, and grease
HHW	household hazardous waste
HHS	Health and Human Services
IDDE	illicit discharge detection and elimination
KTMPO	Killeen-Temple Metropolitan Planning Organization
lbs	pounds
LDC	load duration curve
LID	low impact development
LIP	Landowner Incentive Program
LSHS	Lone Star Healthy Streams
LULC	land use land cover
MGD	million gallons per day
MPN	most probable number
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking

NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NLCD	National Land Cover Database
NRCS	Natural Resource Conservation Service
OSSF	on-site sewage facility
ortho	orthosphosphate
P	phosphorus
RTF	Recreational Trails Fund
RUAA	Recreational Use Attainability Assessment
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SCS	Soil Conservation Service
SEP	Supplemental Environmental Project
SSO	sewer system overflow
STEP	Septic Tank Elimination Program
SURRGO	Soil Survey Geographic Database
SWCD	Soil and Water Conservation District
SWMP	Stormwater Management Plan
TBD	to be determined
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TFS	Texas A&M Forest Service
TIAER	Texas Institute for Applied Environmental Research
TMDL	Total Maximum Daily Load
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TV	television video
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
TxDOT	Texas Department of Transportation
USDA	United States Department of Agriculture
USCB	United States Census Bureau
USGS	United States Geological Survey
WAP	Watershed Action Plan
WCID	Water Control and Improvement District
WCRC	Williamson County Recycle Center
WFPO	Watershed and Flood Prevention Operations
WPP	Watershed Protection Plan
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Executive Summary

The Nolan Creek/South Nolan Creek watershed comprises nearly 73,000 acres, largely located within the western portion of Bell County (Figure ES-1). South Nolan Creek flows through the cities of Killeen, Harker Heights, and Nolanville before merging with North Nolan Creek west of the City of Belton to form Nolan Creek. Nolan Creek then flows through Belton converging with the Leon River east of Belton. The most northern portion of the South Nolan Creek watershed and most of the North Nolan Creek watershed are part of the Fort Hood Military Reservation.

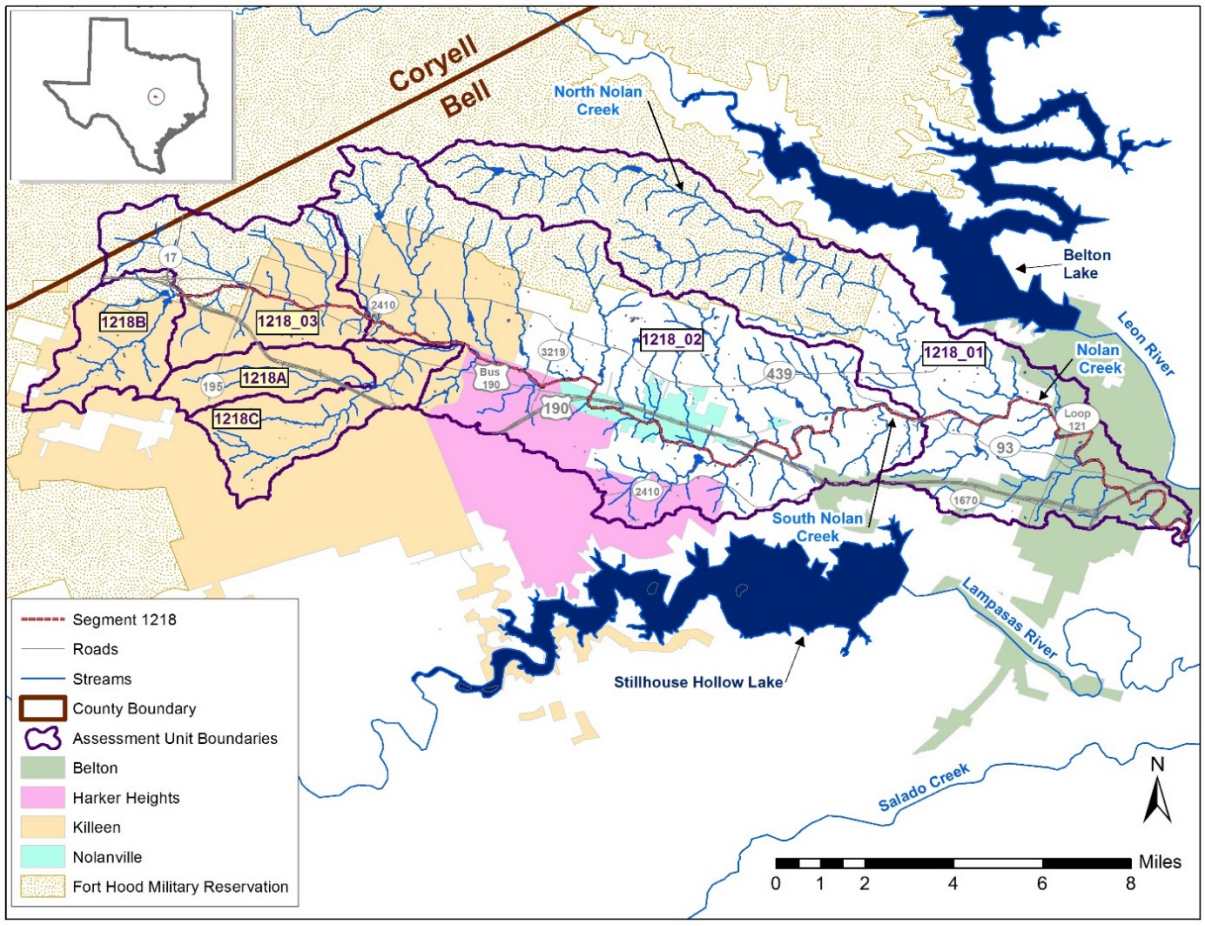

Figure ES-1 Watershed and assessment units associated with Segment 1218, Nolan Creek/South Nolan Creek. Inset shows watershed location within Texas.

Nolan Creek/South Nolan Creek (Segment 1218) has a history of elevated bacteria concentrations, and since 1996, the Texas Commission on Environmental Quality (TCEQ) has listed Segment 1218 as impaired for bacteria based on Texas State Water Quality Standards. This impairment means that portions of the creek do not meet the criterion for primary contact recreation (PCR) indicating an increased health risk if participating in activities, such as swimming, which have a high likelihood of water ingestion. The criterion for PCR is 126 colonies per 100 milliliters (mL). The TCEQ assesses support by comparing the geometric mean of *Escherichia coli* from samples collected over a set period (generally 10 years) as part of its water quality inventory, which is conducted once every two years. This water quality inventory

is presented within the Texas Integrated Surface Water Quality Report. The most recently approved Texas Integrated Report from 2014 indicates bacteria impairments within assessment units (AUs) 1218A, Little Nolan Creek, and 1218_02, a portion of South Nolan Creek (Figures ES-1 and ES-2). Concerns are also indicated for elevated bacteria concentrations along AU 1218C, a tributary to Little Nolan Creek. Of note, *E. coli* units of colonies/100 mL and most probably number (MPN)/100 mL are used interchangeably by TCEQ. Within the 2014 Texas Integrated Report, concerns for elevated nitrate and total phosphorus concentrations are also noted in comparison to statewide screening levels within AU 1218_02 (Table ES-1).

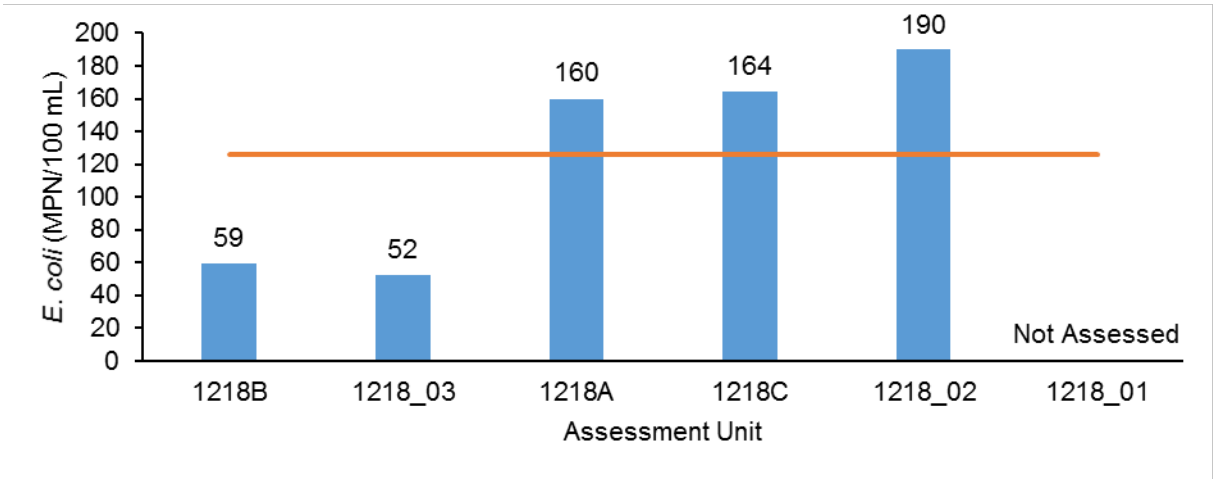

Figure ES-2 2014 Texas Integrated Report geometric mean assessment results by AU for bacteria along Nolan Creek/South Nolan Creek based on data collected between December 1, 2005 and November 30, 2012. Values above bars are the reported geometric means used in the assessment. The red line indicates the assessment criterion (126 MPN/100 mL) for primary contact recreation.

Table ES-1 2014 Texas Integrated Report assessment results for AU 1218_02 for nitrates and total phosphorus based on data collected between December 1, 2005 and November 30, 2012.

1218_02	# Exceeded	# Samples	Screening Level	Mean of Samples Exceeding Screening Level
Nitrate	37	38	1.95	8.64
Total Phosphorus	22	28	0.69	1.93

To address these water quality issues, the Nolan Creek Partnership has developed a watershed protection plan (WPP) outlining activities to aid in improving water quality. A WPP identifies management practices to improve and protect water quality and watershed health using a voluntary approach with educational outreach as a large component. The Nolan Creek Partnership stakeholder committee includes private citizens as well as representatives from Killeen, Harker Heights, Nolanville, Belton, Bell County, Water Control and Improvement Districts (WCIDs), and Fort Hood. A technical advisory group to this stakeholder committee

included representatives from the Texas Commission on Environmental Quality (TCEQ), Texas Parks and Wildlife Department (TPWD), Texas State Soil and Water Conservation Board (TSSWCB), Texas A&M Forest Service (TFS), the Central Texas Council of Governments (CTCOG), and the United States Department of Agriculture-Natural Resource Conservation Service (USDA-NRCS). The Texas Institute for Applied Environmental Research (TIAER) acted as a facilitator in development of the WPP with oversight and funding provided by TCEQ and EPA through the Section 319(h) Clean Water Act grant. The Nolan Creek/South Nolan Creek WPP focuses on activities to control bacteria contributions as the main water quality impairment, but also addresses concerns related to elevated nutrients.

As part of an earlier characterization of the watershed, several locations were monitored intensively between May 2013 and June 2015 under a variety of flow conditions including routine monthly and some biased storm sampling. These data helped define needed load reductions and flow conditions under which most bacteria loadings occurred using a load duration curve (LDC) approach. The LDC approach superimposes allowable loads based on the *E. coli* criterion (126 MPN/100 mL) with measured concentration and flows (see Figure ES-3). The difference between the criterion loading and the geometric mean of loading associated with measured values estimates the load reductions needed to meet water quality standards.

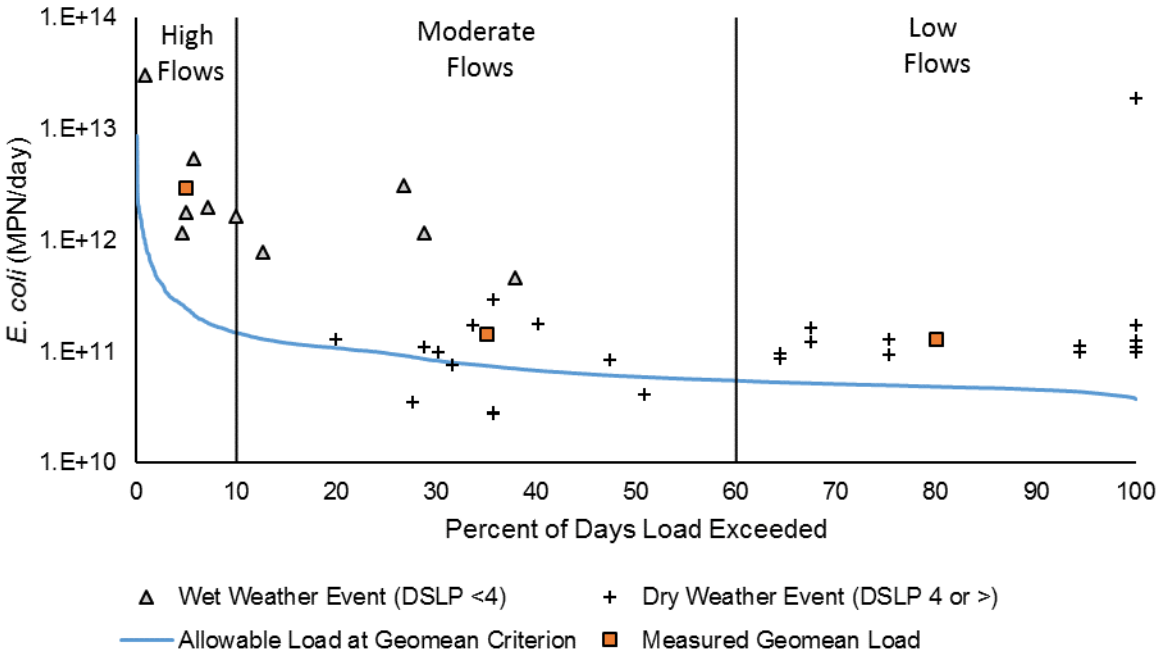

Figure ES-3 Examples load duration curve for station 11913, South Nolan Creek at Roy Reynolds Road. Value 77,000 MPN/100 mL collected on July 10, 2013 excluded from calculation of low flow geometric mean.

The LDC approach was evaluated at four locations (Figure ES-4):

- 18828 located on South Nolan Creek at 38th Street in Killeen
- 11913 located on South Nolan Creek at Roy Reynolds Road in Killeen
- 11910 located on South Nolan Creek at US Highway 190 in Nolanville
- 11905 located on South Nolan Creek at Backstrom Crossing

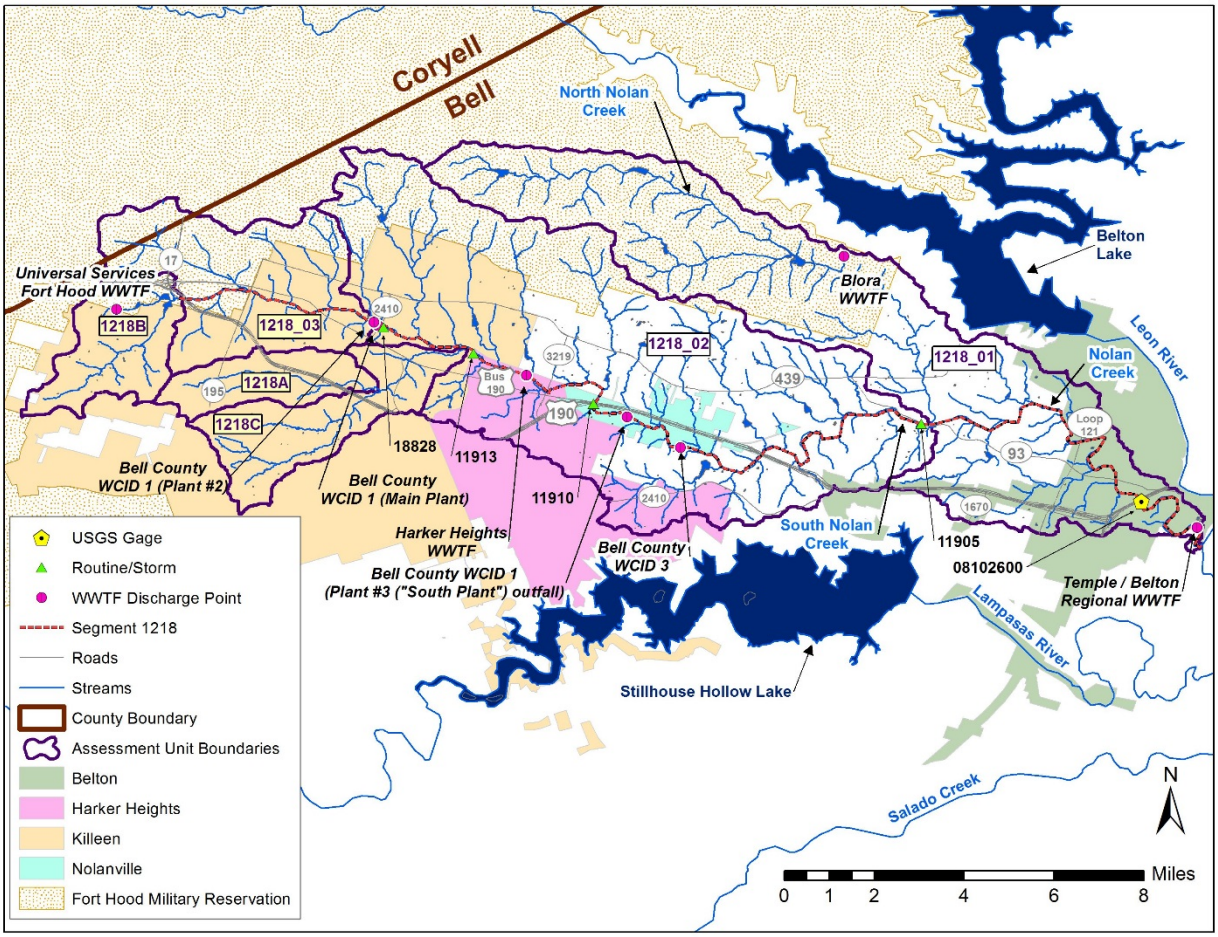

Figure ES-4 Monitoring stations and wastewater treatment facility (WWTF) discharge locations used in FDCs and LDCs along Nolan Creek/South Nolan Creek.

While high flows consistently indicated the largest reduction estimates, these conditions occur 10 percent or less of the time and are often associated with flood flows making them difficult to plan for and manage (Table ES-2). Because assessment data focuses more on normal flow conditions, reduction estimates during moderate and low flow conditions were used in identifying management activities for water quality improvement. At the most upstream station, 18828, no reductions were needed during moderate flows, but at the other three stations and station 18828 for low flows, reduction estimates ranged from 16 to 80 percent.

The land use/land cover within the watershed varies with location and, thus, the likely sources of bacteria (Figure ES-5). Urban development comprises about 40 percent of the full watershed of Segment 1218 with most urban land occurring in the western third. Forest and grassland jointly comprise almost 50 percent of the land cover with forest predominately in the area of North Nolan Creek and grassland in the more central to eastern portion of the watershed. Cattle grazing is the primary agricultural activity as much of the land within the watershed is not suitable to support intensive cropland due to the shallow nature of most of soils in this area.

Table ES-2 Geometric mean concentrations of measured bacteria by flow regime and estimated reductions needed to meet the primary contact recreation criterion of 126 MPN/100 mL for stations along South Nolan Creek. Zero percent reductions (shaded in grey) indicate criterion is met and reductions are not needed.

Station	High Flows (0-10%)		Moderate Flows (10-60%)		Low Flows 60-100%)	
	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction
18828	865	85%	95	0%	155	19%
11913	1521	92%	243	48%	335	62%[a]
11910	2049	94%	616	80%	227	44%
11905	1405	91%	326	61%	149	16%

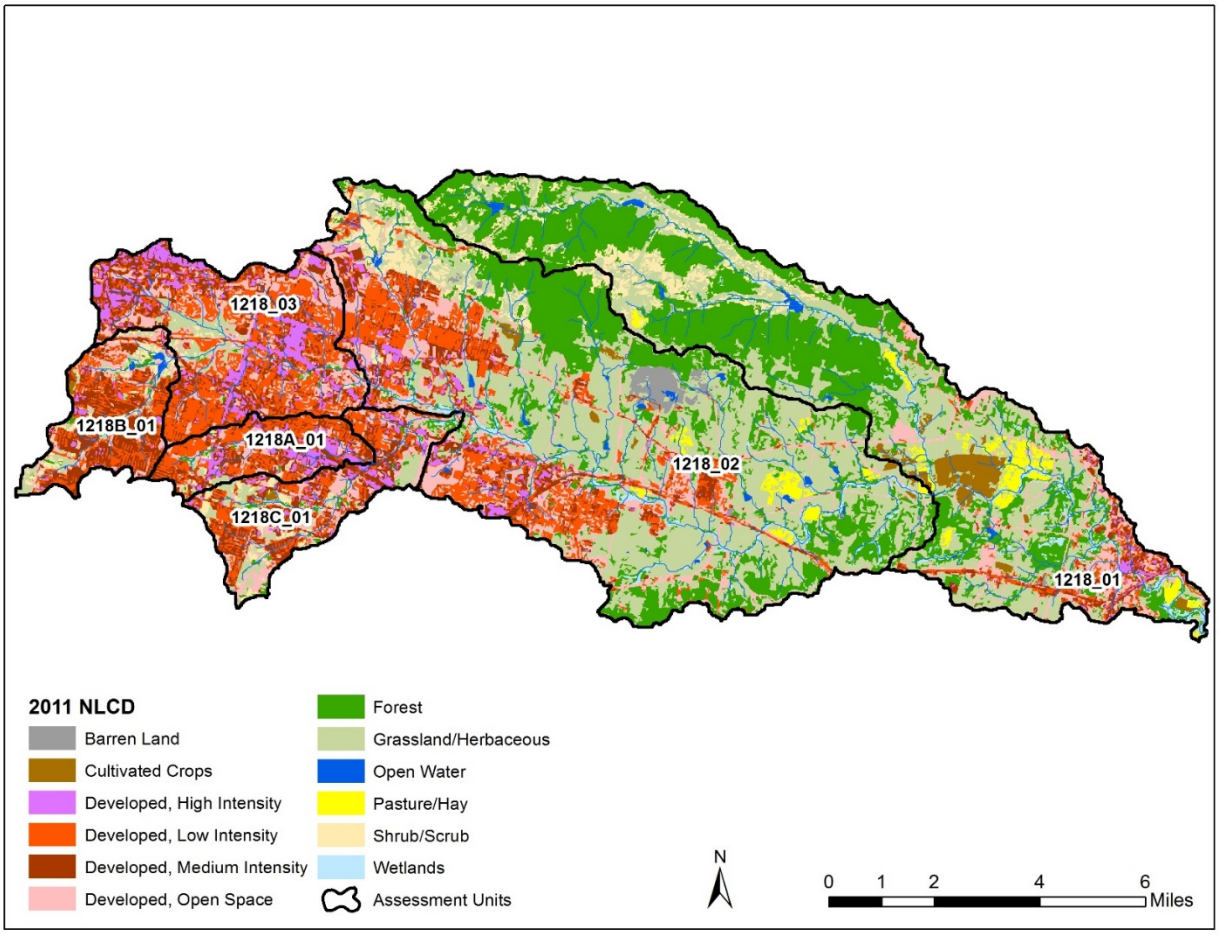

Figure ES-5 Land use/land cover for the Nolan Creek/South Nolan Creek watershed based on 2011 National Land Cover Database.

To aid in identifying the spatial distribution of potential bacteria sources with varying land use/land cover, the Spatially Explicit Load Enrichment Calculation Tool (SELECT) was used. Potential bacteria loadings are calculated via SELECT based on density and bacteria production rate estimates of various sources, such as wastewater treatment facilities, cattle, feral hogs, dogs, and on-site sewage facilities (OSSFs). Potential contributions by source are then spatially allocated largely based on location or land cover. An urban stormwater runoff component was also included in using SELECT to capture potential contributions from urban runoff. From SELECT, a series of maps is produced allowing visual assessment of the distribution of potential loadings to the land surface for subbasins throughout the watershed (see Figure ES-6 as an example). Similar maps were developed for regulated sources including WWTFs and urban stormwater runoff and non-regulated sources including cattle, sheep/goats, horses, feral hogs, deer, pets, and OSSFs. These maps aid in targeting "hot spots" for specific sources, and in conjunction with LDCs, guided the stakeholder committee in identifying proposed management activities.

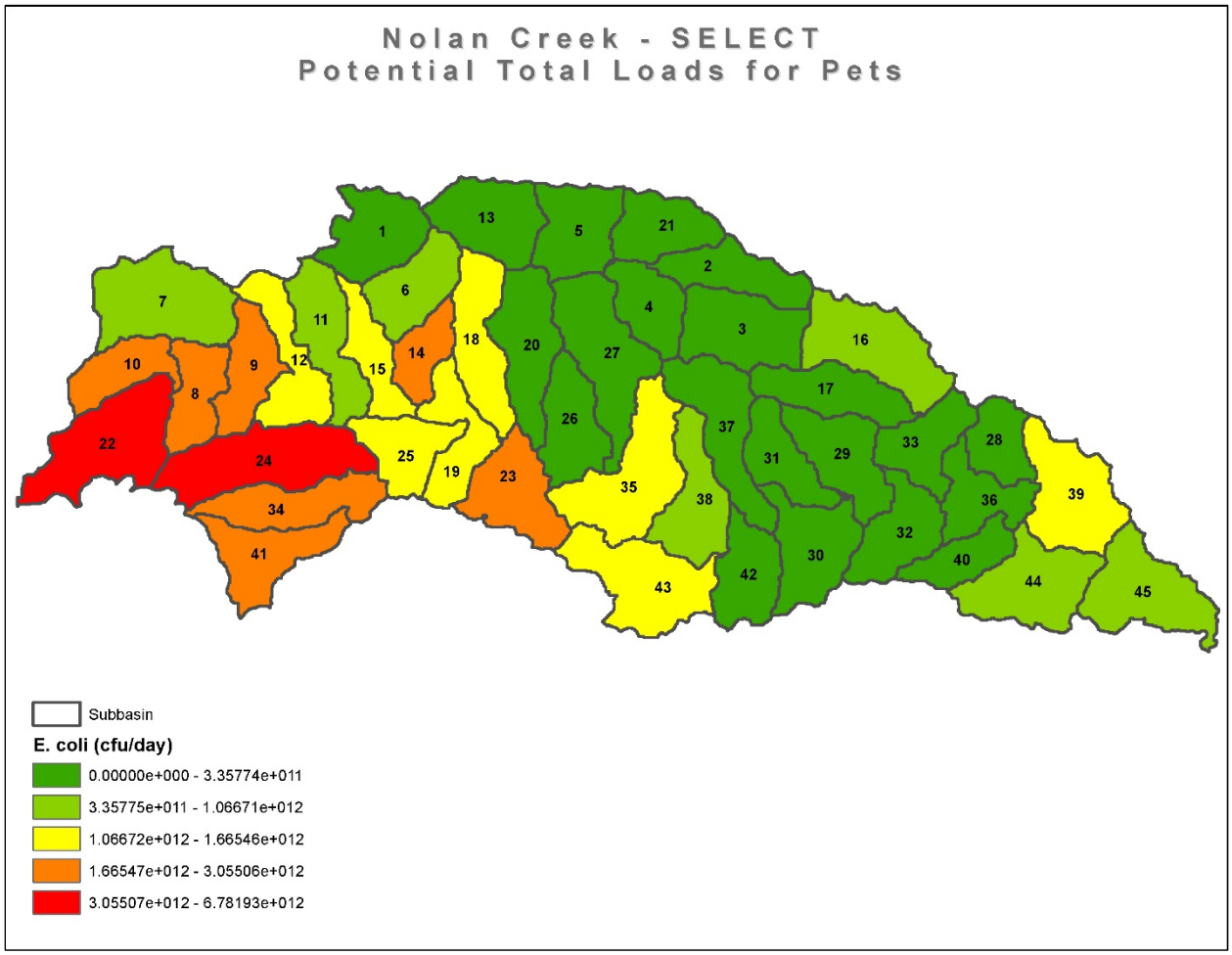

Figure ES-6 Example SELECT map showing the distribution of potential *E. coli* loads from pets by subbasin within the Nolan Creek/South Nolan Creek watershed. Pets are represented as an estimate of the dog population assuming 0.6 dogs per household using 2010 Census Data to distribute across subbasins.

Because contributions appear to be primarily from nonpoint sources within the watershed, the overall management strategy targets multiple sources. While it is recognized that not everything can be done at once in prioritizing management activities, those involved with the Nolan Creek Partnership expressed frustration that a clear dominant source was not identified. A polling of the stakeholder committee indicated that human sources should be prioritized over nonhuman sources. Human sources are primarily associated with wastewater management, whether part of a centralized sewer system or OSSF. Of the nonhuman sources, dog waste was given the highest management priority in urban areas for control, while livestock and, to a lesser degree, feral hogs were considered the highest management priority in the more rural areas. Other considerations in developing the WPP included ease of implementation, cost, potential reduction expectations, and ongoing efforts associated with Storm Water Management Plans (SWMPs) related to municipal separate storm sewer system (MS4) permits, flood management planning efforts, and variations in recreational use along different reaches of Nolan Creek/South Nolan Creek.

For wastewater management, most management activities are already addressed under discharge permits associated with wastewater treatment facilities (WWTFs) or MS4s. Private connections to public sewer lines and proper maintenance of OSSFs were identified as areas where further education and assistance (both technical and financial) is needed. For private connections to public sewer lines, the focus would be in educating landowners on how to identify and address sewer line problems on their property. For OSSFs, educational outreach would focus on proper maintenance, but also technical and financial assistance for repairing or replacing failing OSSFs or aid in connecting to centralized sewer systems of annexed areas within municipal boundaries. The Nolan Creek Partnership also recognized that the homeless population is increasing in the watershed, and as municipalities develop strategies addressing the homeless issue, this plan will need to evolve to include some of these activities.

In mitigating nonpoint source contributions, there are a large number of management activities presented within the WPP including adding pet waste stations, promoting low impact development, developing water quality management plans for livestock and horse owners, trapping feral hogs, and organizing creek clean up events. There was a desire from stakeholders not to overlook anything that might assist in remedying the water quality issues. The highest priority for mitigating bacteria associated with nonpoint source pollution was given to educational outreach focusing on control of waste from pets, primarily dogs. Within these urban areas, parks and trails provide very important recreational areas within these communities. These parks and trails are often close to the creek concentrating use, and, thus, potential contribution from pet waste as many people use these parks and trails as areas to recreate with their dogs.

As part of adaptive management, the Nolan Creek Partnership recommends microbial source tracking (MST) as a management measure to aid in refining the identification of potential sources. Implementation of MST can be expensive but may allow the WPP to better direct efforts towards specific sources, particularly if large amounts of money are to be invested. A monitoring plan is also recommended to measure instream progress towards the water quality goal of 126 MPN/100 mL *E. coli*. An adaptive management approach is recommended with an evaluation at the end of years three, six, and ten to assess if priorities should be changed, particularly if new information arises through monitoring or MST efforts.

In moving toward implementation of this WPP, some measures, such as educational outreach, can be integrated at certain levels with on-going efforts, while other activities will take additional funding. While municipalities and other entities are expected to step forward to assist in implementing this plan, no financial obligations have yet been made beyond resources obligated to complimentary activities already being conducted. Within the plan, a listing of resources is provided for areas where more technical and financial assistance might be obtained to aid in moving forward from planning to implementation.

SECTION 1

Introduction

The Federal Water Pollution Control Act (33 U.S.C. 1251 et seq., 1972), commonly called the Clean Water Act (CWA), requires Texas to set water quality standards including designated uses for each water body. Every two years, per Section 305(b) of the CWA, the status of water bodies throughout Texas is assessed and a list of impaired water bodies (those not meeting water quality standards) is developed. This list of impaired water bodies is known as the 303(d) List in reference to Section 303(d) of the CWA. The Texas Commision on Environmental Quality (TCEQ) presents this assessement and list of impaired water bodies jointly in the Texas Integrated Report of Surface Water Quality. The 2014 Texas Integrated Report of Surface Water Quality represents the most recent approved report, as of January 2018 (TCEQ, 2015a).

Once a water body is listed as impaired, one or more of the following actions may be recommended by TCEQ:

- More monitoring, if data used for designating the impairment were considered insufficient,
- A standards review to determine if the designated use is appropriately assigned,
- Development and implementation of a Watershed Protection Plan (WPP), and/or
- Establishment of a Total Maximum Daily Load (TMDL).

Nolan Creek/South Nolan Creek Watershed

The full length of Nolan Creek/South Nolan Creek (Segment 1218)stretches nearly 30 river miles from a point 100 meters upstream of the most upstream crossing of US 190 and a spur of Texas State Highway 172 within Fort Hood, just below the Soil Conservation Site 1 Reservoir, to its confluence with the Leon River in Belton (Figure 1-1). Within the 2014 Texas Integrated Surface Water Quality Report (TCEQ, 2015a), portions of Nolan Creek/South Nolan Creek were assessed as impaired due to elevated bacteria concentrations. The impaired reaches include assessment unit (AU) 1218_02, which extends from the confluence of South Nolan Creek with North Nolan/Nolan Creek upstream to the confluence with Liberty Ditch in Killeen (Figure 1-1), and AU 1218C, which represents Little Nolan Creek, a tributary of South Nolan Creek in Killeen. A bacteria impairment was first designated for AU 1218_02 in 1996, while AU 1218C was not listed until 2010. Concerns for bacteria are also noted for AU 1218A, a tributary to Little Nolan Creek.

In the 2014 Texas Integrated Report (2015b), impairments are defined for AUs with a geometric mean *Escherichia coli* concentration above 126 colonies/100 mL for primary contact recreation based on samples collected between December 1, 2005 and November 30, 2012 (Figure 1-2). Of note, *E. coli* units of colonies/100 mL and most probably number (MPN)/100 mL are used interchangeably by TCEQ. Besides bacteria impairments and concerns, water quality concerns are reported for nitrates and total phosphorus within AU 1218_02 (TCEQ, 2015a). Concerns for nutrients are based on a comparison of stream concentrations to state-wide screening levels (Table 1-1).

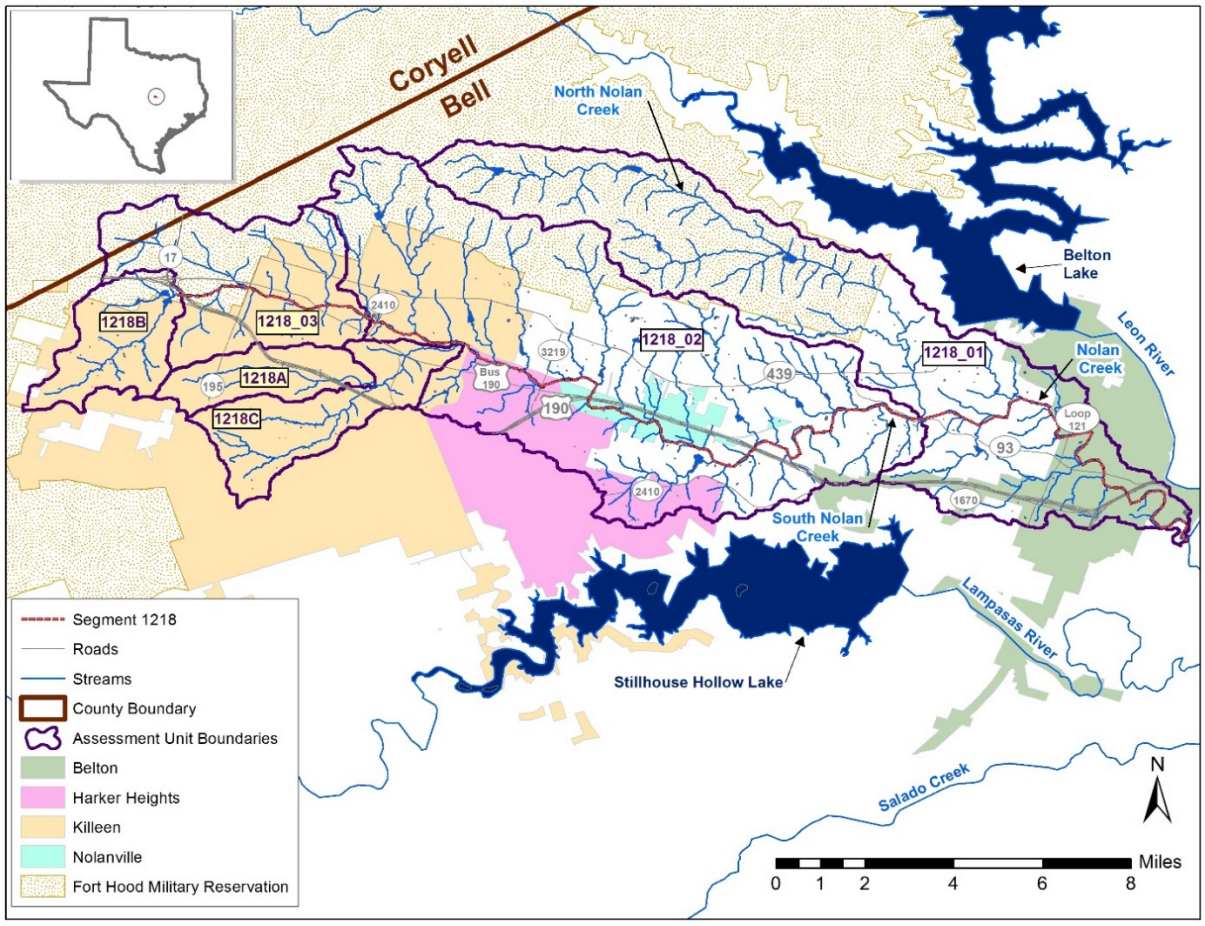

Figure 1-1 Watershed and assessment units associated with Segment 1218, Nolan Creek/South Nolan Creek. Inset shows watershed location within Texas.

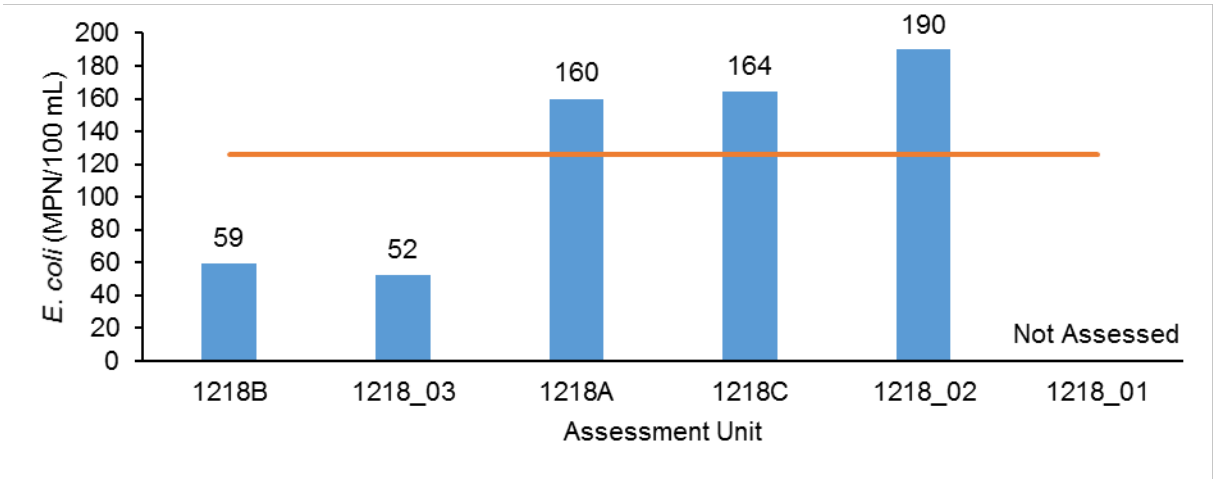

Figure 1-2 2014 Texas Integrated Report assessment results by AU for bacteria along Nolan Creek/South Nolan Creek. Source: TCEQ (2015a). Values above bars are the reported geometric means used in the assessment. The red line indicates the assessment criterion (126 MPN/100 mL) for primary contact recreation.

Table 1-1 2014 Texas Integrated Report assessment results for AU 1218_02 for nitrates and total phosphorus. Source: TCEQ (2015a).

1218_02	# Exceeded	# Samples	Screening Level	Mean of Samples Exceeding Screening Level
Nitrate	37	38	1.95	8.64
Total Phosphorus	22	28	0.69	1.93

For impairments associated with recreational use due to elevated bacteria concentrations, a standards review is recommended before initiating a WPP or TMDL. By default, all water bodies in Texas, except the Houston Ship Channel, are presumed to have a designated use of primary contact recreation, which means they may be used for activies, such as swimming, where there is a significant risk of ingesting the water. To assess the recreation use designated to a water body, a Recreational Use Attainability Assessment (RUAA) may be conducted as part of a standards review to determine if the water body has sufficient depth or other characteristics to support primary contact recreation (TCEQ, 2018). The RUAA process also includes interviews with individuals within the watershed to document current and historic recreational use. If the findings of an RUAA do not support primary contact recreation, a change in the designated use may be recommended, which could potentially lead to delisting. If after a standards review, the water body is still considered impaired, then a WPP or TMDL is often the next step.

Based on findings from a RUAA conducted for Segment 1218 representing the full length of Nolan Creek/South Nolan Creek (Winemiller et al., 2010), TCEQ recommended that the presumed use of primary contact recreation be retained as primary contact recreation activities, such as swimming, have been documented (https://www.tceq.texas.gov/assets/public/waterquality/standards/ruaa/brazos1/NolanCreek_recommendation.pdf). Since the RUAA, more monitoring and further characterization of the watershed has occurred, leading to a stakeholder recommendation for development of a WPP rather than a TMDL.

In comparing WPPs and TMDLs, both WPPs and TMDLs identify management practices needed to improve and protect water quality and watershed health. The main differences between these two approaches is that a WPP is a voluntary driven approach, with a broader focus than just impaired waters often focused on nonpoint sources of pollution. A TMDL is a regulatory driven process with intensive stakeholder involvement that often focuses on point source pollution leading to regulatory limits on permitted discharges.

While development of a WPP does not preclude later development of a regulatory TMDL, a WPP can be a more viable approach for water quality restoration than a TMDL, particularly when nonpoint sources are considered the primary cause of impairment. This is because nonpoint sources involve contributions from landscape runoff that can come from a variety of sources. Controlling nonpoint source pollution can be challenging in that there may not be a clear source, and changing the behavior of many individuals in a variety of ways may be needed to make notable reductions.

The WPP Approach

The WPP approach holistically characterizes water quality issues and impairment sources with the goal of water quality recovery. The success of the planning process involves multiple steps and depends on stakeholder involvement. Because sources of impairments are not always clear, local knowledge is needed from a variety of individuals throughout the watershed to determine sources and management practices.

The Environmental Protection Agency (EPA) requires the following nine elements to be addressed in a WPP (EPA, 2008):

a) Identification of causes that will need to be controlled to achieve load reductions described in (b).

b) Estimates of load reductions expected from the management measures described in (c).

c) Description of the management measures needed to achieve load reductions described in (b) and critical areas where they will be implemented.

d) An estimate of the technical and financial assistance needed to implement the plan.

e) Identification of an information/education component that will be used to enhance public understanding of the plan.

f) A schedule for implementing management measures described in (c).

g) A description of interim, measurable milestones for tracking implementation of management measures described in (c) in comparison to the schedule outlined in (f).

h) A set of criteria that can be used to determine whether load reductions described in (b) are being achieved.

i) A water quality monitoring component to evaluate effectiveness of implementation measured against established criteria as described in (h).

Stakeholder involvement is critical to the WPP process in providing insight into sources as well as defining what management measures will best be embraced by the community. For the development of the Nolan Creek/South Nolan Creek WPP, involvement included representatives from each municipality (Killeen, Harker Heights, Nolanville, and Belton), Fort Hood, Bell County, Bell County Water Control and Improvement Districts (WCIDs) as well as private individuals as the core stakeholder committee (Figure 1-3). Technical advisors to the process routinely included representatives from the Texas Commission on Environmental Quality (TCEQ), Texas Parks and Wildlife Department (TPWD), Texas State Soil and Water Conservation Board (TSSWCB), Texas A&M Forest Service (TFS), the Central Texas Council of Governments (CTCOG), and the United States Department of Agriculture-Natural Resource Conservation Service (USDA-NRCS). The Texas Institute for Applied Environmental Research (TIAER) acted as a facilitator for development of the WPP with oversight provided by TCEQ and EPA.

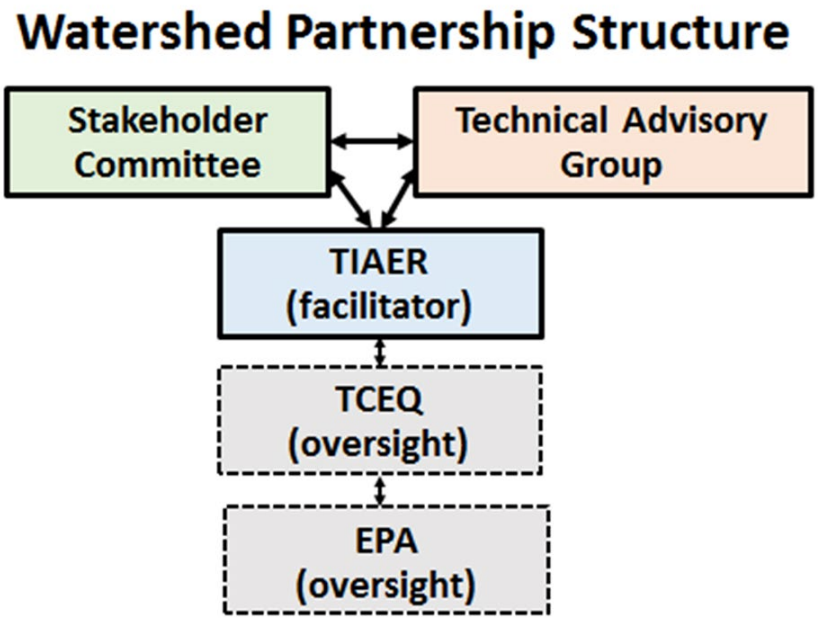

Figure 1-3 Partnership structure for development of the Nolan Creek/South Nolan Creek WPP.

Meeting dates, minutes, handouts, and presentations of the Nolan Creek partnership in development of this WPP are available on the project website at: http://www.nolancreekwpp.com/ (under the News tab below the calendar of Upcoming Events). Information on meetings and stakeholder involvement prior to May 4, 2016 leading up to development of the WPP are available on TIAER's website at: http://tiaer.tarleton.edu/ruaa/nolan-creek-watershed.html.

SECTION 2

Watershed Characteristics

Nolan Creek has two main forks, South Nolan Creek and North Nolan Creek, which converge about two miles northwest of the City of Belton (Figures 1-1 and 2-1). South Nolan Creek flows about 20 river miles primarily in an eastward direction with its headwaters, as represented by AUs 1218A, 1218B, 1218C, and 1218_03, extending around the City of Killeen and including portions of the Fort Hood Military Reservation. North Nolan Creek, which represents most of AU 1218_01) extends nearly 14 river miles through primarily grassland and forest representing a large portion part of the Fort Hood Military Reservation. After South Nolan Creek and North Nolan Creek merge to form Nolan Creek, just downstream of AU 1218_02, Nolan Creek continues for about 10 more river miles through forest and then increasing urban development as it nears and passes through the City of Belton prior to converging with the Leon River.

Demographics

The major population centers within the Nolan Creek/South Nolan Creek watershed are the cities of Killeen (2016 population estimate 142,083), Harker Heights (29,779), and Nolanville (4,919) along South Nolan Creek and the City of Belton (20,798) along Nolan Creek (Texas Demographic Center, 2018). The Fort Hood Military Reservation also has a large fluctuating population and provides some base housing for military families with about 7,000 units near or within the Nolan Creek/South Nolan Creek watershed. Likely due to the influx of personnel from Fort Hood, the median age estimated within the watershed area is about 27 years based on 2010 census data, which is about 15 percent lower than the median age across Texas. Population growth based on comparison of 2010 Census data and 2016 population estimates for the municipalities is about 1.7 percent per year.

Land Use/Land Cover

The land use in the Nolan Creek/South Nolan Creek watershed is predominately urban with the western portion covered by the cities of Killeen, Harker Heights, and Nolanville and the most eastern portion covered by the City of Belton (Figure 2-1). Between Nolanville and Belton along South Nolan and Nolan Creek, grassland comprises much of the land cover intersected by developed land representing roads and small subdivisions. A very notable section of the watershed near the center is categorized as barren land. This barren area represents the Lhoist North American quarry located north of Nolanville. Within the North Nolan Creek subwatershed, the majority of which is part of the Fort Hood Military Reservation (see Figure 1-1), the land cover is largely a mix of forest and grassland. Only a relatively small portion of the watershed is in cultivated crops or pasture hay (Table 2-1). The watershed is almost all within Bell County with only a very small portion (less than one percent) to the northwest within Coryell County. While situated primarily within Bell County, the land use of the Nolan Creek/South Nolan Creek watershed varies greatly from Bell County as a whole with a much larger portion of the watershed associated with urban development and less to cropland, pasture, or grassland (Table 2-1).

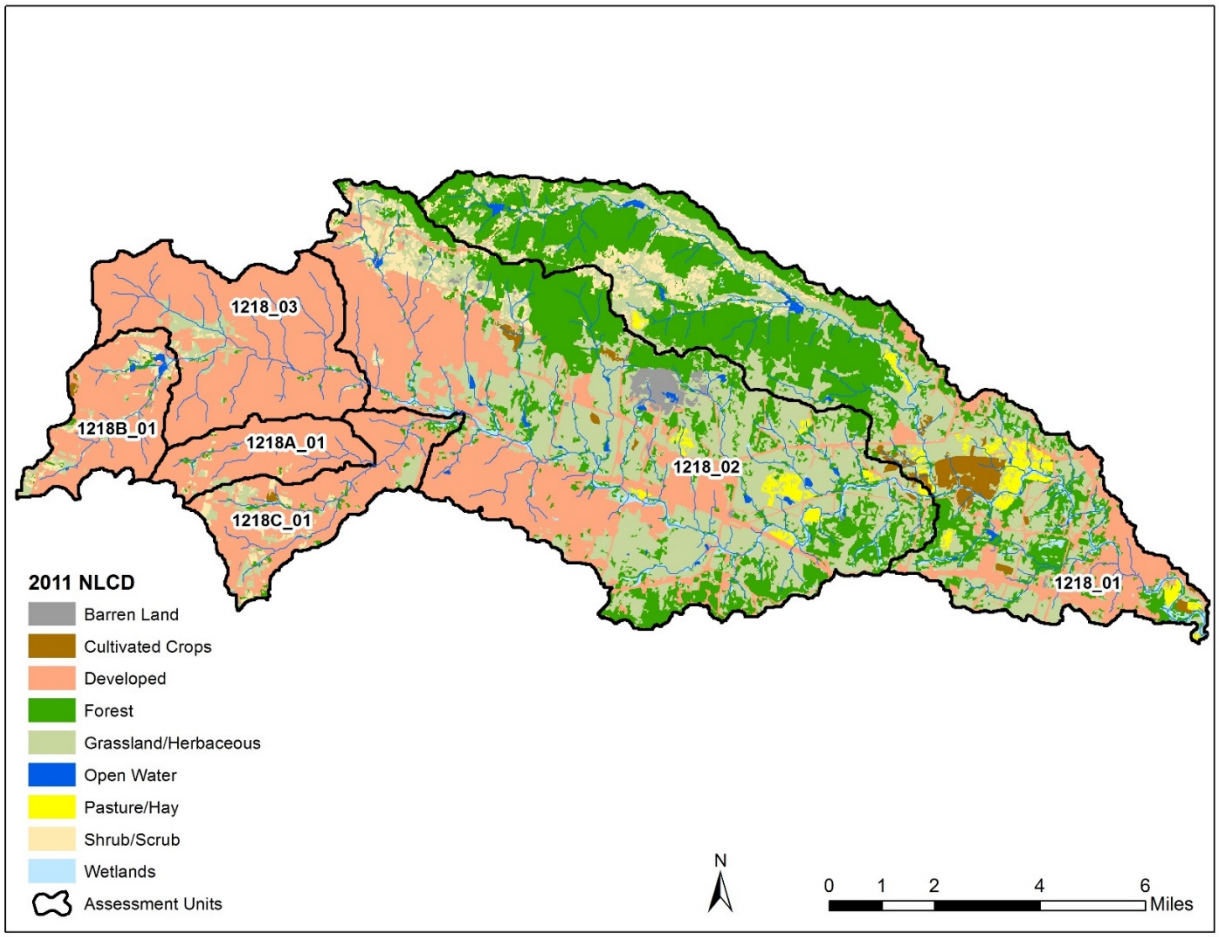

Figure 2-1 Land use/land cover for the Nolan Creek/South Nolan Creek watershed. Source: 2011 National Land Cover Database (NLCD) (USGS, 2014).

Ecology

The Nolan Creek/South Nolan Creek watershed is located within the Cross Timbers ecoregion (Level III 29) as part of the Limestone Cut Plain (Level IV 29e; Griffith et al., 2007). The Limestone Cut Plain is known for its stair-step topography of mesas intertwined with broad valleys underlain by Lower Cretaceous limestones. Native grasslands represent a mix of tall, mid, and short grasses, while woodland are fairly open with oak, cedar elm, and ash species prevalent. Historically, much of this area was grassland and woodland, but now much is urbanized.

Soils

Soils are critical in defining land cover and land use. Within the watershed, soils fall into two major associations; the Denton-Purves and the Speck-Tarrant-Purves (Huckabee et al., 1977). The majority of the watershed draining to South Nolan Creek is part of the Denton-Purves soil association, while the watershed draining to North Nolan Creek and most of Nolan Creek is part of the Speck-Tarrant-Purves association.

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

Category	Nolan Creek/South Nolan Creek Watershed (%)	Nolan Creek/South Nolan Creek Watershed (acres)	Bell County (%)	Bell County (acres)
Developed	40.1	29,196	13.3	92,480
Barren	0.8	590	0.3	2,086
Forest	22.6	16,708	17.5	121,684
Shrub/Scrub	4.2	3,040	4.3	29,899
Grassland Herbaceous	26.8	19,517	32.0	222,508
Pasture Hay	1.5	1,072	7.5	52,150
Cultivated Crops	1.4	991	19.0	132,114
Wetlands	1.8	1,337	2.9	20,165
Open Water	0.5	360	3.2	22,251
Totals	100.0	72,811	100.0	695,336

The land area within the Denton-Purves association is often nearly level or gently sloping with silty clay soils extending about a foot to three feet thick resting over hard limestone bedrock. The Denton-Purves soils are noted as suitable for cultivation in a few areas, but largely, if not urbanized, used for livestock grazing due to their shallow nature. In urban areas, the shrink-swell potential of these soils can cause cracking and shifting of structures and corrosion of underground pipelines. Both the Denton and Purves soil series are noted to have severe limitations for septic tank absorption fields as they have a shallow depth to bedrock (8 to 40 inches). The Denton series is also noted for slow permeability.

The Speck-Tarrant-Purves association underlying the more northeastern part of the watershed is more undulating than the Denton-Purves association and represents shallow, gravelly clay loam or silty clay loam soils resting on limestone bedrock. This association primarily supports range and woodland used by livestock and wildlife habitat. Small areas at the base of hills provide deeper loamy soils that may be cultivated. The woodland is considered noncommercial and due to encroachment of oak, juniper, and other plants described as a scrub forest by Huckabee et al. (1977). Features of this soil association that can affect urban developments are the shallow depth to bedrock and the shrink-swell potential in more clayey areas. Severe limitations are noted for septic tanks absorption fields for the three major soil series in the Speck-Tarrant-Purves association due to shallow depth to bedrock (8 to 20 inches) and slow permeability for the Speck soil series.

Climate

The climate of the watershed is humid subtropical with hot summers and winters that are generally mild (Orton, 1977). Snowfall is very unusual for the watershed, but can occur on rare occasions. Freezing temperatures (below 32ºF) generally 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).

Precipitation based on 30-years of data from the National Weather Service for Killeen (1981-2010) averages 33.1 inches per year varying 1.8 to 4.2 inches per month (Figures 2-2 and 2-3). Since 1980, annual precipitation has ranged from a low of about 17 inches in 2014 to a high of almost 57 inches in 2007 (Figure 2-2). Seasonally, the wettest months are generally May and June with over four inches of precipitation on average and the driest months are July and August with less than two inches on average (Figure 2-3). Monthly normals represent averages over three decades as evaluated by the National Centers for Environmental Information under the National Oceanic and Atmospheric Administration. 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.

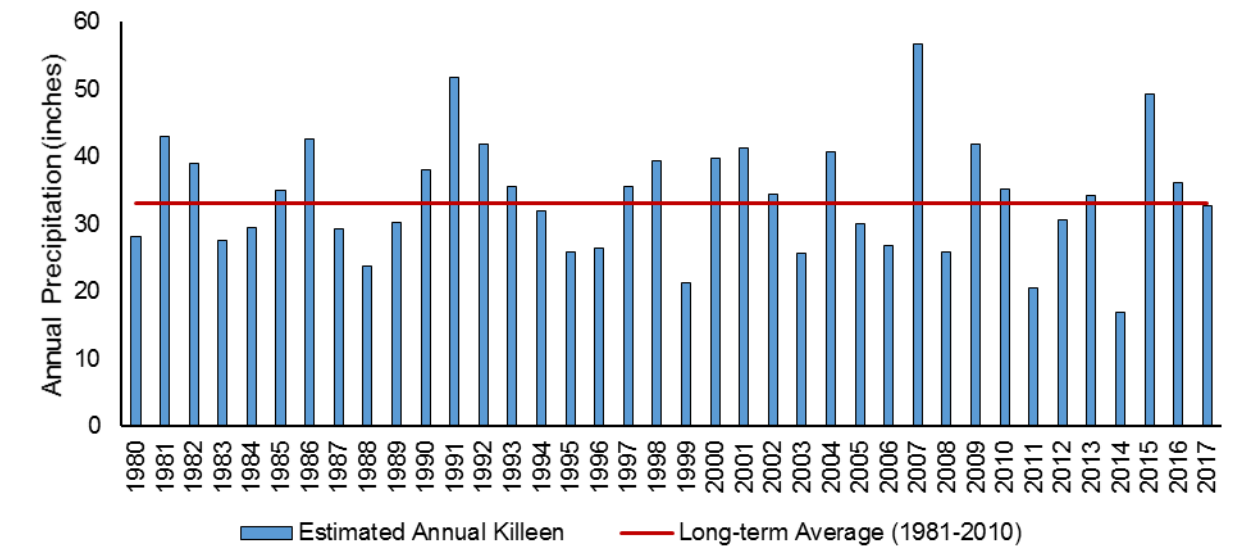

Figure 2-2 Estimated annual precipitation for Killeen, Texas for 1980 through 2017. For years with missing daily values for Killeen, annual precipitation was estimated using the sum of daily values for Stillhouse Hollow Lake Dam for 1980-1982, 1989-1991, and 2003-2012 and for Copperas Cove in 1997 and 2013. Source: National Climatic Data Center (NCDC, 2018).

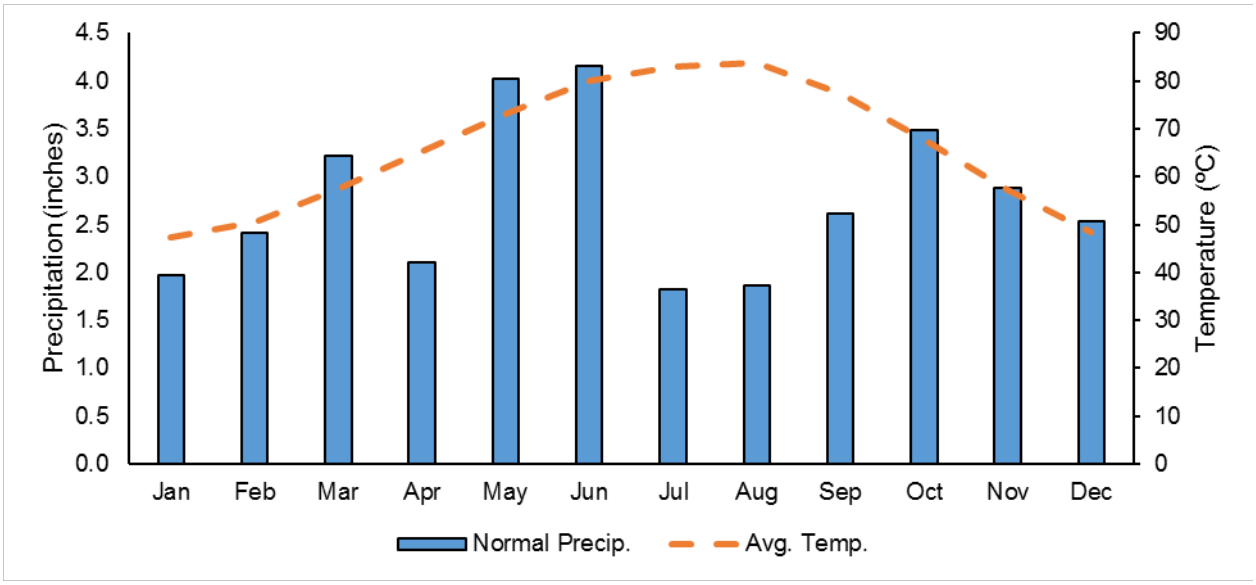

Figure 2-3 Monthly normal precipitation and average temperature for Killeen, Texas. Source: National Climate Data Center, monthly normals represent averages over three decades from 1981-2010 (NCDC, 2014).

Hydrology

Watershed hydrology is influenced by the interplay of rainfall with topography, land cover, soils, and geology. Other factors influencing the hydrology of Nolan Creek/South Nolan Creek includes permitted discharges that add flow at various points, water rights that remove or divert water, and surface impoundments that store water, many of which were designed to aid with flood control (Figure 2-4).

Streamflow

Historical streamflow data for Nolan Creek/South Nolan Creek is limited. Only one United States Geological Survey (USGS) gaging station, 08102600 on Nolan Creek at Belton, has historical data (Figure 2-4; USGS, 1984). Streamflow at station 08102600, which was located at the crossing of Interstate 35 below Confederate Park, was measured from January 31, 1974 through November 3, 1982 (Figure 2-5). During this period, median discharge for station 08102600 was 39 cubic feet per second (cfs) and the lowest average daily flow reported was 9 cfs. At least 50 percent of the time, flows were 30 cfs or less (Figure 2-6). Only about 12 percent of the time were flows greater than 100 cfs and less than 1 percent of the time were flows greater than 1,000 cfs. In comparing long-term flow with precipitation data, the pattern of average monthly flows generally follows that of precipitation the highest average flows in May and June and some of the lowest flows in the summer months of July, August, and September (see Figures 2-3 and 2-7). In late March 2018, the USGS started recording gage height at station 08102595 for Nolan Creek at South Penelope in Belton, Texas, which should provide important future information aiding management of this watershed. This gaging station is not shown in Figure 2-4 because due to the scale of the map, it would overlay the same general location as station 08102600.

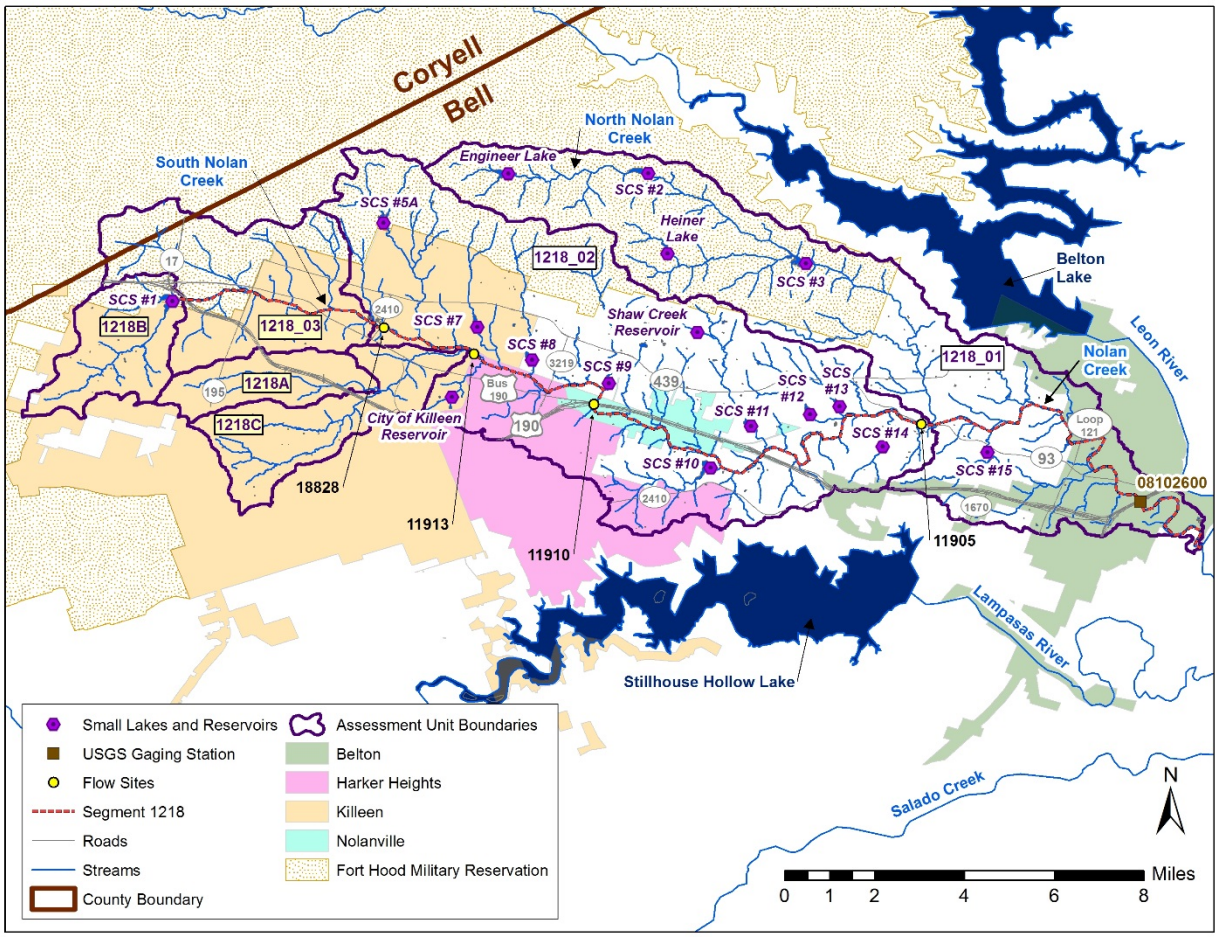

Figure 2-4 Hydrologic features within the Nolan Creek/South Nolan Creek watershed.

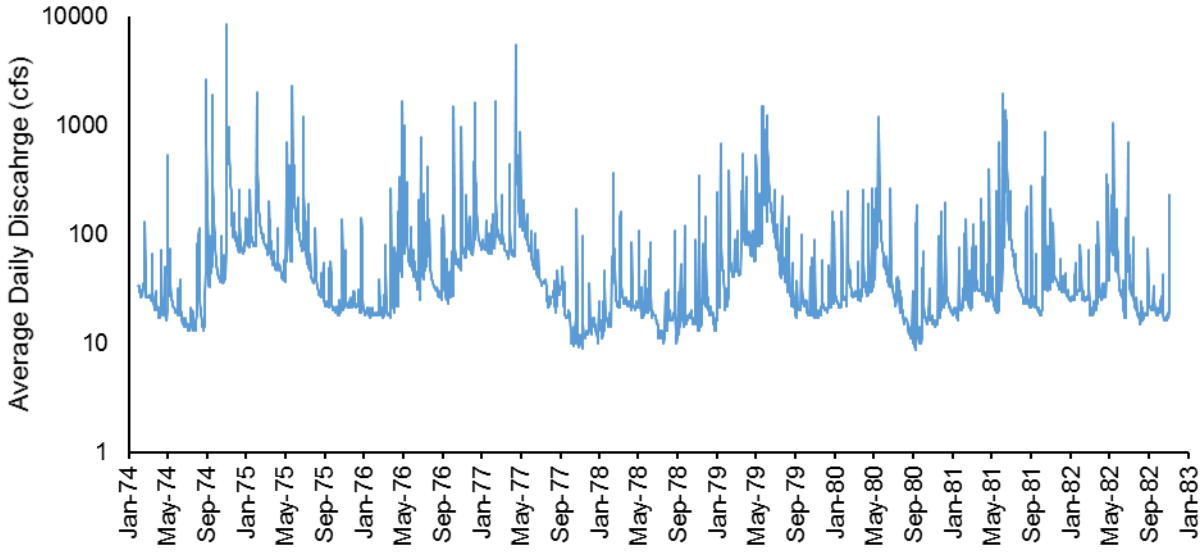

Figure 2-5 USGS daily data for station 08102600 on Nolan Creek at Belton, Texas. Daily values for January 31, 1974 through November 3, 1983. Source: USGS (1984).

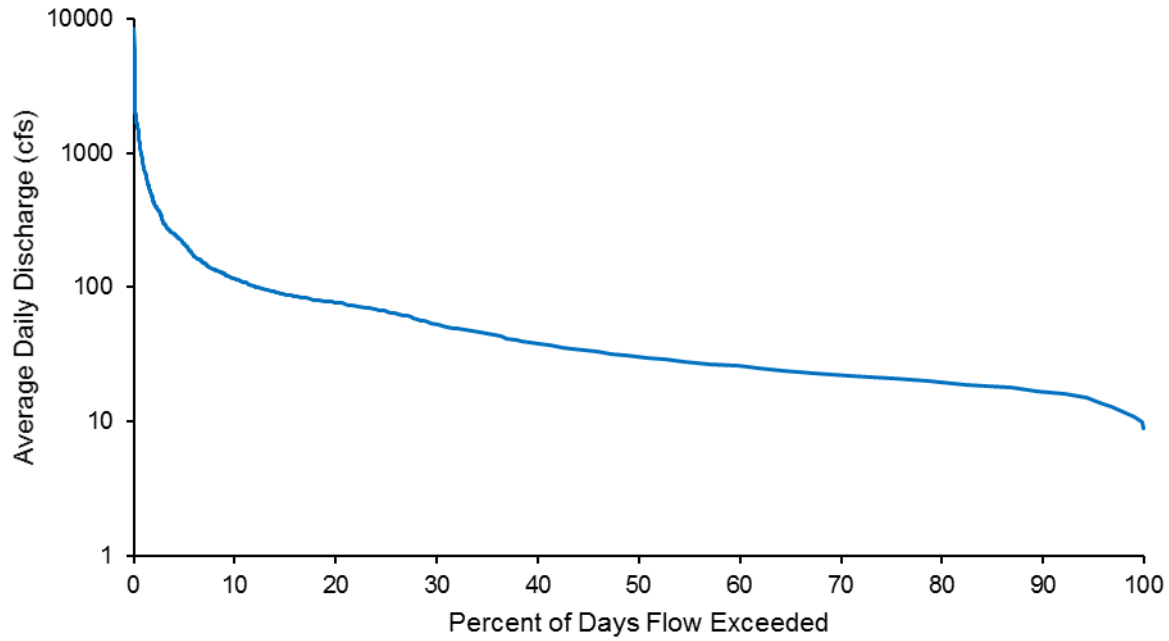

Figure 2-6 Flow duration curve based on daily data from January 31, 1974 through November 3, 1982 for station 08102600 on Nolan Creek at Belton, Texas. Source: USGS (1984).

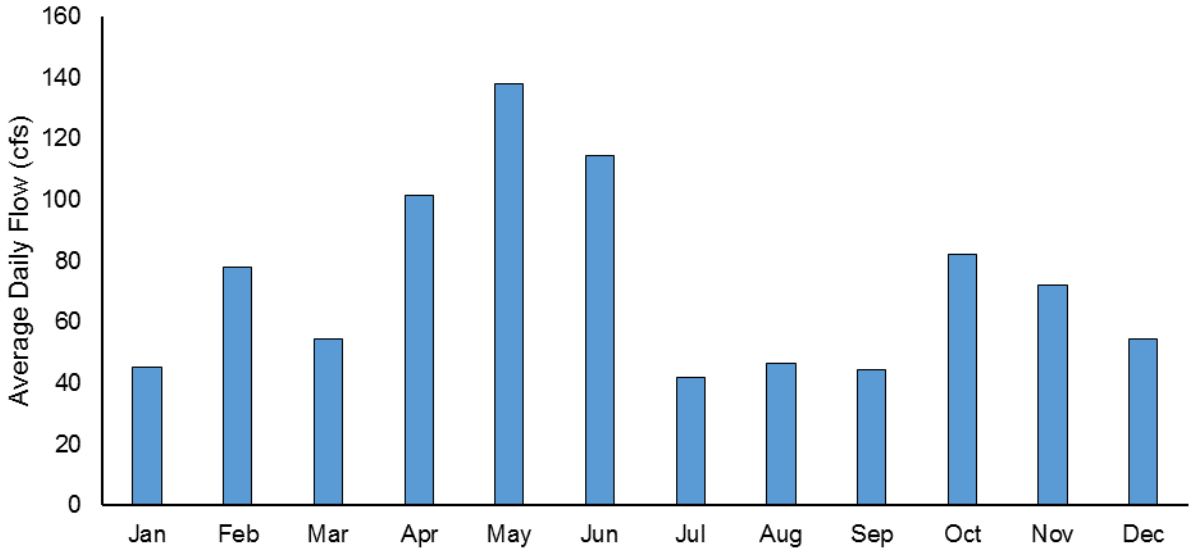

Figure 2-7 USGS average monthly data (1974-1981) for station 08102600 on Nolan Creek at Belton, Texas. Source: USGS (1984).

Some continuous flow data has been collected as part of special projects. As part of a characterization project, four flowmeters were installed in July 2013 through June 2015 at TCEQ stations 18828 on South Nolan Creek at 38th Street in Killeen, 11913 on South Nolan Creek at Roy Reynolds Road in Killeen, 11910 at US 190 in Nolanville, and 11905 at Backstrom Crossing (Figure 2-4; McFarland and Adams, 2016a).

Due to flooding concerns, municipalities and Bell County have jointly installed stream elevation monitors at five locations along Nolan Creek/South Nolan Creek to provide real-time information. These stream five level stations are located at Twin Creek Road in Killeen, Roy Reynolds Road in Harker Heights, Paddy Hamilton Road between Nolanville and Belton, North Wheat Road just west of Belton, and Main Street in Belton. Stream level data from these stations can be accessed by the public via the Belton website (http://www.beltontexas.gov/departments/parks_and_recreation/nolan_creek.php).

Groundwater

Most of the Nolan Creek/South Nolan Creek watershed overlays the outcrop of the Trinity Aquifer (George, et al., 2011) with the fractured limestone producing springs providing year-round flow to the headwaters. Baseflow in the headwaters of South Nolan Creek most notably comes from seeps and small springs occurring where shallow soils overlie limestone that has weathered within the karst bedrock. Drinking water for municipalities within the watershed comes from Lake Belton as surface water, but groundwater does provide drinking water to some private residences with well depths to the Trinity Aquifer often greater than 500 ft.

Bell County is part of the Clearwater Underground Water Conservation District. The Texas Water Development Board in cooperation with the Clearwater Underground Water Conservation District maintains three monitoring wells in Bell County that reach down into the Trinity Aquifer. Of these three wells, one (State Well 4058201) resides within the most western portion of the South Nolan Creek watershed.

Permitted Discharges

There are eight permitted point source outfalls along Nolan Creek/South Nolan Creek providing discharges from wastewater treatment facilities (WWTFs) (Table 2-2). These effluent discharges supplement groundwater providing a continuous source of baseflow to the creek (Figure 2-8). In the upper portion of South Nolan Creek, discharges from the Bell County WCID No. 1 Main Plant and Plant 2 represent about 92 percent of baseflow based on monthly field measurements between May 2013 and June 2015 upstream and downstream of the discharge point (McFarland and Adams, 2015a). All eight WWTFs have an average daily discharge limit for *E. coli* of 126 MPN/100 mL and a daily maximum of 399 MPN/100 mL. Nutrient limitations for permitted discharges within the watershed exist only for ammonia at 5 to 6 mg/L as a daily average. Bell County WCID No. 1 (Plant 3, South Plant) as of August 27, 2015 amended its permit for a second discharge into Trimmeir Creek, which is outside the watershed area. The Bell County WCID No. 1 (Plant 3, South Plant) does have a total phosphorus limitation of 1 mg/L as a daily average for discharges into Trimmier Creek, but as of September 2018 had not yet discharged any effluent to Trimmeir Creek. More information regarding the split in discharge from the Bell County WCID No. 1 (Plant 3, South Plant) is presented in Section 5.

Table 2-2 Permitted WWTF within the Nolan Creek/South Nolan Creek watershed. Source: Central Registry TCEQ. Facilities listed in order from east to west.

Facility Name	Operator	TCEQ Permit #	Permitted Discharge (Million Gallons per day, MGD)	Permitted Discharge (cfs)
Universal Services Fort Hood WWTF	Universal Services Fort Hood, Inc.	WQ0013358001	0.09	0.14
Bell County WCID No. 1 (Plant 2)	Bell County WCID No. 1	WQ0010351003	6	9.3
Bell County WCID No. 1 WWTF (Main Plant)	Bell County WCID No. 1	WQ0010351002	18	27.9
City of Harker Heights WWTF	City of Harker Heights	WQ0010155001	3	4.6
Bell County WCID No. 1 (Plant 3, South Plant)	Bell County WCID No. 1	WQ0014387001	6	9.3
Bell County WCID No. 3 WWTF	Bell County WCID No. 3	WQ0010797001	0.675	1
Blora WWTF	American Water Operations and Maintenance, Inc.	WQ0014994001	0.03	0.05
Temple Belton Regional WWTF	Brazos River Authority	WQ0011318001	10	15.5

Water Rights

Active water rights drawing from Nolan Creek/South Nolan Creek are limited with a total permitted diversion amount of about 740 acre-ft per year based on information from TCEQ. Almost all water rights are for irrigation. This small amount represents less than 3 percent at median stream flows (39 cfs), with diversions representing a negligible amount on average of total annual flow (< 0.0001 percent).

Surface Water Impoundments

Other hydrologic features in the watershed include 2 small lakes and 15 reservoirs, 13 of which are Soil Conservation Service (SCS) reservoirs (Figure 2-4). Many of these SCS reservoirs were built in the 1950s and 60s for flood control. Bell County WCID No. 6 operates and maintain 13 of these SCS reservoirs, while other reservoirs and lakes in the watershed are privately maintained. These small water bodies capture and slow down the release of stormwater aiding flood control during storms. After storm events, discharge from these reservoirs is limited, and they are not considered to provide a steady source of baseflow to the creek (Wolfe, 2014).

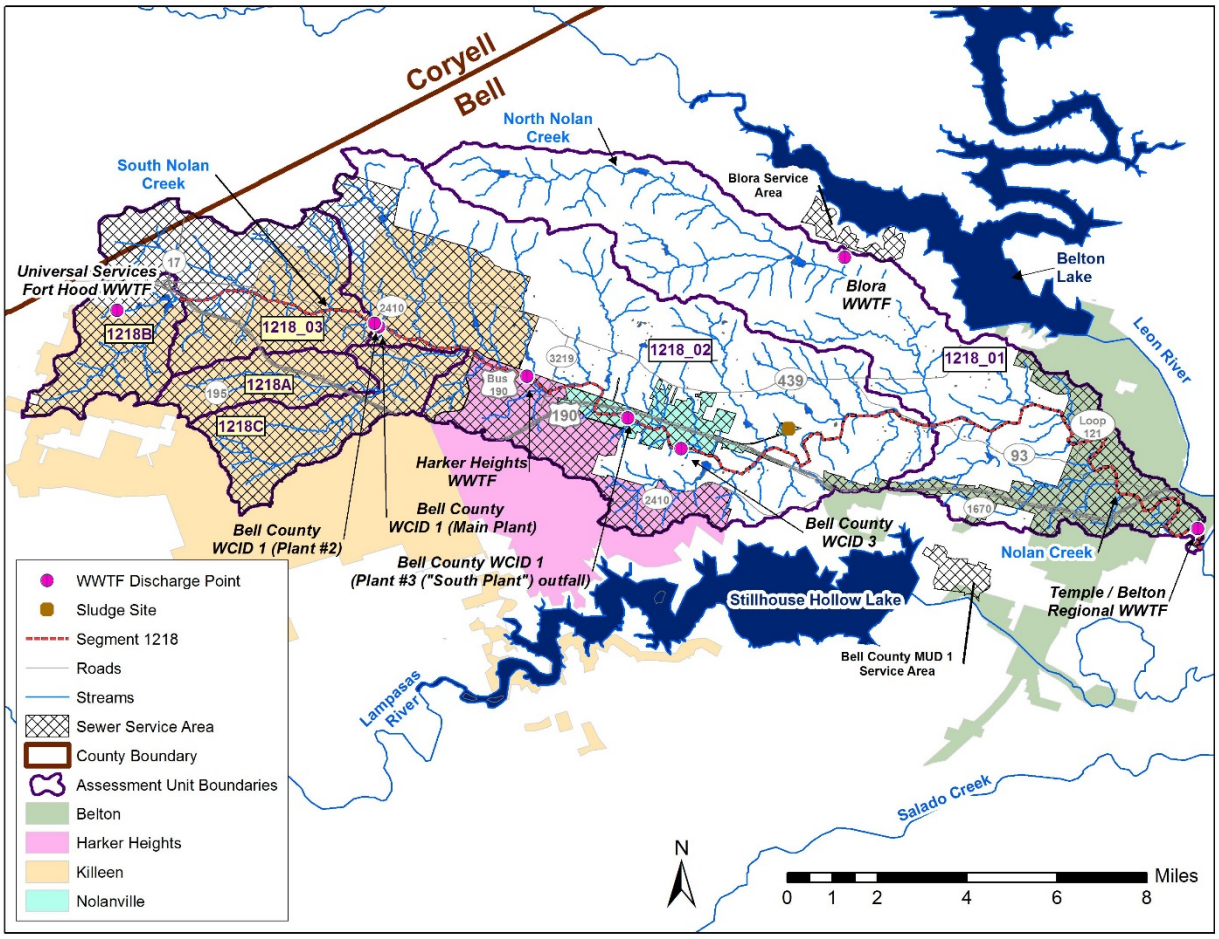

Figure 2-8 Location of WWTF discharges and service areas for wastewater collection for the Nolan Creek/South Nolan Creek watershed. Note: The service areas are based on Certificates of Convenience and Necessity (CCN) and municipal boundaries within the watershed. Some WWTFs have service areas that extend outside the watershed boundary but largely follow municipal boundaries.

Recreational Use

Recreational use of South Nolan/Nolan Creek varies from its headwaters northwest of Killeen to its confluence with the Leon River southeast of Belton. Low flows generally limit recreational use in the areas of Killeen and Harker Heights to noncontact activities, such as walking or biking along trails near the creek. Several parks and hiking trails exist along or near the creek or its tributaries, including the Community Center and Long Branch Parks in Killeen, the Booker Green Space and Summit Soccer Complex in Harker Heights, and the Lions, Harris Community, Yettie Polk, and Confederate Parks in Belton. As flows increase, secondary contact recreation activities increase, such as fishing and wading by adults, which have been observed below the US 190 in Nolanville. More downstream during periods with adequate baseflow, kayaking and canoeing are common activities, and primary contact recreation activities including swimming and wading by children has been observed (Winemiller et al., 2010).

SECTION 3

Estimating Needed Load Reductions

In determining needed load reductions to meet water quality criterion, it is useful to relate measured concentrations to the amount of flow occurring when samples were collected. Relating concentration to flow allows calculation of a loading (e.g., for bacteria MPN/day). Comparing estimated loadings from measured concentrations to loadings based on our target concentration (126 MPN/100 mL) can aid in indicating the dominant type of contributing sources (point or nonpoint). This kind of graphical presentation is referred to as a load duration curve (LDC). The LDC approach was developed as an aid in assessing nutrient water quality issues in streams (EPA, 2007) and is now commonly used in evaluating bacteria issues (e.g., Johnson et al., 2009; Prcin et al., 2013). Several publications promote the use of a LDC approach in evaluating water quality problems, particularly in watersheds with limited stream data, and provide detailed guidance on LDC development and interpretation (e.g., Morrison and Bonta, 2008; EPA, 2007; Bonta and Cleland, 2003; Cleland, 2002; 2003; Bonta, 2002).

By relating loads to flow conditions, LDCs assist in determining patterns in pollution loadings with varying streamflow. If exceedances occur primarily during low flow conditions, then point sources are likely the contributing source. If exceedances occur primarily during high flow conditions, then nonpoint sources are likely the contributing source. Load duration curves are also important as aid in estimating load reductions needed from management measures to meet the water quality target.

The LDC methodology is simple to apply and effective in differentiating point and nonpoint contributions based on flow regime (EPA, 2007; Cleland, 2003). The flow regime is defined using a duration curve, which is a graph that illustrates the percentage of time a given flow is equaled or exceeded based on long-term stream data (see Figure 2-6). The flow duration curve (FDC) identifies general hydrologic conditions (i.e., wet versus dry) and generally how long each condition occurs (Cleland, 2003). For example in Figure 2-6, average daily flows exceed 54 cfs 30 percent of the time and 30 cfs 50 percent of the time for Nolan Creek. Average daily flows exceed 9 cfs 100 percent of the time.

A LDC, which is related to the FDC, shows the corresponding relationship between contaminant loadings and stream flows for a given station and is developed by associating a concentration, generally the water quality criterion or screening level, with each flow value to develop a series of allowable loadings. Monitoring data representing the concentration of the constituent of interest collected at a given flow is then overlaid with the allowable LDC to aid in identifying flow conditions under which allowable or desired loads are exceeded.

Flow Duration Curves

For the Nolan Creek/South Nolan Creek watershed, FDCs and LDCs were developed for four locations (Figure 3-1).

- 18828 located on South Nolan Creek at 38th Street in Killeen,
- 11913 located on South Nolan Creek at Roy Reynolds Road in Killeen,
- 11910 located on South Nolan Creek at US Highway 190 in Nolanville, and
- 11905 located on South Nolan Creek at Backstrom Crossing.

These stations were intensively monitored between May 2013 and June 2015 under a variety of flow conditions including routine monthly monitoring and some biased storm monitoring. The raw water quality data used in the LDC presented below can be found in the report, *Characterizing Water Quality within Nolan Creek/South Nolan Creek* (McFarland and Adams, 2016a). The location of WWTF discharges is shown as an important contributor of flow to the creek, particularly during low flow conditions (Table 2-2 and Figure 3-1).

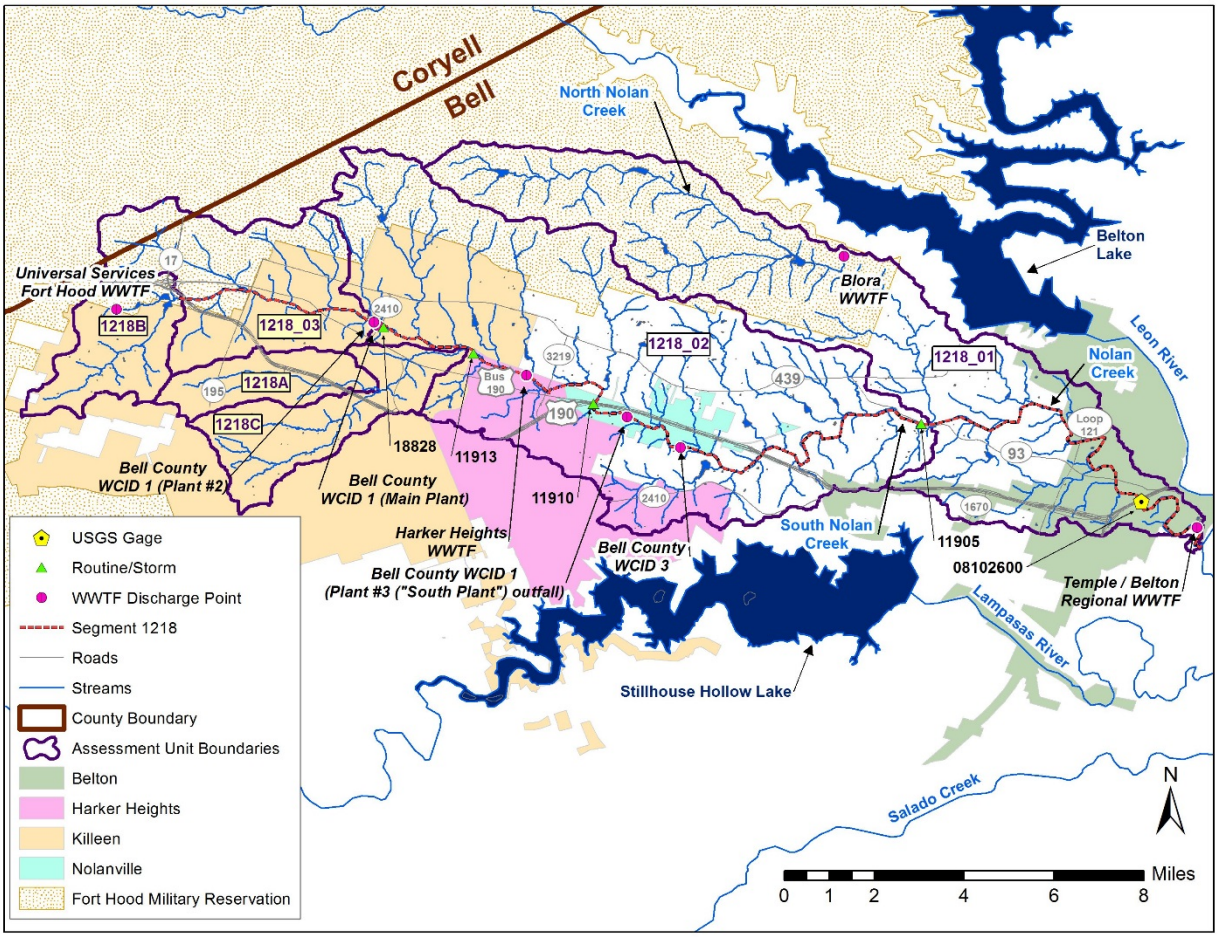

Figure 3-1 Monitoring stations and wastewater treatment facility (WWTF) discharge locations used in FDCs and LDCs along Nolan Creek/South Nolan Creek.

Because streamflow data for these four stations were very limited (less than 2 yrs), FDCs were estimated from historical flows monitored at USGS station 08102600 on Nolan Creek at Belton as the best available long-term data (see Figure 2-6; USGS, 1984). Drainage area ratios were developed between each monitoring station and the USGS station on Nolan Creek (Table 3-1). Discharges from WWTFs can be prominent contributors to stream flow, especially during periods of low flow. Estimates of the average daily discharge from each WWTF were obtained from the EPA Enforcement and Compliance History Online (ECHO) website for each facility that discharged above station 08102600 (Table 3-2). Of note, the Temple Belton Regional WWTF discharges below the location of station 08102600, and, thus, flows for the Temple Belton Region WWTF are not included in Table 3-2. Also, reported discharges for Bell County WCID No. 1 (Plant 2) are zero (see Table 3-2), because the discharges for this facility are included with the reported discharges for the Bell County WCID No. 1 WWTF (Main Plant).

The FDC for USGS station 08102600 (shown in Figure 2-6) was generated by

1) Ranking daily flows from highest to lowest
2) Calculating the percent of days each flow value was exceeded (rank/(number of data points)*100
3) Plotting each flow value (y-axis) against it exceedance value (x-axis).

The FDCs for each monitoring station were then estimated from the FDC for station 08102600 by first adjusting the streamflow record by removing the estimated WWTF discharges. Estimated WWTF discharges were based on the mean of reported values (Table 3-2). This adjusted streamflow was then multiplied by the drainage area ratio (DAR) for each monitoring station and then the estimated WWTF discharge above each monitoring station was added to the DAR-adjusted flow (Figure 3-2).

Table 3-1 Area and drainage area ratios for monitoring stations compared to USGS station 08102600 on Nolan Creek.

Station	Area (acres)	Drainage Area Ratio
18828	12,388	0.173
11931	24,089	0.336
11910	34,072	0.475
11905	49,415	0.689
USGS 08102600	71,680	1.000

More details regarding development of these FDCs can be found in the report, *Characterizing Potential Pollutant Loads to Nolan Creek/South Nolan Creek* (McFarland and Adams, 2016b).

Table 3-2 Estimated average daily discharge from WWTFs above station 08102600 on Nolan Creek/South Nolan Creek. Source: EPA ECHO (https://echo.epa.gov/), data accessed in August 2015.

EPA ID	Facility Name	Mean (MGD)	Median (MGD)	Standard Deviation (MGD)	Min. (MGD)	Max. (MGD)	First Record Used	Last Record Used	Number of Obs.
TX0101869	Universal Services Ft Hood WWTF	0.05	0.05	0.01	0.04	0.06	Aug-10	May-15	58
TX0024597	Bell County WCID No. 1 WWTF (Main Plant)	11.2	10.8	1.82	8.77	18.7	Aug-10	Jun-15	59
TX0102938	Bell County WCID No. 1 (Plant 2)	0[a]	0[a]	0[a]	0[a]	0[a]	Aug-10	Mar-13	0[a]
TX0024473	City of Harker Heights WWTF	1.86	1.83	0.29	1.53	3.25	Aug-10	Jun-15	59
TX0125377	Bell County WCID No. 1 (Plant 3, South Plant)	2.55	2.81	0.88	0.81	4.49	Aug-10	Jun-15	59
TX0069191	Bell County WCID No. 3 WWTF	0.31	0.24	0.42	0.15	2.86	Apr-12	Jun-15	39
TX0132446	Blora WWTF	0.01	0.01	0.01	0.00	0.03	Jul-11	Jun-15	48

a. Reported discharges for the Bell County WCID No. 1 (Plant 2) are included with reported values for Bell County WCID No. 1 (Main Plant).

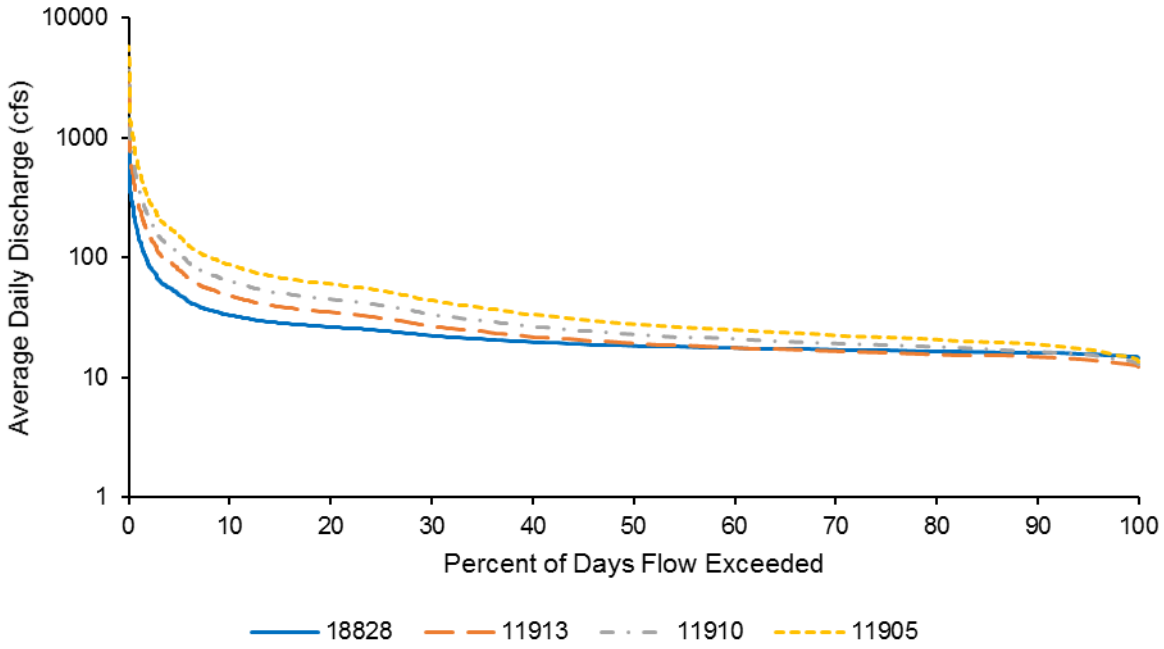

Figure 3-2 Estimated FDCs for stations along Nolan Creek/South Nolan Creek.

Load Duration Curves

To convert FDCs into LDCs, flow data are multiplied by a threshold or target concentration. For freshwater, *Escherichia coli* is used as the indicator bacteria, and the geometric mean criterion for *E. coli* of 126 MPN/100 mL from the Texas State Water Quality Standards was used as the target level for LDCs. (As nutrients are also a concern in this watershed, relevant LDCs for nutrients are presented in Appendix A.)

Measured data were then superimposed on the graph showing allowable loads by obtaining the load for each sample based on its concentration and flow and relating the measured flow with the corresponding percent exceedance from the FDC. Values below the allowable loading line are considered "in compliance" while values above the allowable loading line are considered "out of compliance." To further inform, measured data were categorized as influenced by wet or dry weather conditions based on the parameter "days since last significant precipitation" (DSLP, parameter code 72053). If DSLP was recorded as less than 4 days, the sample was considered wet-weather influenced.

The LDCs for bacteria are shown below (Figures 3-3 – 3-6). For all LDCs, the curve was divided into three flow-regimes representing high flows (0-10% exceedance), moderate flows (10-60% exceedance), and low flows (60-100% exceedance). In general, the high flow regime (0-10% exceedance) is related to flood conditions and nonpoint source loadings, the moderate flow regime (10-60% exceedance) is related to point and nonpoint source loadings, and the low flow regime (60-100% exceedance) is related to dry conditions and point source loadings. For reference, the geometric mean of measured values within each flow regime is shown at the midpoint of the percent days exceeded (Figures 3-3 – 3-6).

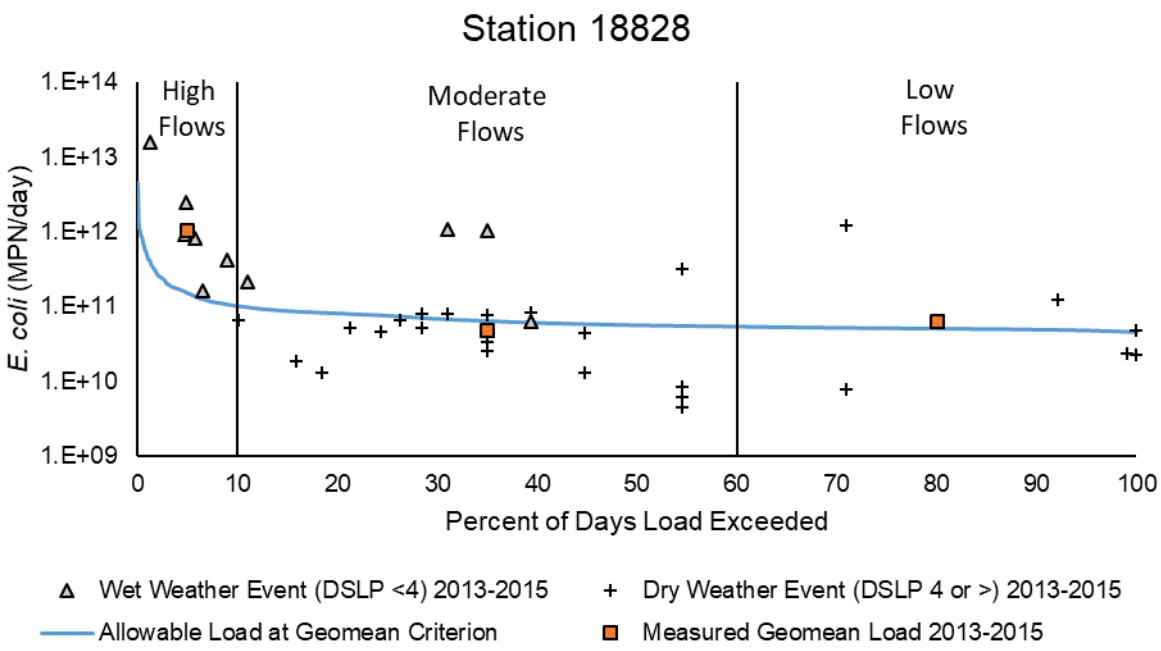

Figure 3-3 Load duration curve for station 18828, South Nolan Creek at 38th Street. Located directly below discharge for Bell County WCID No. 1 WWTF (Main Plant and Plant #2).

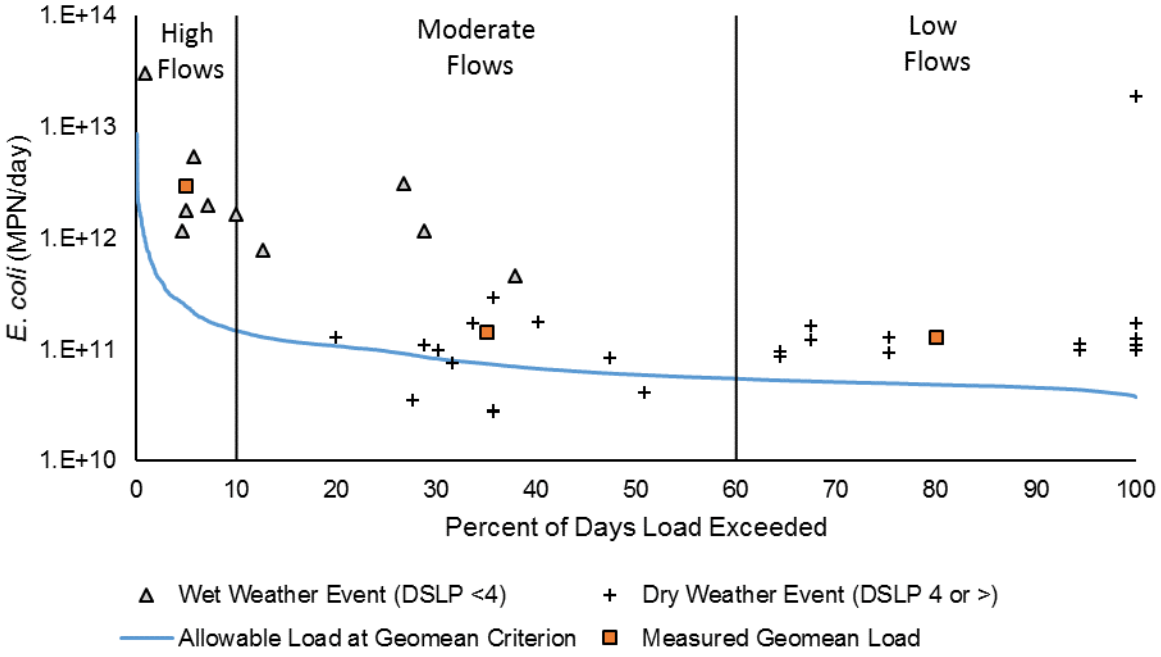

Figure 3-4 Load duration curve for station 11913, South Nolan Creek at Roy Reynolds Road on boundary between Killeen and Harker Heights. Value 77,000 MPN/100 mL collected on July 10, 2013 excluded from calculation of low flow geometric mean as representative of an SSO event since corrected.

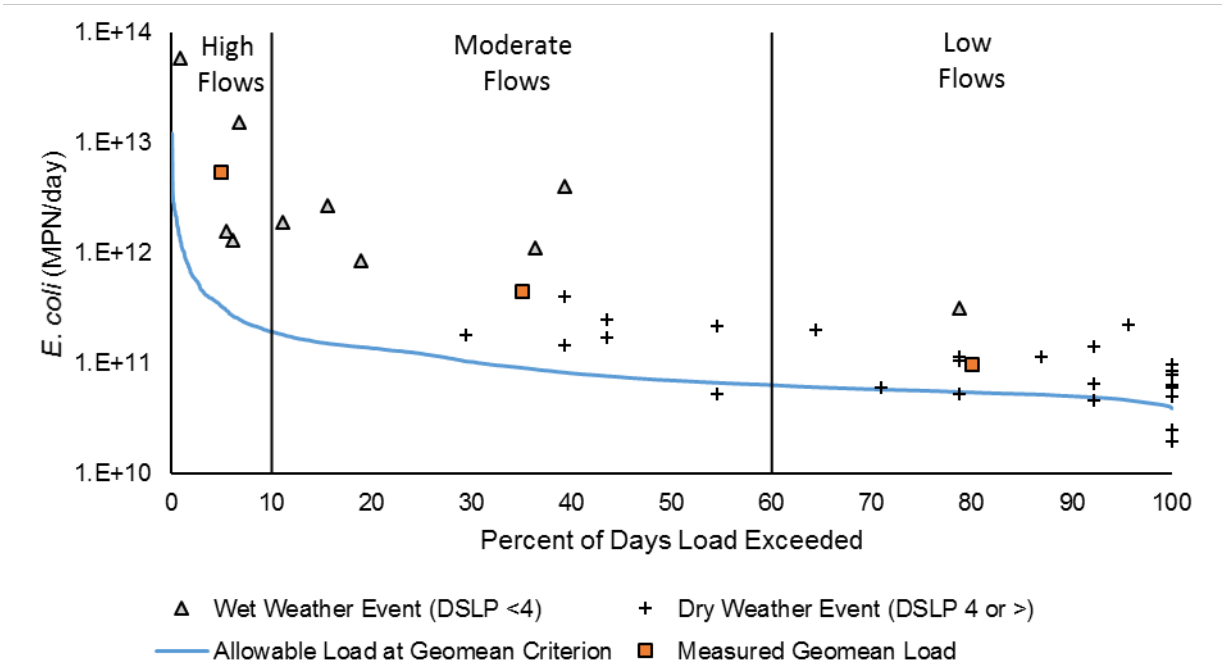

Figure 3-5 Load duration curve for station 11910, South Nolan Creek at US 190 in Nolanville.

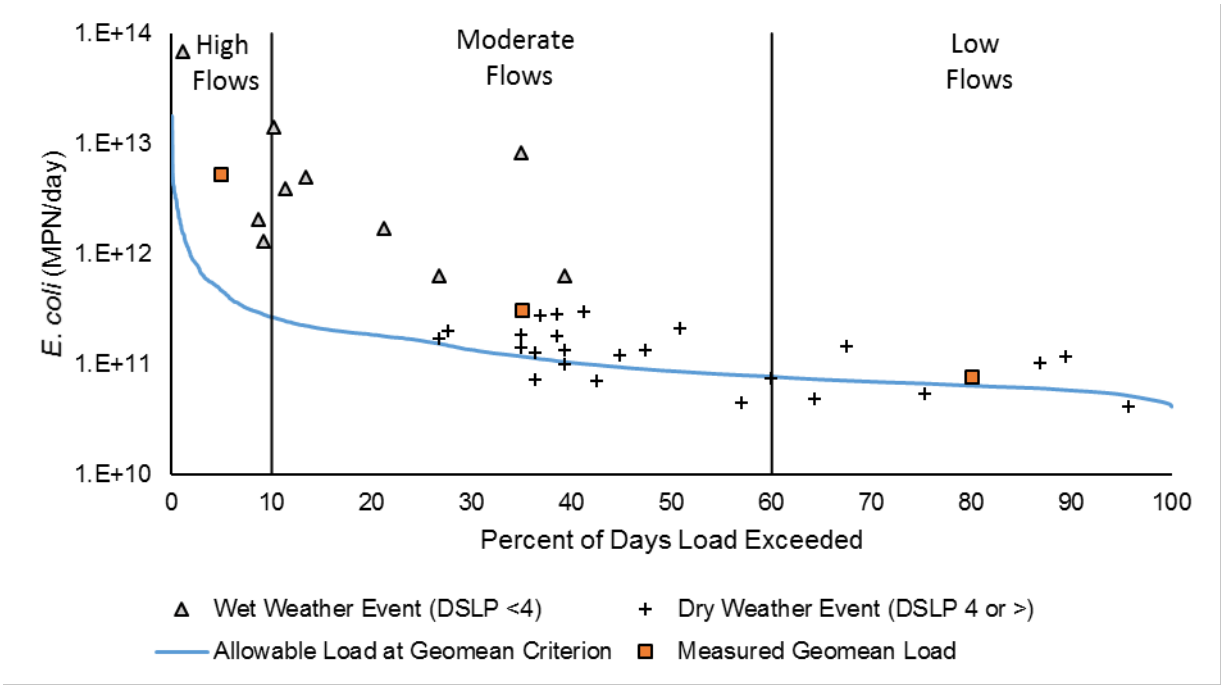

Figure 3-6 Load duration curve for station 11905, Nolan Creek at Backstrom Crossing between Nolanville and Belton.

For all four stations, measured bacteria loadings for high flows were associated with wet-weather events with all values exceeding the allowable loading based on the 126 MPN/100 mL criterion (Figures 3-3 – 3-6). For moderate flows, loadings during wet and dry events at all stations generally exceeded criterion loadings, except at station 18828. At station 18828, the most upstream station located along South Nolan Creek at 38th Street in the City of Killeen, most dry event samples collected under moderate flow conditions led to loadings below the criterion load. In almost all cases, loadings associated with wet-weather events lead to higher loadings than dry-weather events when monitored at similar flows. For low and high flows, all stations indicated geometric mean loadings above the criterion.

Estimated Load Reductions

To satisfy part of EPA's nine elements for watershed plans (EPA, 2008), bacterial reduction estimates were calculated within each flow regime. This was done for bacteria by taking the geometric mean of measured values by flow regime that were greater than the criterion and calculating the percent difference in relation to the criterion (126 MPN/100 mL) then dividing that difference by the measured geometric mean concentration (Table 3-3). The end result is load reductions needed to meet the water quality criteria for *E. coli*.

At station 11913 off Roy Reynolds Road, there was one very high bacteria value (77,000 MPN/100 mL) at station 11913 that occurred during low flows in association with a sample collected on July 10, 2013. This stream sample was related to a sewage discharge reported on July 2, 2013 (see McFarland and Adams, 2015b). This value of 77,000 MPN/100 mL was removed prior to calculating load reductions as an outlier representing a localized problem that has been fixed (Table 3-3). No other data points were removed in calculating needed load reductions.

Table 3-3 Geometric mean concentrations of measured bacteria values by flow regime and estimated percent reductions needed to meet the primary contact recreation criterion of 126 MPN/100 mL for four stations along Nolan Creek/South Nolan Creek. Zero percent reductions (shaded in grey) indicate the criterion is already met and reductions are not necessary.

Station	High Flows (0-10%)		Moderate Flows (10-60%)		Low Flows 60-100%)	
	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction	Geometric Mean *E. coli* (MPN/100 mL)	Estimated Percent Reduction
18828	865	85%	95	0%	155	19%
11913	1521	92%	243	48%	335	62%[a]
11910	2049	94%	616	80%	227	44%
11905	1405	91%	326	61%	149	16%

a. Value of 77,000 MPN/100 mL removed prior to calculating load reductions as an outlier representative of a SSO problem that has since been fixed.

Load reductions to meet the water quality target highlight the influence of nonpoint source pollution with the much larger reductions needed within the high and moderate flow regimes. The highest estimated load reductions were noted during high flows with over 90 percent noted at all four stations. For moderate flows, no reductions were noted as needed for station 18828. The highest percent reduction during moderate flows was noted at station 11910 for Nolan Creek at US 190. The highest percent reduction during low flows was noted at station 11913 on South Nolan Creek at Roy Reynolds Road between the City of Killeen and the City of Harker Heights. At station 11913 off Roy Reynolds Road, higher load reductions were indicated at low flows than moderate flows, potentially indicating a point source influence.

Of note, Figure 3-3 and values in Table 3-3 for station 18828 differ a little from those presented in the report by McFarland and Adams (2016) as an error was found in the in calculation of the measured geometric mean for moderate and low flow conditions. In McFarland and Adams (2016), 50 percent rather than 60 percent flow exceedance was found to have been used to divide measured points into moderate and low flow categories for calculation of the geometric mean. Also, some measured points for the LDC figure for station 18828 had been hidden as the y-axis in this previous report extended only to 1.E+10 rather than to 1.E+9 *E. coli* (MPN/day).

SECTION 4

Potential Pollutant Sources

While LDCs are useful in identifying pollutants as coming from primarily point or nonpoint sources, other tools are needed to help differentiate potential sources within these two broad categories. Besides LDCs, a source survey was conducted within the watershed. This source survey included a visual assessment with input from stakeholders as well as an intensive data inventory including information on land uses, WWTF discharges, unauthorized discharges (sewer system overflows), on-site sewage facilities (OSSFs), livestock densities, and other potential sources (see McFarland and Adams, 2015a; 2015b).

To aid in evaluating potential contributions from many of these sources, the Spatially Explicit Load Enrichment Calculation Tool (SELECT) was used. Researchers with the Department of Biological and Agricultural Engineering and the Spatial Science Laboratory at Texas A&M University developed SELECT for use as a screening tool for evaluating potential bacteria loads from various sources within a watershed (Teague, et al., 2009). Within a watershed, SELECT calculates potential bacteria loadings from various sources and then spatially allocates these loadings, largely based on land-use. The end product from SELECT is a series of maps that allow a visual assessment of the distribution of potential loadings to the land surface, throughout the watershed.

Potential loadings estimated via SELECT do not take into account losses associated with treatment or transport across the landscape or instream (Teague et al., 2009). These potential loadings present what might be considered a "worst case" scenario assuming all fecal material produced by a given source makes it into the stream system. With biological transport processes, there are some losses of bacteria loadings from the landscape to the stream system, as well as die-off and regrowth that can occur over time instream. The details associated with the fate and transport processes of bacteria are quite complex (e.g., Benham et al., 2006 and Vidon et al., 2008) and are outside the scope and purpose of SELECT. The purpose of SELECT is to target potential sources and contributing areas within a watershed to focus implementation of bacteria control practices and educational efforts; not to calculate explicit loadings.

SELECT Methodology

To estimate potential bacteria loadings by source for a watershed, SELECT relies on land-use classification data integrated with information regarding the soils, the layout of the stream network, human population and animal densities, as well as the location and discharge of point sources, such as municipal WWTFs. Many of the inputs used for SELECT were identified in the data inventory and source survey reports completed for this project (McFarland and Adams, 2015a; 2015b). Input from local stakeholders was also important in deriving the types and densities of potential pollution sources and feedback on preliminary inputs was obtained from stakeholders at the September 25, 2014 meeting of the Nolan Creek Partnership. For the Nolan

Creek/South Nolan Creek watershed, the following source categories were evaluated using SELECT:

Regulated Sources
- Municipal Wastewater Discharges
- Urban Stormwater Runoff

Non-Regulated Sources
- Cattle
- Sheep/Goats
- Horses (including ponies, mules, burros, and donkeys)
- Feral Hogs
- Deer
- Dogs
- On-Site Sewage Facilities (often referred to as septic systems)

While wildlife besides deer was also identified as a potential source, SELECT at this time is unable to include small wildlife, such as waterfowl, birds, raccoons, opossums, and skunks. For small wildlife, the appropriate animal density and fecal production data are not yet available for integration into SELECT (Borel et al., 2012). Also, unauthorized discharges from sanitary sewer overflows (SSOs) were not included in SELECT as there is not a consistent loading or loading point that can be associated with SSOs. The potential contribution from SSOs is better targeted through SSO reports and monitoring (see McFarland and Adams, 2015a; 2015b).

To aid in targeting areas and potential sources across the landscape, SELECT divides the watershed into multiple subbasins based on elevation changes along tributaries and the mainstem of the river. To delineate subbasins, the ArcView Soil and Water Assessment Tool (AVSWAT, 2006; Di Luzio et al., 2002; 2004) was applied. A minimum subbasin (stream threshold) size of 200 acres was used for initial delineations. A few subbasins were then manually combined to obtain a more even distribution, resulting in 45 subbasins varying in size from 889 to 2,579 acres with an average subbasin size of 1,618 acres (Figure 4-1 and Table 4-1).

To calculate bacteria loadings for potential sources, such as livestock, an animal density and fecal production rate is needed, which is then related with particular land covers to estimate the distribution of animals across the watershed (Table 4-2). Fecal production rates for potential sources followed previous applications of SELECT (see Teague et al., 2009; Brazos River Authority and Espey Consultants, 2010; and Borel et al., 2012), which were based primarily on information provided in EPA guidance for *E. coli* (EPA, 2001).

Land use/land cover data were obtained from the 2011 National Land Cover Database. The 2011 National Land Cover Database applies a 30-meter spatial resolution and is based on circa 2011 Landsat satellite data (USGS, 2014). Defining the land use associated with each potential source is outlined in more detail below by category.

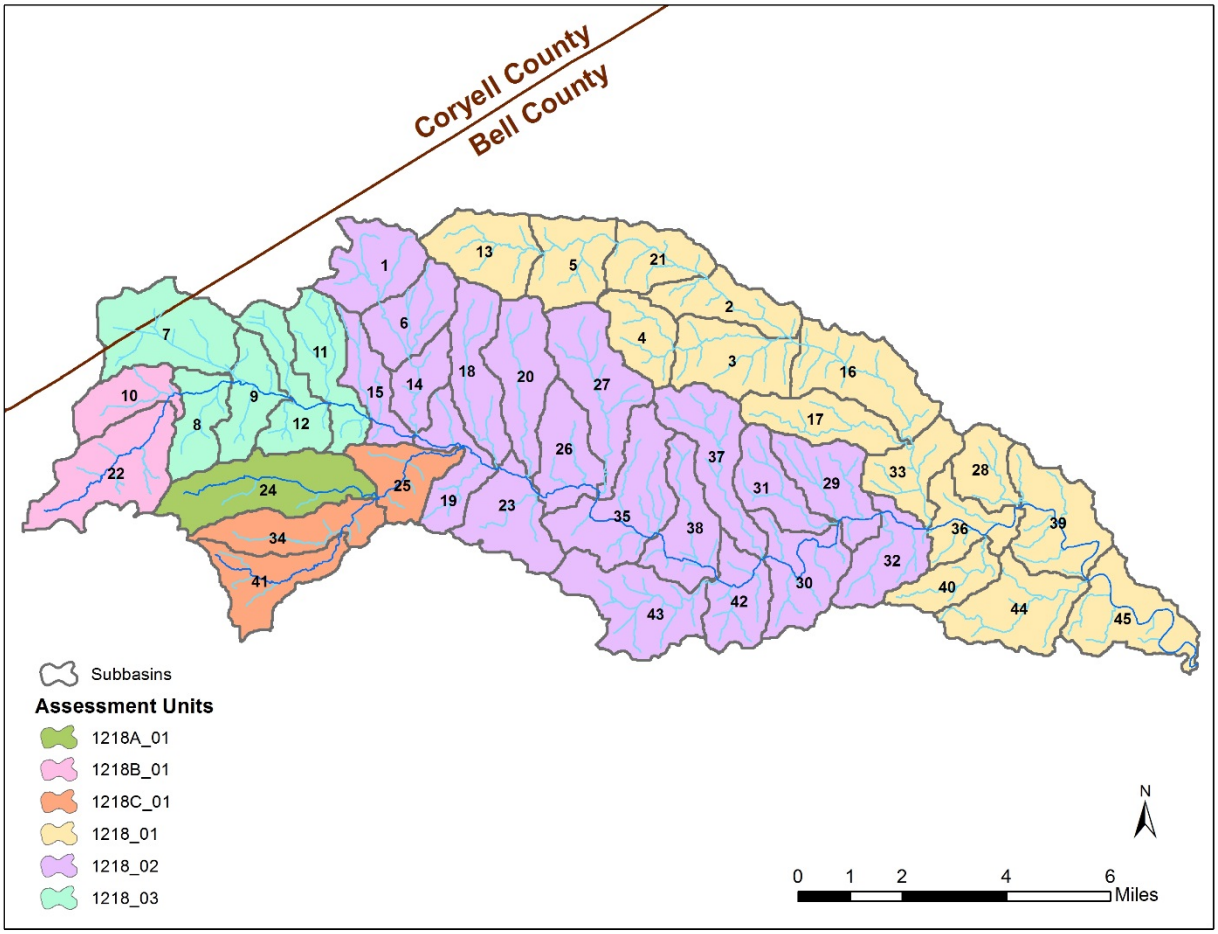

Figure 4-1 Delineated subbasins for Nolan Creek/South Nolan Creek watershed. Subbasins delineated using AVSWAT.

Table 4-1 Size of delineated subbasins grouped by assessment unit for Nolan Creek/South Nolan Creek watershed. Colors correspond to assessment units in Figure 4-1.

Associated AU	Subbasin #	Acres
1218A_01	24	2,579
1218B_01	10	1,116
1218B_01	22	2,472
1218C_01	25	1,265
1218C_01	34	1,603
1218C_01	41	1,560
1218_01	2	1,345
1218_01	3	1,905
1218_01	4	1,184
1218_01	16	2,225
1218_01	17	1,491
1218_01	28	985
1218_01	33	1,288

Associated AU	Subbasin #	Acres
1218_01	36	1,206
1218_01	39	2,069
1218_01	40	971
1218_01	44	2,025
1218_01	45	2,046
1218_01	13	1,704
1218_01	5	1,563
1218_01	21	1,312
1218_02	1	1,613
1218_02	6	1,388
1218_02	14	889
1218_02	15	1,059
1218_02	18	1,705
1218_02	19	1,346
1218_02	20	1,831
1218_02	23	1,671
1218_02	26	1,455
1218_02	27	2,287
1218_02	29	1,611
1218_02	30	1,753
1218_02	31	1,201
1218_02	32	1,454
1218_02	35	2,464
1218_02	37	1,932
1218_02	38	1,618
1218_02	42	1,351
1218_02	43	2,274
1218_03	7	2,424
1218_03	8	1,169
1218_03	9	1,260
1218_03	11	1,623
1218_03	12	1,521

Table 4-2 Production rates of *E. coli* by source. Source: EPA (2001).

Source	Production Rate, *E. coli* (cfu/day) [a]	Load Calculation (cfu/day)
Municipal Wastewater Discharges	126 cfu/100 mL[b]	Production rate times permitted discharge in milliliters
Urban Stormwater	$2.87x10^2$ to $1.04x10^6$ [c]	Estimated runoff volume times *E. coli* loading associated with impervious cover
Cattle	$10x10^9$ cfu/day * 0.5	Production rate times number of cattle
Sheep/Goats	$1.2x10^{10}$ cfu/day * 0.5	Production rate times number of sheep & goats
Horses	$4.2x10^8$ cfu/day * 0.5	Production rate times number of horses
Feral Hogs	$1.1x10^{10}$ cfu/day * 0.5	Production rate times number of hogs
Deer	$3.5x10^8$ cfu/day * 0.5	Production rate times number of deer
Dogs	$5x10^9$ cfu/day * 0.5	Production rate times number of dogs
On-Site Sewage Facilities	$10x10^6$ cfu/100 mL * 0.5	Production rate times potential failure discharge amount[d]

a. Production rate values are in colony forming units (cfu) per day and multiplied by 0.5 where appropriate to convert fecal coliform to *E. coli* using a conversion factor suggested by Doyle and Erikson (2006).
b. For permitted dischargers, the criterion of 126 cfu/100 mL associated with primarily contact recreation was used as the maximum potential production rate for bacteria.
c. Production rates for urban stormwater runoff based on estimates from a study by PBS&J (2000) with the curve adjusted for a zero intercept as the percent impervious cover reaches zero.
d. Failure rates for OSSFs were based on limitation classes for septic drainage fields of underlying soils within each subbasin.

Regulated Sources

Municipal Wastewater Discharges

There are eight permitted outfalls that discharge within the Nolan Creek/South Nolan Creek watershed (Table 4-3, Figure 2-8). Of note, the Bell County Water Control and Improvement District (WCID) No. 1 - Plant 3 facility, also known as the "South Plant", is physically located south of the watershed on 8290 Chaparral Road in Killeen, but discharges to South Nolan Creek

within the City of Nolanville. Managers at the WCID No. 1 - Plant 3 have indicated that their permit as of August 27, 2015, allows for 30 to 37 percent of the wastewater from this plant to be discharged to Trimmier Creek, outside the Nolan Creek/South Nolan Creek watershed. However, as of July 2018, no discharges from WCID No. 1 - Plant 3 have occurred to Trimmier Creek. Further information on changes to the discharge from the WCID No. 1 - Plant 3 are discussed with the management measures presented in Section 5. For evaluation with SELECT, the total discharge from WCID No. 1 - Plant 3 was assumed to discharge into South Nolan Creek. Within SELECT, the maximum permitted discharge and the *E. coli* concentration permit limit of 126 cfu/100 mL was applied to each subbasin with a WWTF outlet (Table 4-3).

Table 4-3 Potential loading rates and subbasin location for permitted dischargers within the Nolan Creek/South Nolan Creek watershed.

Facility Name	Subbasin of Outfall	Permit #	Permitted Discharge (MGD)	Potential Daily *E. coli* Loading (cfu/day)
Temple Belton Regional WWTF	45	WQ0011318001	10	4.74E+10
Bell County WCID No. 3 WWTF	38	WQ0010797001	0.675	3.20E+09
City of Harker Heights WWTF	23	WQ0010155001	3	1.42E+10
Bell County WCID No. 1 WWTF (Main Plant)	15	WQ0010351002	18	8.52E+10
Bell County WCID No. 1 (Plant 2)	15	WQ0010351003	6	2.84E+10
Bell County WCID No. 1 (Plant 3, South Plant)	35	WQ0014387001	6	2.84E+10
Universal Services Fort Hood WWTF	10	WQ0013358001	0.09	4.26E+08
BLORA WWTF	16	WQ0014994001	0.03	1.42E+08

a. Loadings for permitted dischargers were calculated as *E. coli* (cfu/day) = permitted MGD*(126 cfu/100 mL)*(10^6 gallons/MGD)*(3758.2 mL/gallon).

Potential loadings from WWTFs were associated with subbasins relative to the location of each discharge point (Figure 4-3). The maps from SELECT categorize loadings across subbasins with the lowest loadings noted in shades of green, moderate loadings in yellow to orange, and the highest loadings in shades of red. For potential loadings, the *E. coli* criterion of 126 cfu/100 mL is assumed, but in reality, WWTF discharges generally have a much lower bacteria concentrations reported for all eight facilities (see McFarland and Adams, 2015a). Compliance with the bacteria criterion is generally met by these WWTFs, although some compliance issues have arisen and are discussed in Section 5.

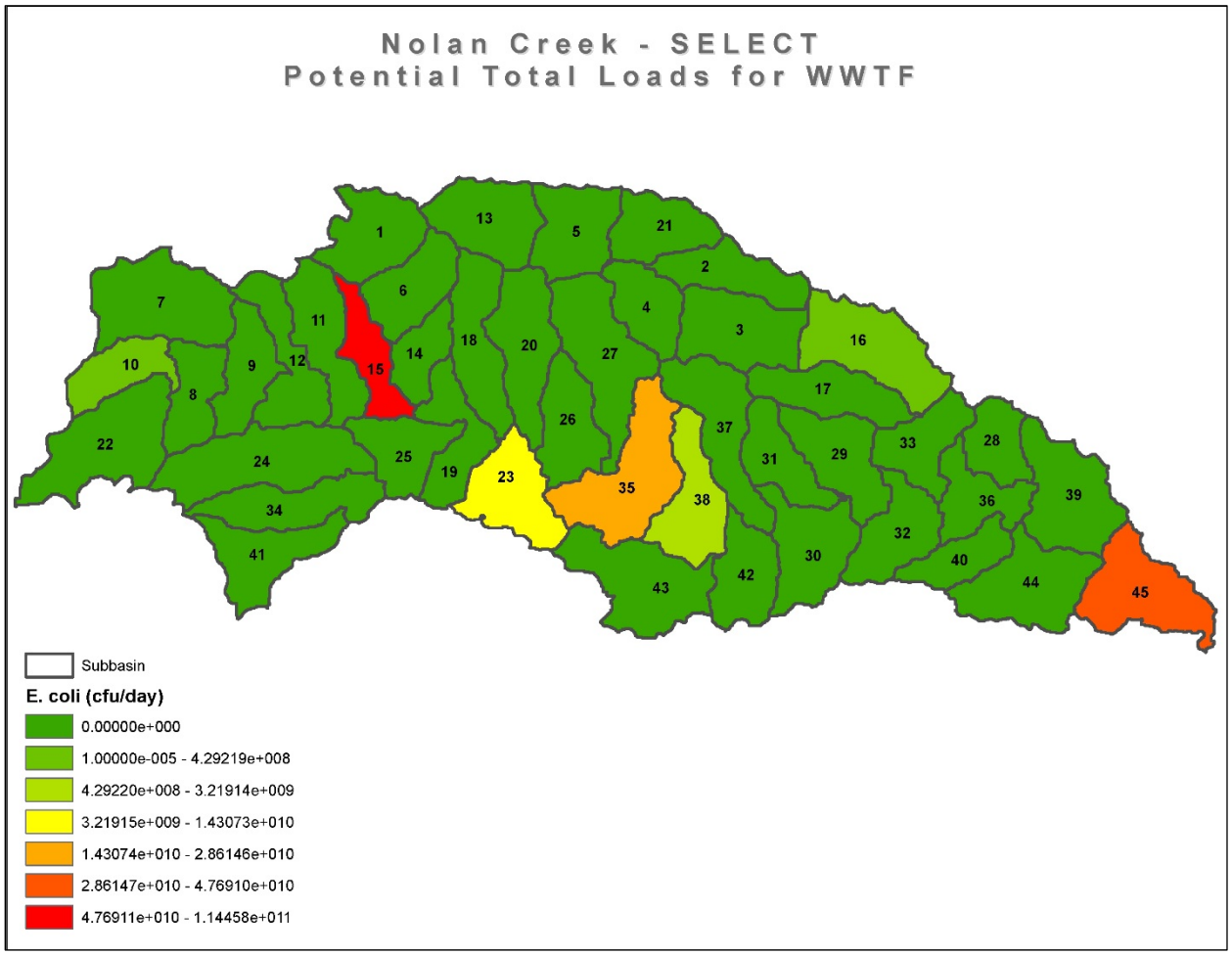

Figure 4-3 Distribution of potential *E. coli* loads from WWTFs by subbasin within the Nolan Creek/South Nolan Creek watershed.

Urban Stormwater Runoff

While SELECT was developed for rural watersheds, the urban area, represented by municipal separate storm sewer system (MS4) areas, can also be considered with some modifications (e.g., Ling et al., 2012). Estimating the contribution of bacteria from urban areas is more challenging with SELECT due to the large variety of potential sources. In using SELECT, potential loadings

from urban area have been associated with runoff amounts and the land area associated with impervious cover (e.g., Ling et al., 2012).

Stormwater runoff from urban areas falls under MS4 permitting regulations with the permitted "Urbanized Area" defined by the U.S. Census Bureau as areas with populations greater than 50,000 that have an overall population density of at least 1,000 people per square mile (Figure 4-4). Within these urbanized areas, the percentage of impervious cover is often related to developed land use/land cover. Because SELECT focuses on land use, the potential loadings from urban stormwater runoff were not limited to the MS4 boundaries, but focused on the impervious cover within each subbasin.

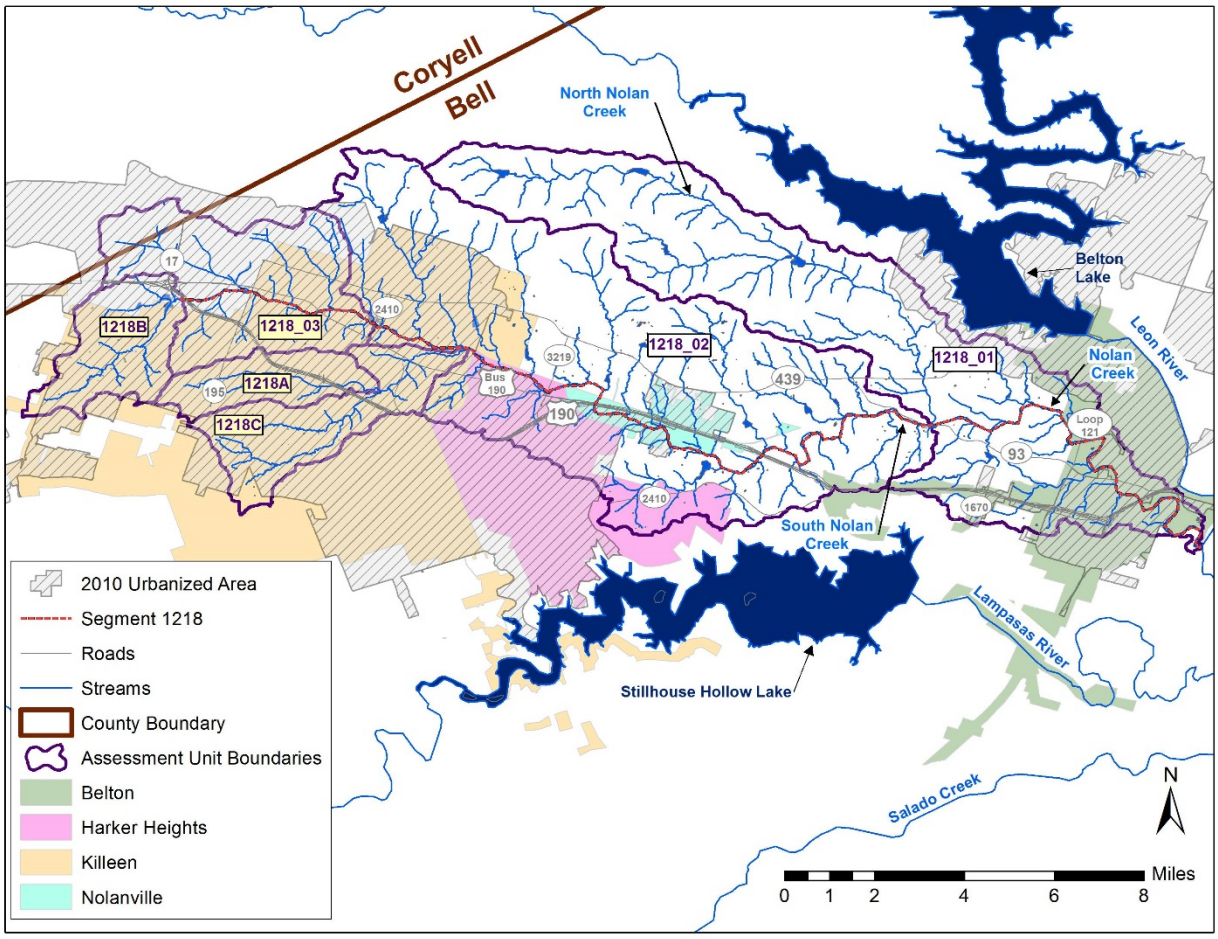

Figure 4-4 Location of MS4 areas within the Nolan Creek/South Nolan Creek watershed. For the watershed, the MS4 areas for cities include the 2010 Census Data for urbanized areas and extend to municipal boundaries.

From the National Land Cover Database for 2011, about 40 percent of the Nolan Creek/South Nolan Creek watershed is comprised of developed areas (Figure 4-5). The intensity of development varies greatly. Within the National Land Cover Database, developed land is considered a mixture of constructed materials and vegetation with impervious cover ranging from less than 20 percent in developed, open space to 80 percent or greater in high intensity

developed areas (USGS, 2014). For low intensity developed areas, impervious cover accounts for 20 to 49 percent of total cover, while in medium intensity developed areas, impervious cover accounts for 50 to 79 percent of total cover (USGS, 2014). For reference, the percent of developed land by subcategory within each AU within the Nolan Creek/South Nolan Creek watershed is given in Table 4-4. The largest percentage of high intensity developed area is found within the drainage areas of AUs 1218_03 and 1218A.

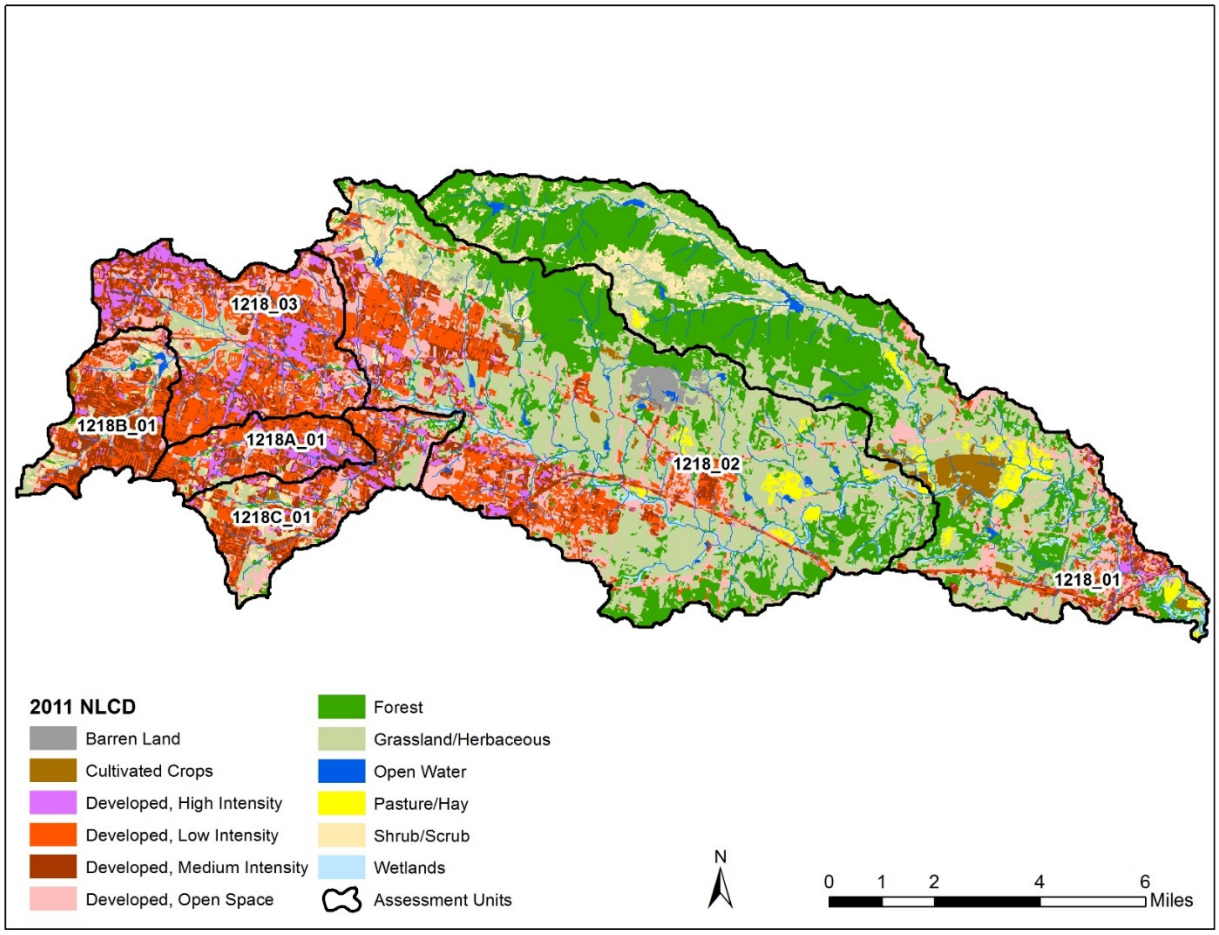

Figure 4-5 Land use/land cover for the Nolan Creek/South Nolan Creek watershed showing developed subcategories. Source: 2011 National Land Cover Database (USGS, 2014).

To estimate potential loadings from urban stormwater runoff, the amount of impervious cover was estimated using the middle of the range for impervious cover for each subcategory of developed land as noted within the 2011 National Land Cover Database (USGS, 2014). Percent impervious cover was assumed to be 90 percent for high intensity developed land, 65 percent for medium intensity developed land, 35 percent for low intensity developed land, and 10 percent for developed open space. For example, if a 200-acre subbasin was 30 percent high intensity developed land and 20 percent medium intensity developed land, and 50 percent in land uses other than developed, the impervious area was estimated to cover 80 acres or 40 percent of the subbasin.

Table 4-4 Percent developed land by subcategory and number of total acres of developed land within each AU of the Nolan Creek/South Nolan Creek watershed. Source: 2011 National Land Cover Database (USGS, 2014).

Developed Subcategory	1218_01	1218_02	1218_03	1218A	1218B	1218C
Developed, High Intensity	6%	6%	17%	18%	4%	8%
Developed, Medium Intensity	18%	18%	24%	30%	43%	32%
Developed, Low Intensity	19%	37%	36%	37%	34%	30%
Developed, Open Space	57%	39%	22%	15%	20%	30%
Total Acres Developed	**3,106**	**9,913**	**7,488**	**2,430**	**2,867**	**3,391**

The bacteria production rate was then estimated for each subbasin based on the estimated percent impervious cover using the following equation derived by PBS&J (2000):

$$FC = [10^{(4.03 + 0.0229*(IC))}]$$

where

FC = fecal coliform in cfu/100 mL and

IC = percent impervious cover

The equation above was modified to indicate zero loadings when the percent impervious cover was zero in a subbasin by subtracting 10,722. As the purpose of SELECT is to estimate potential relative loadings between subbasins, it made sense that loadings from urban runoff should be zero when no urban land existed in a subbasin rather than producing an artificial loading. Because the Water Quality Standards are for *E. coli*, and the above equation for impervious cover uses fecal coliform, a translator is needed. The production rate for FC was multiplied by 0.5 to estimate the production rate of *E. coli* within a subbasin (Doyle and Erikson, 2006).

The equation above provides an estimate of the event mean concentration of bacteria associated with stormwater runoff. To get at an estimate of the volume of runoff, a curve number approach was applied using standard equations on the impervious land cover within each subbasin for a typical storm event (McCuen, 1982). A curve number of 98 was used as a typical number recommended for impervious surfaces (SCS, 1986). Curve numbers have a range of 30 to 100, with larger numbers indicating increased runoff potential. Volume estimates assumed average antecedent moisture conditions. Historical daily precipitation data from 1981-2010 were reviewed and a typical storm event for the City of Killeen was estimated as 0.45 inches.

Potential loading from urban stormwater are shown for areas with the highest percent impervious cover (Figure 4-6). Of note, subbasins with the highest potential loading from urban stormwater based on SELECT appear to be associated with assessment unit areas (1218_03 and 1218A_01, see Figure 4-1) that are not noted as impaired for bacteria (TCEQ, 2015a).

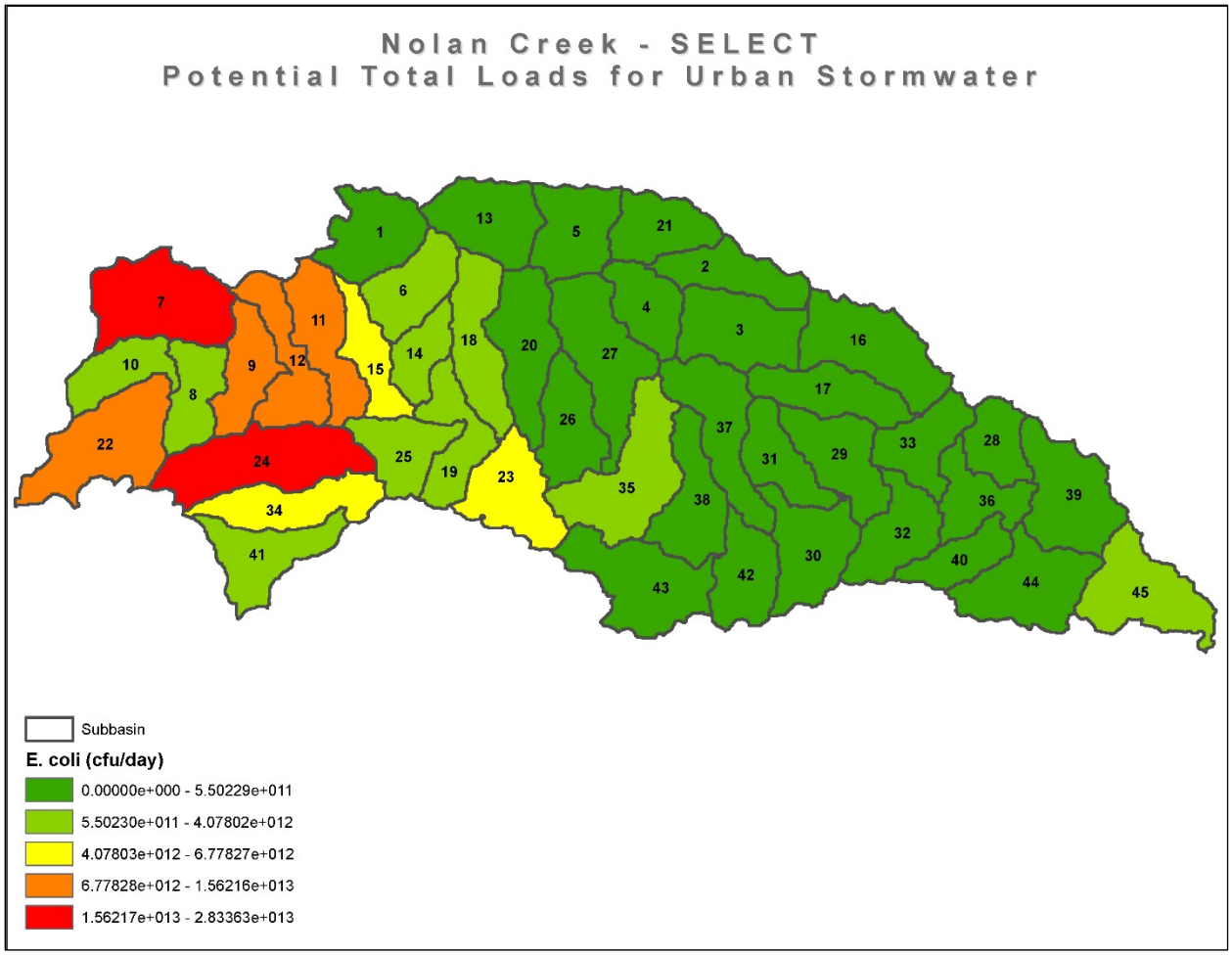

Figure 4-6 Distribution of potential *E. coli* loads from urban stormwater runoff by subbasin within the Nolan Creek/South Nolan Creek watershed.

Non-Regulated Sources

Livestock

For livestock, county level data were used to estimate livestock numbers as the best available information (see Teague et al., 2009). For Bell County, the latest USDA Census of Agriculture conducted by the National Agriculture Statistics Service (NASS) in 2012 notes cattle followed by goats and sheep as the dominant types of livestock (USDA-NASS, 2014) (Table 4-5). Horses and ponies combined with estimates of mules, burros, and donkeys were also considered as prominent livestock categories within SELECT. Poultry, while noted as a major livestock category within Bell County with almost 14,000 chickens, primarily egg layers, was excluded as a category for the Nolan Creek/South Nolan Creek watershed within SELECT as the large poultry facilities within Bell County are located outside the watershed area. Hogs and pigs were also excluded from SELECT as there were no large hog facilities within the watershed.

Livestock estimates within SELECT were then distributed by category across what were considered suitable land covers. For example, cattle grazing is most often associated with grassland herbaceous and pasture hay land covers. Because the land use for Bell County overall is quite different from the land use within the Nolan Creek/South Nolan Creek watershed (see Table 2-1), a relative weighting of the land covers most often associated with each livestock type within Bell County compared to the watershed area was used to estimate livestock numbers within the Nolan Creek/South Nolan Creek watershed (Table 4-5).

Table 4-5 Livestock estimates for the Nolan Creek/South Nolan Creek watershed. Based on 2012 Census of Agriculture for Bell County (USDA-NASS, 2014) and 2011 NLCD (USGS, 2014).

Category	Estimated Animals in Bell County	Associated Land Use/Land Cover (LULC)	Land Area in Bell County represented by LULC (acres)	Land Area in Nolan Creek/South Nolan Creek Watershed associated with LULC (acres)	Estimated Animals in Nolan Creek/South Nolan Creek Watershed
Cattle & Calves	34,922	Grassland Herbaceous & Pasture Hay	274,658	20,589	2,618
Sheep & Goats	17,082	Grassland Herbaceous, Pasture Hay, Shrubland & Forest	396,342	37,297	1,607
Horses & Ponies and Mules, Burros, & Donkeys	3,735	Grassland Herbaceous & Pasture Hay	274,658	20,589	280

Another slight complication in using SELECT in a watershed with a large urban component is that within some municipal boundaries, there are areas of land that would be considered suitable for livestock grazing, but such a use would be prohibited by municipal ordinances. In running SELECT, suitable land use areas within municipal boundaries were masked out so livestock would not be distributed within municipalities. Of note, there are some exceptions where livestock do occur within a municipal boundary. For example, based on the timing of annexation, land that was in agricultural use when annexed can be maintained in that use. For the watershed as a whole, these types of exceptions were considered rare and would be very minor contributors at the subbasin scale currently being evaluated with SELECT.

Loadings for cattle were calculated as the number of head based on the adjusted number of cattle within the watershed times the production rate (see Tables 4-2 and 4-5). The *E. coli* loading from grazing cattle was then distributed within SELECT on grassland herbaceous and pasture/hay land covers, excluding municipal boundaries (Figure 4-7). The resulting stocking rate would be about 0.13 cows/acre on these land categories or 8 acres per cow. As might be anticipated, the largely rural areas between Nolanville and Belton indicated some of the largest potential loadings from cattle (Figure 4-7).

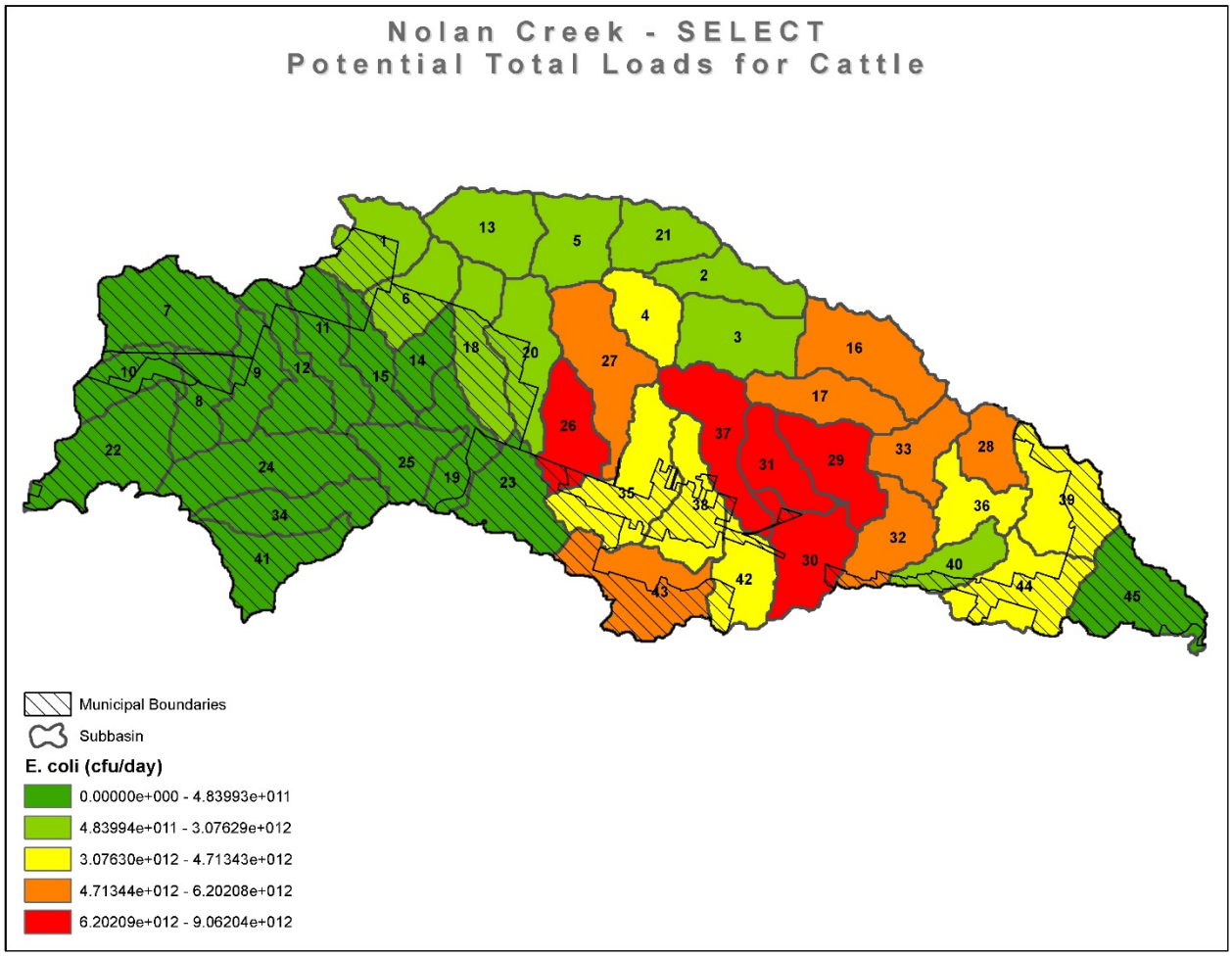

Figure 4-7 Distribution of potential *E. coli* loads from cattle by subbasin within the Nolan Creek/South Nolan Creek watershed. Municipal boundaries shown to indicate areas where livestock were excluded per city ordinances.

Similar to cattle, estimated sheep and goat numbers were obtained at the county level from USDA National Agricultural Statistics Service for Bell County and adjusted for the watershed as shown in Table 4-5. Loadings for sheep and goats were calculated as the adjusted number of head times the production rate (see Table 4-2) and distributed on the land-use categories of grassland/herbaceous, pasture/hay, shrub land, and woodland within the watershed, excluding the area within municipal boundaries (Figure 4-8). Based on the difference in land-use categories

associated with sheep and goats than cattle, a higher density, and, thus, potential loadings were noted in subbasins associated with woodland.

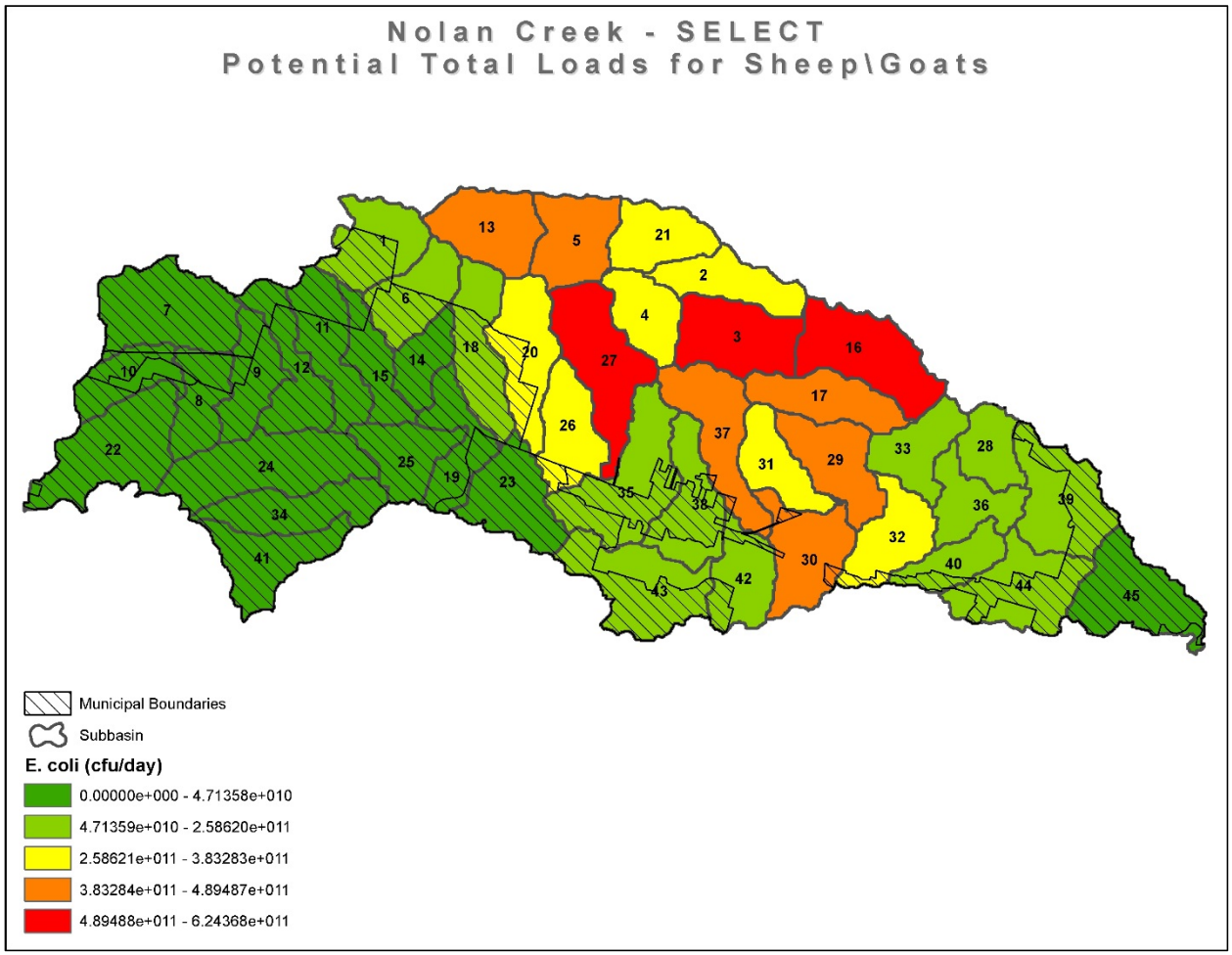

Figure 4-8 Distribution of potential *E. coli* loads from sheep and goats by subbasin within the Nolan Creek/South Nolan Creek watershed. Municipal boundaries shown to indicate areas where livestock were excluded per city ordinances.

Ponies, mules, burros, and donkeys were grouped with horses into one category within SELECT and estimated numbers were distributed across the area associated with grassland herbaceous and pasture hay, again excluding municipal boundaries (Figure 4-9). Because the same land-use categories were associated with horses as with cattle, the distribution pattern for the two sources looks similar (Figures 4-7 and 4-9), but the range of potential loadings varies. Higher potential loadings were associated with cattle than horses, because there were larger cattle numbers than horses (see Table 4-5).

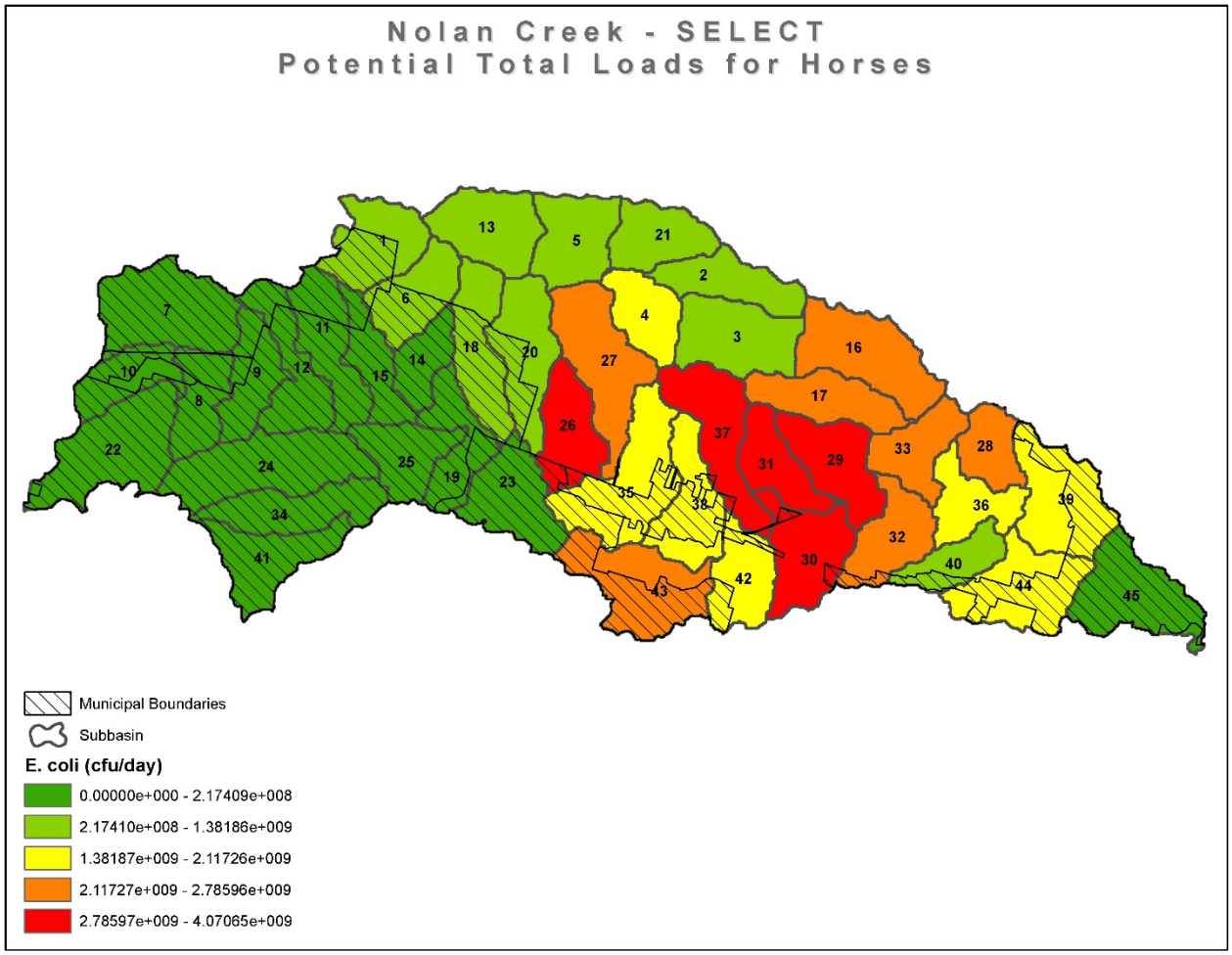

Figure 4-9 Distribution of potential *E. coli* loads from horses by subbasin within the Nolan Creek/South Nolan Creek watershed. Note: Horses represents a combination of horses, ponies, mules, burros, and donkeys. Municipal boundaries shown to indicate areas where livestock were excluded per city ordinances.

Feral Hogs

Feral hogs, while not natural wildlife, are invasive, unmanaged animals that are found throughout Texas and can contribute bacteria to streams in a manner similar to native wildlife. Feral hogs are classified by the TPWD as unprotected, exotic, non-game animals. Feral hogs are noted for moving in groups along waterways. Particularly in times of drought, feral hogs will congregate near perennial water sources to drink and wallow (Taylor, 2003). While generally not found in urban areas, in rural areas of Texas hog densities have been estimated to range from 20 to 54 acres per hog (Borel et al., 2012). For feral hogs, a density of 30 hogs per square mile or 0.05 hogs/acre is considered typical (Taylor, 2003; Hone, 1988; and Tate, 1984). Feedback from stakeholders indicated that the number of feral hogs in the watershed was very low, particularly in the urban areas. Feral hog wallows have been noted within the area of North Nolan Creek, which is largely comprised of forest and grassland (see Figure 2-1). Assuming feral hogs do not reside within developed areas or on open water, the number within the Nolan Creek/South Nolan

Creek watershed was estimated 0.03 hogs/acre times the remaining land area (43,255 acres; see Table 2-1) as 1,298 feral hogs. This density of 0.03 hogs/acre matches that used in adjoining watershed of the Lampasas River when applying SELECT (Prcin et al., 2013).

Total loadings for feral hogs were calculated as the total number of feral hogs in the watershed times the *E. coli* production rate (see Table 4-2). Because feral hogs are noted for moving in groups along waterways (Taylor, 2003), SELECT distributes the loading of *E coli* associated with feral hogs among the subbasins by first defining the land area for a 100-meter buffer around the stream network including all land uses but open water and developed areas. Areas with a higher density of stream networks and more land associated with rural or agricultural uses are, thus, indicated to have higher potential of feral hog bacteria loadings (Figure 4-10).

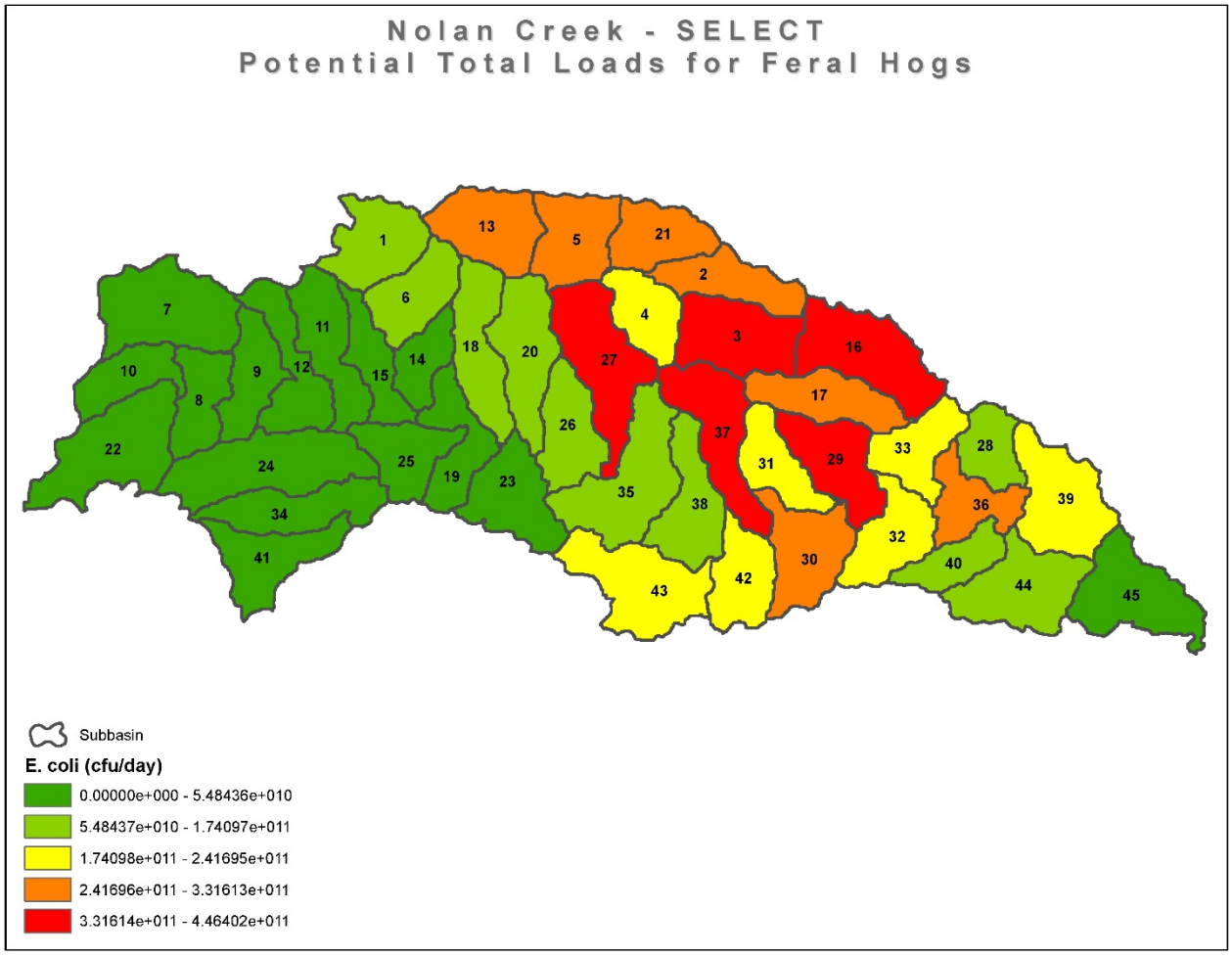

Figure 4-10 Distribution of potential *E. coli* loads from feral hogs by subbasin within the Nolan Creek/South Nolan Creek watershed.

Deer

For deer, a density of 12.3 deer per 1,000 acres or about 81 acres per animal was applied in SELECT based on survey data obtained from the TPWD for the Cross Timbers Ecoregion (TPWD, 2012). *E. coli* loads for deer were estimated based on potential production rates (Table 4-2). Within SELECT, deer were distributed across the land uses of woodland, shrubland, and near riparian forest (Figure 4-11).

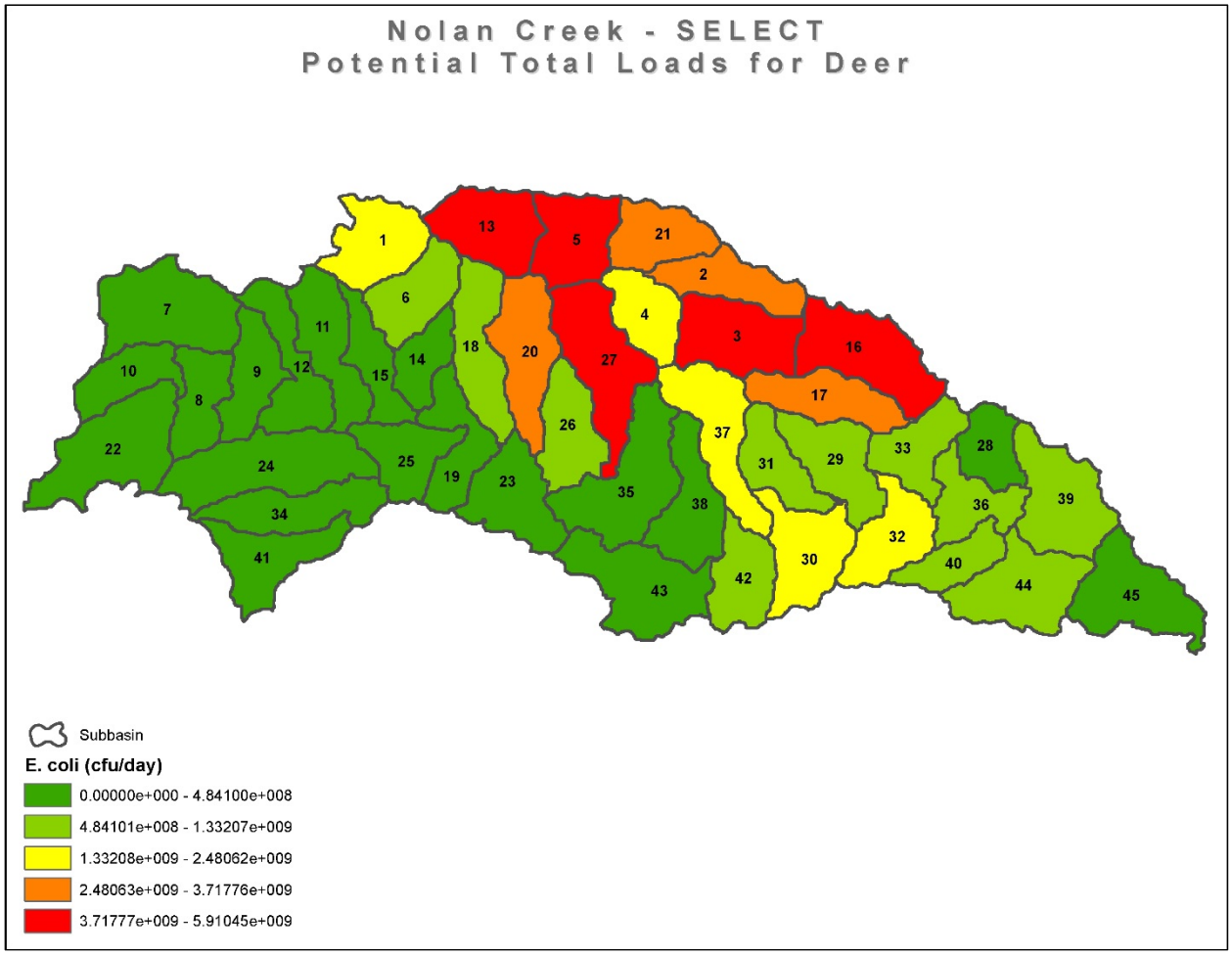

Figure 4-11 Distribution of potential *E. coli* loads from deer by subbasin within the Nolan Creek/South Nolan Creek watershed.

Pets

Domestic pets are another unregulated source of *E. coli* bacteria, particularly from dogs, because storm runoff often carries these wastes into streams (EPA, 2008). Other domestic animals, such as outdoor cats, also will contribute to potential loadings, but the number of cats is difficult to estimate as many are feral. In using SELECT, dogs are generally considered a surrogate for pets in general. The American Veterinarian Medical Association (AVMA) estimates about 0.6 dogs per household throughout the U.S. (AVMA, 2012). For loadings of *E. coli* from dogs, an estimate of 0.6 dogs per household was used with SELECT with the distribution of potential

bacteria from dogs then based on the number of homes in each subbasin using 2010 Census Block data (USCB, 2010; Figure 4-12).

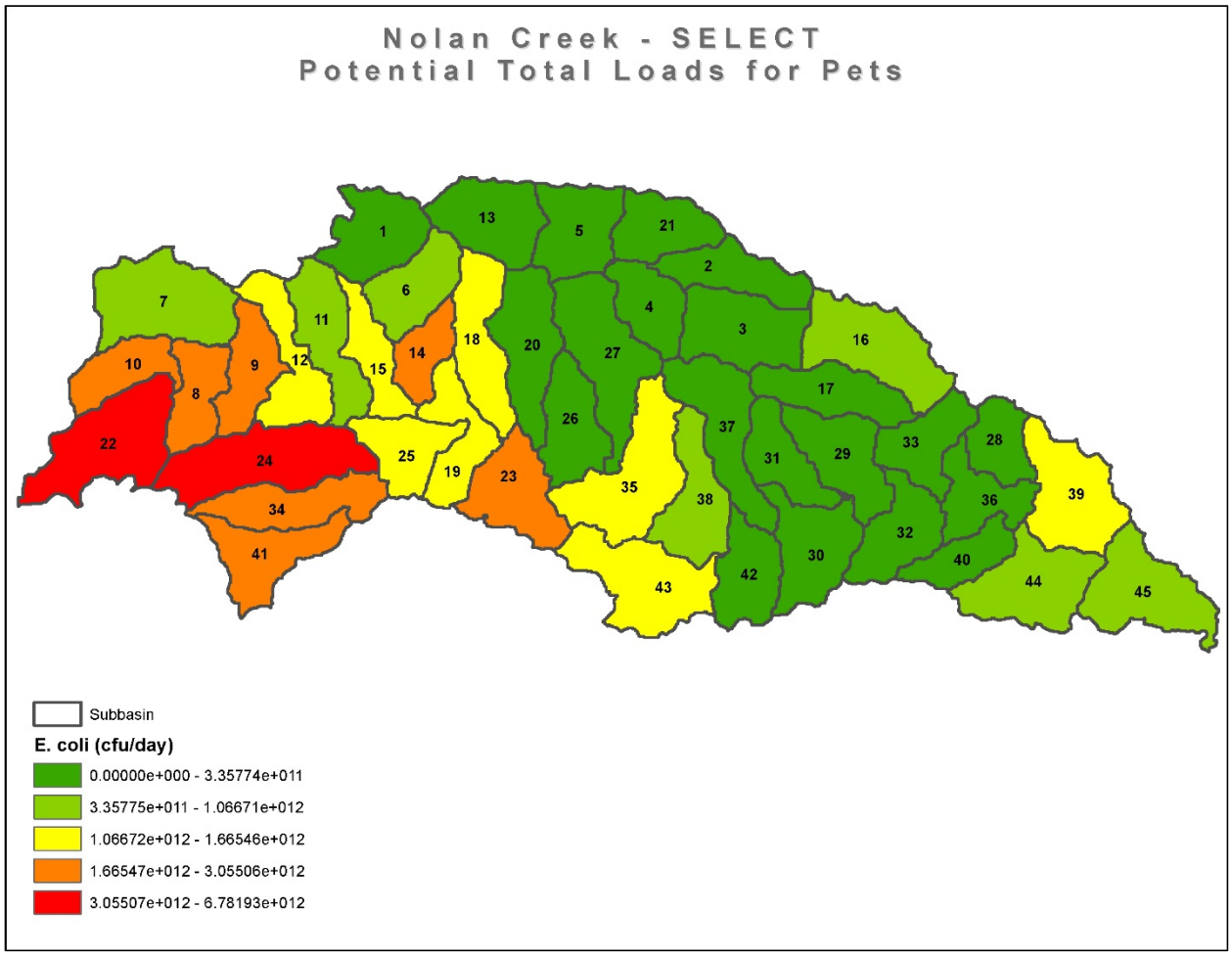

Figure 4-12 Distribution of potential *E. coli* loads from pets by subbasin within the Nolan Creek/South Nolan Creek watershed. Note: Pets are represented by an estimate of dog population density.

While stakeholders felt that the density was probably higher than 0.6 dogs per household, the pictorial display via SELECT (Figure 4-12) would be similar with the most dogs noted in the higher population subbasins. Of note, the estimation of loadings by dogs is in essence part of urban stormwater runoff for developed areas as it is based on housing density. Potential loadings from dogs were presented separately to allow the relative contribution of this source to be compared between subbasins. Also, the potential loadings from dogs will vary from the potential loadings associated with urban stormwater runoff as different approaches were used in SELECT for these two types of sources.

On-Site Sewage Facilities

OSSFs are often referred to as septic systems. These small waste management systems are generally associated with houses that are unable to connect to a central wastewater collection system. Septic systems are often used in rural areas, but may also exist in urban areas when subdivisions develop outside the area serviced by a centralized waste management system or when areas are annexed that have OSSFs that have not yet connected to a city's central waste management system. Within the Nolan Creek/South Nolan Creek watershed, the Bell County Health District is the Authorized Agent for permitting of all new OSSFs. While there is a tracking of new systems through the permitting process, older or "grandfathered" systems (generally prior to 1989) are difficult to identify, because permits were not previously required. A complete inventory of OSSFs within the watershed does not exist and available information for most of the watershed is not in a format that can easily be mapped. Some data on locations of OSSFs was made available by the City of Killeen as part of its Septic Tank Elimination Program (STEP) and the location of these is shown in Figure 4-13.

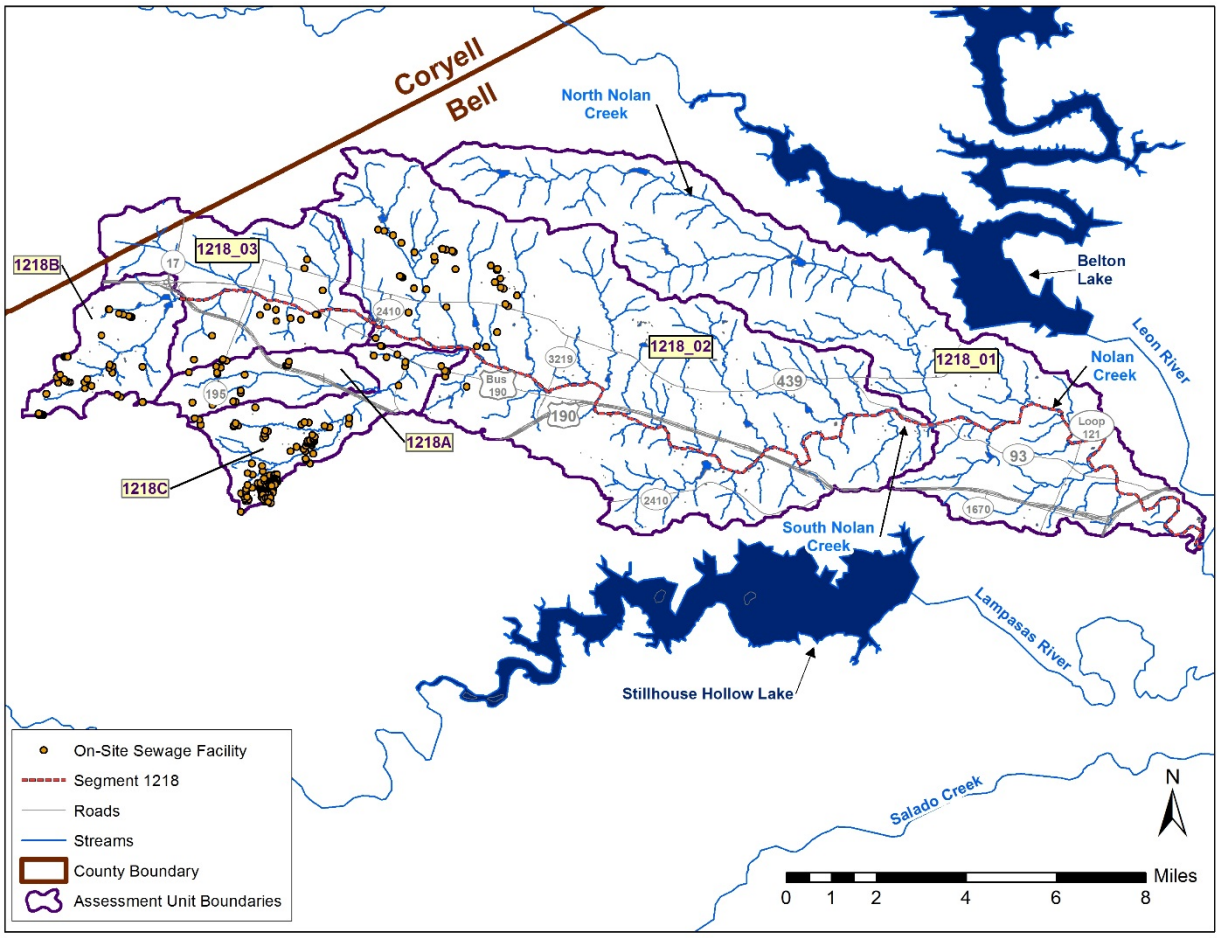

Figure 4-13 Location of OSSFs within City of Killeen municipal boundaries. Source: City of Killeen, data received September 2014.

To account for potential *E. coli* loadings from septic systems with SELECT, the number of homes within each subbasin not covered by public wastewater services were identified by masking out the area serviced by sewer systems in conjunction with 2010 Census Block data (USCB, 2010). Within the rural area, an estimated 2,180 households exist containing on average three people per household based the 2010 census block data (USCB, 2010). Information from the City of Killeen indicated an additional 273 households on OSSFs within its municipal boundaries (Figure 4-13). The estimated rural households in conjunction with the site-specific data provided by the City of Killeen were used in SELECT to estimate the density of OSSFs within each subbasin.

Soils data from the Natural Resources Conservation Service (NRCS) were then obtained from the Soil Survey Geographic (SSURGO) database and used to calculate the potential failure rate of septic systems within a subbasin based on the dominate limitation class associated with septic tank absorption fields (USDA-NRCS, 2005). According to the Bell County Soil Survey, soils within the watershed fall into two major associations; the Denton-Purves and the Speck-Tarrant-Purves (Huckabee et al., 1977). The majority of the watershed draining to South Nolan Creek is part of the Denton-Purves soil association, while the watershed draining to North Nolan Creek and most of Nolan Creek is part of the Speck-Tarrant-Purves association. Both the Denton and Purves soil series are noted to have severe limitations for septic tank absorption fields based on shallow depth to bedrock (8 to 40 inches). The Denton series is noted for slow permeability. Severe limitations are noted for septic tank absorption fields for the three major soil series in the Speck-Tarrant-Purves association due to shallow depth to bedrock (8 to 20 inches) and slow permeability for the Speck soil series.

The failure rate within SELECT associated with limitation classes for septic drainage fields was as follows (Borel, et al., 2012; USDA-SCS, 1993):

- 15% for severely limited,
- 10% moderately limited,
- 5% for slightly limited, and
- 15% for not rated.

Within SELECT, the *E. coli* loading for each subbasin is calculated as follows:

E. coli (cfu/day) = (# septic systems) * (average # people/household) * (*E. coli* production rate in cfu/100 mL) * (failure rate) * (individual usage in gallons/person) * (3758.2 mL/gallon)

For the Nolan Creek/South Nolan Creek watershed, SELECT was applied assuming an *E. coli* production rate of $5x10^6$ cfu/100 mL with a daily usage of 60 gallons per person per day (Borel, et al., 2012). The highest relative loadings from OSSFs generally was associated with an area near Harker Heights and Nolanville and to the northwest of the City of Belton (Figure 4-14). A moderate loading was also associated with subbasin 41, within the City of Killeen, which is an area still containing a high density of households on OSSFs (see Figure 4-13).

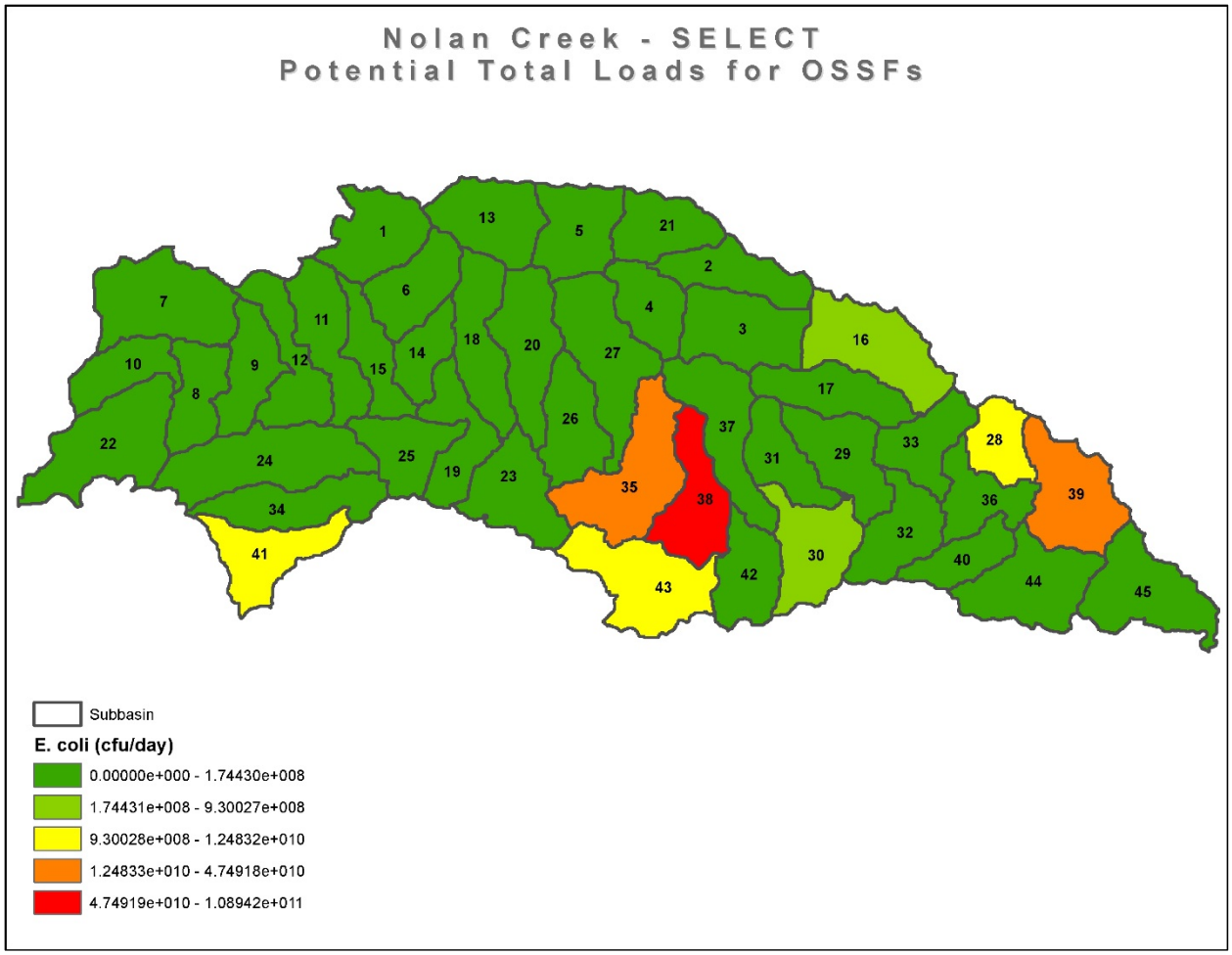

Figure 4-14 Distribution of potential *E. coli* loads from OSSFs by subbasin within the Nolan Creek/South Nolan Creek watershed.

Combined Sources

While the methods used for estimating various potential loadings from regulated and non-regulated sources differ, combining them presents an overall picture of potential "hot spots" within the watershed (Figure 4-15). Of note, even subbasins with low potential loadings (those in dark green in Figure 4-15) still may have loadings exceeding the criterion. For example, the lowest total potential loading was estimated in subbasin 5 as 2.85E+12 cfu/day. Under moderate flow conditions for the LDCs, allowable loads assuming 126 cfu/100 mL as the target were 2.69E+11 cfu/day or less (see Figures 3-3 through 3-6).

Potential loading by source and subbasin are shown in a tabular format in Appendix B along with the percent comprised by each source within subbasin. This aids in identifying potential bacteria sources by subbasin that may need to be controlled, an important element in watershed based planning (EPA, 2008). In the more western portion of the watershed, urban stormwater and pet waste appeared to be the dominant potential sources, while in the mid-portion of the watershed in the yellow-colored subbasins, cattle appeared as the dominant potential source.

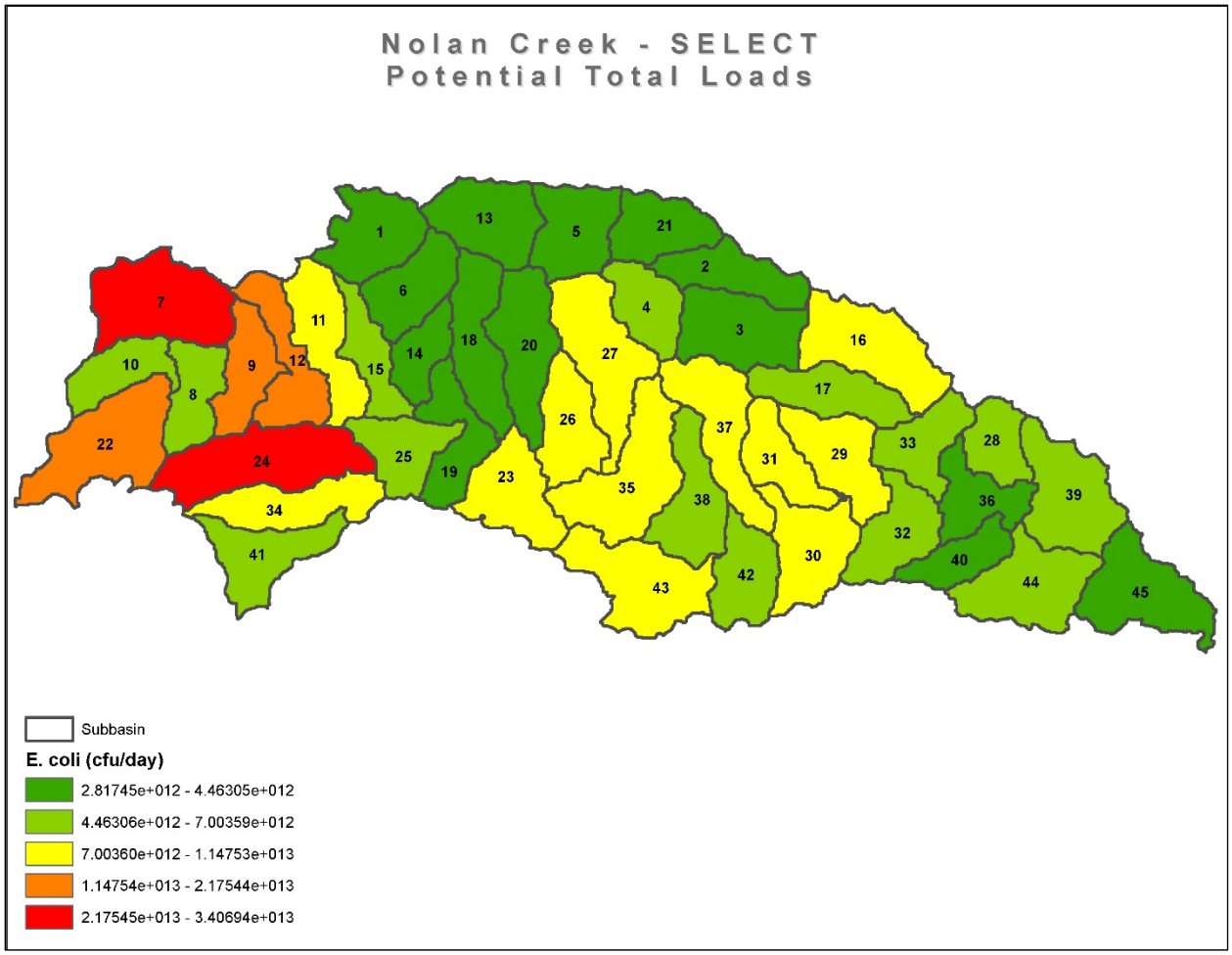

Figure 4-15 Distribution of potential *E. coli* loads from all SELECT sources by subbasin within the Nolan Creek/South Nolan Creek watershed.

Summary of SELECT Results

Use of SELECT in combination with LDCs helps to target flow conditions and potential sources of bacteria loadings within the Nolan Creek/South Nolan Creek watershed. The SELECT maps show a spatial distribution of major potential sources, which include urban stormwater and pets in the western portion and cattle in the mid-portion of the watershed. The LDC approach showed that nonpoint sources are prominent during high and moderate flows, but that during low flows, some dry-weather or point source contributions may need control, particularly in the drainage above Roy Reynolds Road.

Combining results from these two tools helps to even better define sources impacting water quality within the watershed. The LDCs, based on measured data, indicated bacteria concentrations below assessment levels during low and moderate flows at the most upstream station, 18828 (Figure 3-3). Some subbasins from SELECT above station 18828 (subbasins 7, 9, 12 and 22 within AUs 1218_03 and 1218B; see Figure 4-1) in contrast indicated some of the highest potential loadings, primarily from urban stormwater runoff (Figure 4-6). This is a case where potential loadings may already be adequately controlled as water quality is already

meeting target levels. The same appears to be apparent for SELECT subbasin 24, which represents assessment unit 1218A. Based on results presented in the TCEQ 2014 Texas Integrated Report, AU 1218A is in compliance for bacteria (TCEQ, 2015a), even though some of the highest potential bacteria loadings are associated with this subbasin (Figure 4-15).

The areas of the watershed noted as impaired for bacteria are AU 1218C, Little Nolan Creek, and 1218_02, portions of South Nolan Creek (see Figure 1-1). Station 11913 is located on South Nolan Creek below the confluence with of Little Nolan Creek. The SELECT subbasins associated with the area between monitoring stations 18828 and 11913 not associated with Little Nolan Creek (subbasins 1, 6, 14, 15, 18, and 19) show potential loadings primarily from urban stormwater and pets, but also cattle (see Appendix B). Along Little Nolan Creek (subbasins 25, 34, and 41), urban stormwater and pets were the dominant potential sources, although OSSFs were also a minor but notable potential contributor.

Further along South Nolan Creek at station 11910, bacteria loads were generally higher compared to those at station 11913 using the LDC analysis (Figures 3-4 and 3-5). The SELECT subbasins do not break exactly between stations 11913 and 11910, but mainly represent subbasins 18, 20, 23, 26, and 27. Of these five subbasins, cattle is the dominant potential source in subbasins 20, 26, and 27; urban stormwater is the dominant potential source in subbasin 23; and within subbasin 18, cattle and pets are dominant followed by urban stormwater as potential loading sources. While urban land is prominent in the watershed, it appears in the area between stations 11913 and 11910 a focus on both urban and agricultural sources is needed to target reduction efforts.

Moving further downstream to station 11905, loadings are still above target levels based on the LDCs for low and moderate flows, but much closer to compliance levels than those noted at station 11913. Between stations 11910 and 11905, SELECT output indicates cattle as the dominant potential source. Other prominent sources in this area include urban stormwater with subbasin 35, but then pets, sheep/goats, and feral hogs in the more rural subbasins (29-32, 37, 38, and 43).

Overall, SELECT indicates a mix of urban and rural land uses contributing to the potential bacteria loading within the Nolan Creek/South Nolan Creek watershed. SELECT also shows that in relation to instream water quality data, some areas, such as above station 18828 the most upstream station monitored, that what is indicated as potential sources may not be a problem, at least not during baseflow conditions associated with most assessment monitoring. The SELECT methodology enables a pictorial presentation of the potential bacterial loadings from common watershed sources. It should be emphasized that SELECT does not depict all sources nor actual loadings, only potential loadings for the sources modeled. The purpose of applying SELECT, as well as LDCs, is to engage stakeholders in identifying sources within impaired waterbodies, and also to help them determine cost-effective restoration efforts to reduce bacteria loadings in the watershed, thus, preserving its use for primary contact recreation.

SECTION 5

Watershed Action Plan Management Measures for Bacteria

In prioritizing a management strategy for the Watershed Action Plan (WAP), those involved with the Nolan Creek Partnership expressed frustration that a clear dominant source was not identified. As much of the pollution appears to be from nonpoint sources, a strategy targeting multiple sources and activities will be needed. A polling of the stakeholder committee indicated that human sources should be prioritized over nonhuman sources. Of the nonhuman sources, dog waste was noted as the highest management priority. Other considerations in developing the WAP included ease of implementation, cost, potential reduction expectations, and ongoing efforts associated with Stormwater Management Plans (SWMPs) related to MS4 permits (https://www.tceq.texas.gov/permitting/stormwater/ms4/WQ_ms4_AIR.html), flood management planning efforts, and variations in recreational use along different reaches of Nolan Creek/South Nolan Creek.

Wastewater Treatment Facilities

While WWTFs are considered point source dischargers managed under permit, an overview of past issues and changes is provided as discussions by the Nolan Creek Partnership recognized WWTF discharges as a known contributing source. There are eight WWTFs that discharge within the watershed (Figure 2-8), which are managed by various entities (Table 2-2). An overview of status of WWTFs and issues regarding treatment, upsets, upgrades, and changes in discharges is presented below.

Issues with Inadequate Treatment

All WWTFs within the Nolan Creek/South Nolan Creek watershed currently have permits that include effluent limitations for *E. coli*. The requirement for bacteria limitations has been phased in over the past several years with permit renewals based on an amendment to the Texas Administrative Code (Title 30, Texas Administrative Code, Chapter 309.3(h), Effluent limitations on bacteria) effective November 26, 2009 (34 TexReg 8327). The limits are 399 MPN/100 mL for any single grab sample and a daily average of 126 MPN/100 mL *E. coli* for discharges to freshwater. The daily average is calculated as the geometric mean of all effluent samples collected in a calendar month (TCEQ, https://www.tceq.texas.gov/assistance/water/wastewater/wastewater/ww-bac-t.html).

These WWTFs are required to monitor their effluents and report bacteria concentrations to TCEQ. Generally, bacteria concentrations in WWTF discharges have been well below the permit limitation of 126 MPN/100 mL *E. coli* for daily averages (Figure 5-1). While appropriate operation and maintenance is generally the norm, on occasion, violations have occurred. At the Nolan Creek Partnership meeting on August 17, 2017, a chart was shown of the average *E. coli* concentrations for effluent discharges from WWTFs in the watershed. A comment was made from a representative with Bell County WCID No. 1 that their WWTF (Main Plant with its discharge located just above monitoring station 18828 at 38th Street in Killeen) has experienced issues (average *E. coli* concentrations above 126 MPN/100 mL reported in January, March, and April 2017; see Figure 5-1).

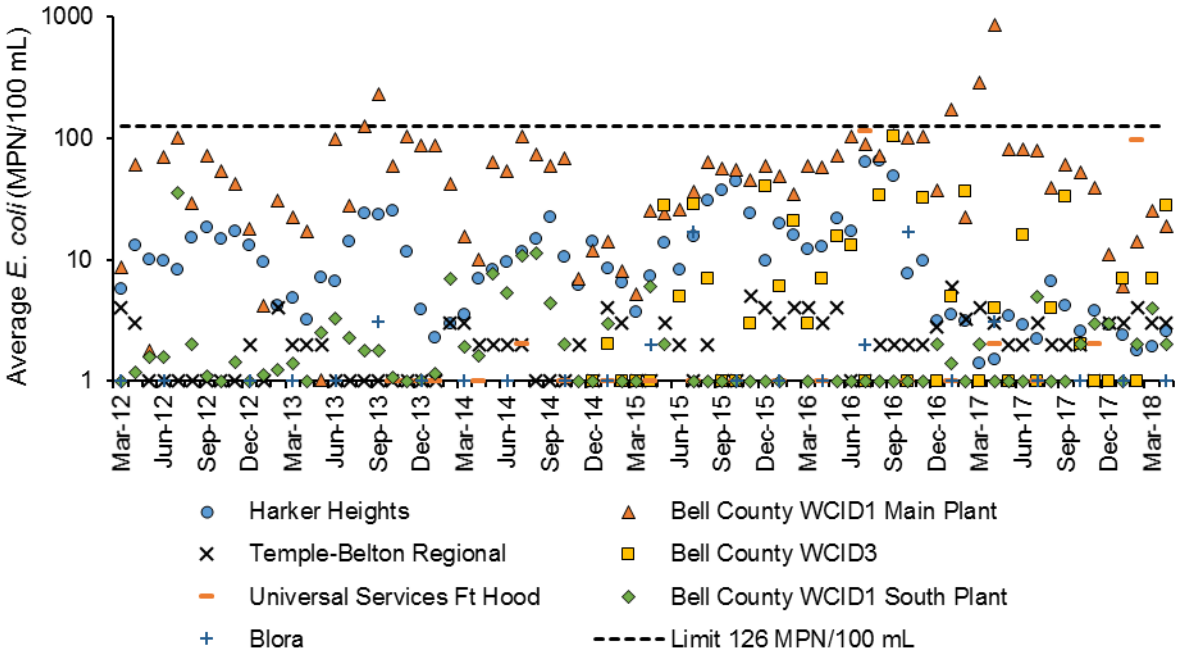

Figure 5-1 Average monthly *E. coli* concentrations reported by WWTFs for discharges within the Nolan Creek/South Nolan Creek watershed. Data represents monthly values from March 2012 through April 2018. Source: EPA ECHO.

Enhancements have been made at the WCID No. 1 Main Plant to address these bacteria exceedances. A new chlorine injection point has been added within the treatment plant immediately downstream from the clarifiers. Prior chlorination points were at the head of the filters and at the head of the chlorine contact basin. This new feed point gives the plant more contact time and a third disinfection point. With this new feed point for chlorine, bacteria concentrations in effluent discharged from the Bell County WCID No. 1 Main Plant WWTF should stay below permit limits. Reported average daily *E. coli* concentrations between May 2017 and May 2018 have been below the 126 MPN/100 mL discharge limitation.

WWTF Upsets

In 2009, a very notable breakdown at the Bell County WCID No. 1-Plant 3, which services portions of the City of Killeen, occurred due to high levels of fats, oils, and grease (FOG), leading to the need for new diffusors. In response to this WWTF upset, the City of Killeen passed an ordinance that regulates FOG entering the City's sewer system. Additional management measures being taken to avoid future WWTF upsets are addressed in a later section dealing with Sewer Line Infrastructure. In addition, screening programs are in place or in development with the municipalities in the watershed as part of detection and elimination programs for illicit discharges as part of SWMPs (see Appendix C).

WWTF Upgrades

While it is recognized that the population within the watershed is growing, current WWTF capacity appears to be adequate to meet short-term needs. Most WWTFs in the watershed run well below maximum capacity under normal circumstances indicating that existing facilities are

adequately equipped to handle some increases in wastewater. No significant treatment plant upgrades are planned within the Nolan/South Nolan Creek watershed within the next 10 years. The City of Killeen Comprehensive Plan indicates within Chapter 3 – Growth Management & Capacity (http://www.killeentexas.gov/index.php?section=178) that current contracts with WCID No. 1 for treatment of wastewater flows are adequate through at least the year 2039 before additional capacity may be needed.

Changes in WWTF Discharges

As of August 27, 2015, the WCID No. 1-Plant 3 (also known as the South Plant) had a permit amendment approved for a second outfall (002) to Trimmier Creek, which flows into Stillhouse Hollow Lake (Segment 1216), so a portion of the discharge from this plant will be redirected to another watershed. The WCID No. 1-Plant 3 facility is physically located south of the watershed on 8290 Chaparral Road in Killeen and will continue to discharge into South Nolan Creek within the City of Nolanville as Outfall 001. The combined flow from Outfall 001 and 002 shall not exceed 6.0 MGD for the WCID No. 1-Plant 3, with annual average flow through Outfall 2 to Trimmier Creek not exceeding 1.8 MGD from May to October and 2.2 MGD from November to April. With discharges to Trimmier Creek WCID No. 1-Plant 3 will be required to meet daily average effluent limits for *E. coli* of 126 MPN/100 mL. In addition, discharge limits to Trimmier Creek for ammonia nitrogen are 1 mg/L May – October and 2 mg/L November – April and for total phosphorus 0.5 mg/L year round. As of July 2018, WCID No. 1-Plant 3 had not discharged any effluent to Trimmier Creek as phosphorus removal steps are being refined to meet discharge limits for Trimmier Creek. According to the General Manager for Bell County WCID No. 1, plans are to commence discharges to Trimmier Creek later this calendar year.

Reuse of treated recycled wastewater for irrigation of park areas and golf courses is something being considered by municipalities, but is not currently done within the communities within the watershed (e.g., City of Killeen Parks and Recreation Draft Master Plan https://www.slideshare.net/CityofKilleen/killeen-parks-master-plan).

WAP Management Measures:

- Track reported bacteria concentrations associated with WWTF discharges and compare with instream water quality. Reporting responsibility is related to each WWTF via its permit. Tracking responsibilities will fall under duties associated with the Watershed Coordinator, recommended for coordinating all WAP activities, as noted later in this document.

Sewer Line Infrastructure

The sanitary sewer collection system is complex in that it provides the conduit via which raw sewage from individual homes, apartments, and businesses reaches the WWTF, where it is then treated and discharged to the creek. Leaks, blockages, or illicit connections can lead to raw sewage within the storm drainage causing water quality issues that can emerge during dry and/or

wet weather conditions. To prevent problems, the public infrastructure as well as the private service lines must be maintained.

Public Infrastructure

Management of the public sewer line infrastructure includes items such as maintenance of the collection system, illicit discharge and elimination programs, procedures for dealing with discharges and spills, as well as programs to minimize sewer overflows and blockages. These items related to the public infrastructure of the sewer system are largely addressed via SWMPs associated with each community. A summary of activities related to the public infrastructure of the sewer system is presented in Appendix C. These represent on-going activities within SWMPs that the WPP will support, as appropriate, through coordinating efforts. Activities associated with MS4-SWMPs are not eligible for CWA 319(h) funding, but to assess contributions from unauthorized discharges, such as SSOs, notifications of water quality noncompliance should be sent to the Watershed Coordinator as well as to TCEQ, as required.

WAP Management Measures:

- Track reported unauthorized discharges within the watershed by coordinating with municipalities regarding any water quality noncompliance notifications. Tracking responsibilities will fall under duties associated with the Watershed Coordinator.

Private Infrastructure

The Nolan Creek Partnership noted that private sewer lines, particularly lateral lines in high density occupancy areas, such as manufactured home communities, mobile home parks, and apartment complexes, were not as clearly addressed within SWMPs. The maintenance of these lateral sewer lines from individual homes, apartments, and businesses to the public sewer system is the responsibility of private property owners. Businesses most often associated with FOG issues are specifically addressed under various ordinances. Some educational outreach occurs to individuals, but more is needed. High density occupancy areas in particular are more vulnerable to sewage line problems than single family dwellings due to the density of users and connections leading to the centralized collection system. Often blockage problems in lateral lines occur due to tree roots, grease, or other items inappropriately entering the sewer system. Discussions within the Nolan Creek Partnership indicated that property owners in general seem to know little about their responsibilities regarding maintenance of these lateral sewer lines. For example some property owners did not know if they had a clean-out for their lateral line and if so, where it was located, thus, emphasizing the need for more education on maintenance of these lateral lines.

All municipalities conduct some educational outreach to the public regarding sewage lines, but consensus was that more outreach is needed beyond what is currently being conducted regarding responsibilities of private individuals for sewer line connections and maintenance of the drainage system to the public sewer infrastructure. In dealing with private sewer lines, blockages are generally obvious, but education also needs to focus on leak detection and the need for repairs when the system appears to be functioning properly. For example, the toilet flushes but not all wastewater is reaching the centralized collection system due to leaks in the lateral lines. For high density occupancy areas that may involve renters rather than homeowners, different educational pathways may be needed. While fliers and brochures are effective at a certain level, different communication strategies may be needed, particularly in reaching younger individuals, involving

social media techniques. The overall education component of the WAP, including marketing, is addressed separately under Educational Outreach.

Beyond education, a need was identified for assistance in dealing with lateral lines issues. High density housing areas were identified as a focus area for maintenance of lateral lines, and many such areas are likely be located in low-income areas where financial assistance may be essential, if repair or replacement of lateral lines is required. Several high density housing areas exist near or along the drainage of Nolan Creek/South Nolan Creek and proximity to the creek makes these areas a higher priority for assistance. A voluntary inspection program run through the cities to help in identifying leakage problems would be useful as well as development of a financial assistance program to aid in the repair and/or replacement of lateral lines on private property. This should include installation of clean-outs, if not already in existence, to simplify future maintenance or repair issues. Repair costs can vary but generally range from $100 to $3,000, if replacement of lateral lines is needed.

WAP Management Measures:

- Educate private property owners on responsibilities regarding lateral lines.
- Educate owners and renters on how to maintain clear lateral lines.
- Educate owners and renters on how to identify leakage or blockage problems with lateral lines for wastewater located on private property and what to do when problems occur.
- Work with municipalities to develop and implement a voluntary inspection program of lateral lines on private property focusing on high density housing/population areas near the creek.
- Develop a financial assistance program for maintenance, repairs and/or replacement of lateral lines.

On-Site Sewage Facilities

Repairs or replacement of improperly functioning OSSFs and education of homeowners on how to properly maintain OSSFs were identified as high priority management measures by the Nolan Creek Partnership. This falls in line with survey findings by Reed et al. (2001), in which they found about 12 percent of OSSFs reported as chronically malfunctioning with about 50 percent of these chronic failure related to older/pre-regulatory systems. Reasons most cited for failure of older OSSFs included installation in improper for soil types, installation on undersized lot, system undersized for current uses, and improper operation and maintenance (Reed et al., 2001). With newer systems, problems with operation and maintenance were more often reported as contributing to OSSF malfunctions and related to a lack of education for OSSF owners (Reed et al., 2001).

While the overall potential contribution of bacteria from OSSFs was considered relatively small within the watershed, OSSFs were considered a high priority, as failures can lead to a direct source of human waste within the stream system. The risk associated with improperly functioning OSSFs, depends on the type of failure and proximity to the creek. An example of a “hard” failure or higher risk situation is when untreated effluent is discharged creating a public health issue. A “soft” failure would be when a failure does not initially cause a public health issue, but could lead to one overtime if not corrected. The risk associated with “soft” failures is much lower as the effluent is contained, at least temporarily, within the soil. Priority areas should

focus on OSSFs closest to the stream as proximity to the creek greatly influences the potential bacteria contributions from OSSF failures.

The Bell County Public Health District, Environmental Health Division handles inspections and complaints on OSSFs throughout the watershed (http://www.bellcountyhealth.org/environmental_health_and_food_protection/introduction_on_on-site_sewage_facilities/index.php). Bell County Health noted that most OSSFs are in compliance and indicated of the 5,000 known aerobic systems in Bell County, there is a 97 to 98 percent compliance rate based on maintenance contract reports.

Identifying Location of OSSFs

While no map exists identifying all OSSFs in the county, Bell County Health Department (BCHD) officials are very knowledgeable of the location, general age, and type of OSSFs prominent in various locations throughout the watershed. Subdivisions with the most issues generally have older OSSF systems placed in relatively high density locations, such as mobile home parks. Most of these are grandfathered systems, and do not require a maintenance contract.

Specific mapping of OSSFs in rural areas was considered a low priority since location of OSSFs within rural subdivisions are already known. Use of 911 numbering and census data have also been used to highlight residences in rural areas outside municipal collection systems. Use of 2010 Census data indicated high densities of OSSFs in the area north of Nolanville. Moderate OSSF densities were indicated when the watershed was evaluated using SELECT for the upper portion of the Little Nolan Creek watershed within Killeen, the area between Nolanville and Harker Heights, and an area northwest of Belton within the North Nolan Creek watershed (Figure 4-14; McFarland and Adams, 2015b).

A moderate priority was identification of OSSFs within annexed areas of municipalities, so removal and tie-in to sewer can be addressed. The City of Killeen has taken steps to map and identify OSSFs within its municipal boundaries. As part of its SWMP, the City of Harker Heights is developing an inventory of OSSFs and categorizing them as currently in use or historic (e.g., tied into the centralized sewer system). The Fort Hood SWMP also includes development of an inventory of all OSSFs. Other municipalities based on annexation maps and the extension of city services have information on the general location of OSSFs, but not detailed maps. One method suggested for tracking annexed houses still on OSSFs, is querying billing databases to determine who is paying for sewer, assuming this is charged separately from other city services. As these maps are developed, they should be shared with the Watershed Coordinator and other pertinent entities in the watershed, such as BCHD.

As cities continue to grow, city officials are aware that the city will be annexing subdivisions on OSSFs and will need to bring these houses onto the centralized wastewater system. Almost all rural subdivisions on OSSFs within the watershed are part of the extra territorial jurisdiction (ETJ) of a municipality, and, thus, likely to be annexed.

For new subdivisions in rural areas, developers should be encouraged to install smaller decentralized OSSFs, such as package wastewater treatment plants, rather than individual OSSFs. Decentralized OSSFs provide a simple treatment system that is generally considered more environmentally friendly.

WAP Management Measures:

- Work with municipalities and Bell County Health to locate OSSFs, particularly those close to the creek.
- Work with municipalities to develop and maintain an inventory of OSSFs still in use and those that have been connected to the centralized wastewater collection system within municipal boundaries and share OSSF maps/databases with watershed coordinator and other entities in the watershed.
- Work with Bell County and the State to develop a mechanism encouraging installation of decentralized OSSFs in new subdivisions rather than installing individual OSSFs with each house.

Removal of Annexed OSSFs within Municipal Boundaries

For municipalities, a priority is removing OSSFs within their boundaries and connecting these systems to the centralized sewer system. Generally, as long as an OSSF is functioning properly on annexed property, the land owner is not required to connect to the centralized sewer system. Once an OSSF fails, the land owner is then obligated to connect, assuming centralized sewer service has been extended to the annexed area. Ideally, OSSFs on annexed properties would be connected to centralized sewer system prior to failure, but the cost of OSSF removal and connection to the centralized sewer system is not insignificant, and financial incentives may be needed to assist some land owners.

- Connecting to city sewer lines – cost depends on circumstances, such as distance, slope, and soil type (cost estimate $2,500 per connection but could run much less or thousands more depending on location).
- In some locations, it may not be practical to connect to the centralized sewer system for example if centralized sewer lines have not yet been run into an annexed area with OSSFs or the location makes it prohibitive for some other reason. Municipalities are recommended to adopt options for when such circumstances occur. In these rare circumstances, replacement or repair of failing OSSFs may need to be considered. The burden of the cost would be the responsibility of the private property owner.
    - OSSF Replacement (cost estimate $5,000 to $10,000 each)
    - OSSF Repair (cost estimate $1,000 to $5,000 each depending on type of repair needed)
- Decommissioning of OSSFs no longer in use (cost about $2,000 each).

Within the Nolan Creek/South Nolan Creek watershed, some assistance programs already exist, which should be supported and possibly expanded under this WPP. The most prominent is the STEP implemented by the City of Killeen. Phase 10 of STEP was approved in July 2017 by the Killeen City Council focusing on homes in the Tucker Subdivision at 6000 S. Clear Creek Road within the Little Nolan Creek subwatershed. The City of Belton has a “Home Grant” program to aid qualified, low income families with building new or bringing an existing property up-to-code. This “Home Grant” can be used to assist homes on OSSFs in connecting to the city sewer. Other assistance options for aiding private property owners with removal of OSSFs and connecting to centralized wastewater systems are needed and some potential funding sources are outlined in the section on Financial and Technical Assistance Needs. The Watershed Coordinator

in conjunction with municipalities will work to identify further funding sources for OSSF removal.

WAP Management Measures:

- Work with municipalities and BCHD to target removal of OSSFs, particularly those close to the creek.
- Have the Watershed Coordinator work with municipalities in identifying and providing financial assistance for connection of households to the centralized sewer system and removal of decommissioned OSSFs.

Assistance with Maintenance and Repair of OSSFs

Within municipalities, the goal is to remove OSSFs and connect to a centralized wastewater collection system. Within rural areas, proper maintenance of OSSFs is the goal, which includes knowing when problems exist and making repairs or replacing a failing OSSF system. Inspections are conducted when new systems are first installed, and for permitted aerobic systems, a maintenance contract is required to inspect the system once every four months. Inspection results for aerobic OSSFs are submitted to the BCHD. For anaerobic systems, inspections are not required but recommended every three to five years. With changes in homeownership, real estate inspections may be requested of BCHD for which BCHD will check records for aerobic systems to note if inspection reports have been submitted and any issues reported.

The BCHD will make physical inspections in response to complaints. Otherwise, BCHD is reliant on inspection reports from licensed maintenance and inspection companies in order to determine OSSF functionality. Failure to report inspections for aerobic systems or failure to address inspection compliance issue can lead to a letter from BCHD. When a letter is sent, the homeowner is given 30 days to fix issues and come into compliance. If issues with an OSSF (aerobic or anaerobic) are not addressed within the prescribed timeframe, then a court case is generally filed. The court may fine the homeowner up to $500. The BCHD noted that even working through the courts does not necessarily mean the problem gets fixed as the timeline for dealing with the OSSF compliance issue is generally reset by the court. The BCHD tries to work with property owners, but it can be difficult to obtain consistent compliance when potential fines are relatively low and repairs may cost thousands of dollars. The BCHD does work with city governments as leverage in dealing with compliance issues. The primary issue with failing OSSFs is financial, as failing systems are frequently older systems in rural subdivisions representing economically disadvantaged individuals.

Costs –

- OSSF Replacement (cost estimate $5,000 to $10,000 each)
- OSSF Repair (cost estimate $1,000 to $5,000 each depending on type of repair needed)

Other issues discussed with regard to rural OSSFs, included minimum lot size for OSSFs. Under State of Texas rules, a half-acre is set as the minimum required lot size. A half-acre was considered too small a lot for an OSSF by stakeholders involved with the Nolan Creek WPP. For anaerobic systems, a larger lot size would allow for a larger drainage field better facilitating treatment. For aerobic systems, a larger lot size would allow a homeowner to include things, such as an outdoor kitchen, patio area, play area and/or pool, so not to overlap with the OSSF

sprinkler spray pattern. As mentioned previously, there is a desire to have new developments install decentralized sewer systems, but financial or other incentives are likely needed, as installing individual OSSFs is still a cheaper option for developers in most areas.

WAP Management Measures:

- Promote installation of decentralized OSSFs in new rural subdivisions rather than individual OSSFs.
- Develop and provide financial assistance program for those with OSSF compliance issues to aid in repairing or replacing failing systems, prioritizing those nearest the creek.

Education on OSSF Maintenance

Education on the maintenance, detection of issues, and repairs of OSSFs was noted as a need throughout the watershed. Focus areas for education would be those OSSFs closest to the creek. New homeowners and renters were also considered focus groups for OSSF education as individuals who may have limited experience with OSSFs. Educational efforts should also target realtors and landlords, who are likely to interact with new homeowners and renters. Education for installers and maintenance providers was also recommended by the Nolan Creek Partnership. Training workshops on OSSFs as presented through Texas A&M AgriLife Extension Service are further discussed in Section 3, Educational Outreach. The Texas Goundwater Protection Committee and the Clearwater Underground Water Conservation District are also recommended as partners in technical assistance in dealing with OSSF maintenance, as failures in OSSFs can also impact groundwater as well as surface water quality.

WAP Management Measures:

- Develop and support on-going media efforts to educate homeowners and renters on proper maintenance and use of OSSFs.
- Sponsor OSSF workshops/trainings for homeowners.
- Sponsor OSSF workshops/trainings for installers and maintenance providers.
- Work with realtors to require inspections during time of sale.

Public Involvement in Good Housekeeping Efforts

Pet Waste

Getting people to pick up dog waste seems to be a problem in most watersheds and Nolan Creek/South Nolan Creek is no exception. Dog waste was considered by the Nolan Creek Partnership as the highest priority of non-human bacteria sources for management measures. Modeling results supported this in indicating pet waste as the largest potential source in many predominately urban subbasins (McFarland and Adams, 2015b). Ordinances are in place in all municipalities in the watershed to deal with dog waste. Enforcement through inspections of businesses, such as kennels and veterinary clinics, occurs, but enforcing these ordinances with the general public is more problematic. Most municipalities provide educational pamphlets, brochures, and even some signage to aid in educating the public regarding dog waste, but most likely a different approach to education on pet waste is needed. Even in dog parks, such as Mickey's Dog Park in Killeen, where waste stations and bags are provided and signage clearly indicates the requirement to pick up dog waste, city employees often are left picking up large amounts of dog waste because people are not utilizing these resources.

To address pet waste as a bacteria source, an education campaign that builds upon what is currently being done is recommended focusing on the importance of picking up pet waste. Critical areas would include parks, particularly dog parks, and other green spaces, such as hiking trails, where people are likely to recreate with their dogs. Booker Green Space at the end of Ann Boulevard in Harker Heights is an example of a public green space very near the creek. Dog parks near but not directly in the watershed should also be targeted, as practices learned in dog parks hopefully would carry over when people recreate with their dogs within the watershed. For example, the dog park in Harker Heights (Purser Family Park) is outside of the watershed, but if people are using it, they are also likely to live or recreate with their dogs in parks within the Nolan Creek watershed. For homeowners, the critical area was considered those nearest the creek as close proximity is more likely to lead to pet waste in the creek if not picked up and properly disposed. Ways to target educational efforts to homeowners with backyards that abut Nolan Creek/South Nolan Creek should be considered in the educational outreach component. As with education on residential sewer lines, tapping into marketing expertise is recommended to aid in targeting the pet waste control message. Creative pet waste campaigns may be needed to get more people engaged in picking up dog waste. Examples are provided on the following website outlining some of the more bizarre campaigns pushing people to pick up dog waste (https://www.petpooskiddoo.com/blog/10-bizarre-campaigns-pushing-people-to-pick-up-dog-poop/).

Along with this pet waste education campaign, the installation and maintenance of more pet waste stations in parks and along hike and bike trails where people are likely to walk dogs should be evaluated and considered by municipalities.

Cost – about $260/station with maintenance about $85/yr/station

WAP Management Measures:

- Support and expand public outreach and educational programs by municipalities encouraging proper disposal of pet waste.
- For the entire watershed area, develop a pet waste pick-up campaign, which may include mailing out notices to homeowners abutting the watershed regarding the impact of pet waste left in the yard.
- Support use and provide additional pet waste stations in public areas within the watershed.

Illegal Dumping

Illegal dumping often has been observed in the watershed adjacent to bridges, and this trash, particularly if it involves animal carcasses, can be a direct source of bacteria to the creek when a decaying carcass washes into or is dumped into the creek. Certain parts of Nolan Creek are "dumping areas" while others, such as Levi Crossing, are known to accumulate trash after storm events as trash washes downstream. Currently, illegal dumping is largely dealt with on a complaint basis or when observed by municipal or county employees. Most SWMPs include educational brochures as an effort to reduce illegal dumping.

The WAP supports ongoing efforts associated with SWMPs and will look for opportunities to expand upon these educational efforts. The TCEQ is working to implement a "Don't Mess with Texas Water" program working with Texas Department of Transportation (TxDOT) and

participating communities to place signs on major highway water crossing notifying drivers of a toll-free number to call to report illegal dumping (https://www.tceq.texas.gov/p2/dont-mess-with-texas-water-a-way-to-report-illegal-dumping#get-involved). The Nolan Creek Partnership would be interested in participating in this signage program.

Trash and Hazardous Waste Management

Creek cleanups and household hazardous waste (HHW) programs are two approaches already being used to reduce illegal dumping in the watershed. Creek cleanups are supported within several SWMPs and include activities, such as the annual cleanup for Trimmier Road Ditch along Lowes Boulevard, a tributary to Little Nolan Creek, sponsored by Keep Killeen Beautiful in association with the Keep Texas Waterways Clean program. The Keep Texas Waterways Clean program provides support and supplies for waterway cleanups across Texas and is open to all affiliate and non-affiliate communities located within 30 miles of an H-E-B or Central Market store location (https://www.ktb.org/keep-texas-waterways-clean). Several area businesses support these cleanup efforts, such as Home Depot, Lowes, and Walmart. Fort Hood hosts a post-wide cleanup program typically twice per year that includes some of the stormwater conveyances. The City of Nolanville within its SWMP includes development of an Adopt-A-Stream program in partnership with the Killeen Independent School District (target date 2020), which would include a creek clean up to help familiarize and educate students on the importance of creeks and keeping them clean. The Nolan Creek/South Nolan Creek WAP will support creek cleanup efforts and plans to promote at least one additional creek cleanup a year in the watershed as a way to connect people to the creek and educate them on trash management. Estimated costs for additional events is about $2,000 per event for supplies and advertising.

HHW programs are estimated to cost $12,500 or more per event, so they can be expensive to conduct and, thus, individual HHW events are often supported by several entities. Within the watershed, the CTCOG through the Solid Waste Advisory Committee coordinates about three household hazardous waste events in communities near and in the Nolan Creek watershed per year (https://ctcog.org/regional-planning/resource-conservation/). These events are open to all residents of Bell, Coryell, Hamilton, Lampasas, Milam, Mills, and San Saba counties. Bell County also partners in sponsoring HHW events and annually sponsors a collection of waste tires event. Fort Hood Directorate of Public Work, Environmental Division, operates a HHW turn-in and reissue facility open daily during normal business hours, which accepts typical household products (e.g., cleaning products, paint, oils, or greases) that can be reused by others. The City of Belton includes within its monthly rate for residential garbage a fee to handle HHW with home pickup (http://www.beltontexas.gov/departments/public_works/solid_waste_services.php). Another option for disposal of HHW is the Williamson County Recycle Center (WCRC). The WCRC is a commercial HHW facility located at 495 County Road 156, Georgetown that accepts HHW from residents in Bell, Travis, Burnet, Milam, and Williamson counties on a fee basis (http://www.mytexashhw.com/accepted-chemicals/). The Nolan Creek Partnership plans to promote education of these options for HHW disposal and HHW events sponsored by other entities through newsletters, website, and other outreach avenues.

Dead Animal Disposal

Education on proper disposal of dead animals (includes wildlife, pets, and livestock) is also needed beyond what is currently being conducted. Disposal of dead animals within riparian corridors, often at bridge crossings, leads to bacteria in the stream as carcasses decay. The

number of dead animal being disposed of in the creek is unknown and difficult to quantify but undesirable even if limited. People need to be aware of the impacts of improper dead animal disposal and how to properly dispose of dead animals. Per ordinance, municipalities within the watershed do not allow disposal of dead animals with garbage collection, but disposal via burial on private lands is allowed. For a fee, veterinary clinics can aid with arrangements for dead pets, which can include cremation and/or burial. For dead animals noticed in the creek or on city streets within municipalities, cities may be contacted, but if on private property, the property owner is responsible for disposal either directly or through a commercial venue. For dead animals on county roads, the Bell County Engineer's Office may be called (254) 933-5275 for carcass removal (http://www.bellcountytx.com/departments/engineer_2/fqa.php). The TCEQ has Special Waste Disposal Information, which includes guidelines for dead animals https://www.tceq.texas.gov/permitting/waste_permits/msw_permits/msw_specialwaste.html. As part of the education component of the WPP, the Watershed Coordinator will include information on proper disposal of animals within newsletters, website, and other outreach venues.

WAP Management Measures:

- Implement signage at major highway crossing on how to report illegal dumping.
- Promote information on website and other venues on how and who to report illegal dumping in various portions of the watershed and the fines associated with being caught.
- Support use of cameras to document illegal dumping.
- Support and aid creek cleanup events planned by other entities and sponsor at least one separate creek cleanup event per year.
- Aid implementation of an aerial assessment prior to waterway cleanups to direct where cleanup efforts are most needed along the creek.
- Promote available options for HHW disposal and planned HHW events through newsletters, website, and other outreach venues.
- Use HHW and creek cleanup events as an opportunity for educational outreach to reduce illegal dumping.
- Promote educational information on proper trash and dead animal disposal through newsletters, website, and other outreach venues.

Homeless

The homeless population within the watershed, was not considered a significant contributing source of bacteria until fairly recently. An increase in the number of homeless camps along Nolan Creek and an increase in the number of individuals within each camp has been observed as well as a large increase in human defecation within public rights of ways (streets, alleys, and sidewalks). While at this time, the Nolan Creek Partnership does not have specific management measures defined to address the bacteria contributions from the homeless, a management measure will include working with municipalities, particularly the City of Killeen, as well as organizations that address the homeless or low income individuals and families to help define how best to address this source.

WAP Management Measures:

- Work with municipalities and other organizations in defining management measures that address the bacteria contributions homeless population within the watershed.

Urban Stormwater Management

Within urbanized areas, SWMPs are required to address management practices associated with maintenance of the storm drainage system. As mentioned previously, all SWMPs include illicit discharge detection and elimination (IDDE) programs, but they also focus on dealing with pollution prevention and good housekeeping for municipal operations, construction site stormwater runoff control, post-construction stormwater management in new development and redevelopment areas, and for larger MS4 areas (populations 100,000 or greater) industrial stormwater sources. The WAP for the Nolan Creek/South Nolan Creek supports these SWMPs. While not a comprehensive listing, within Appendix D are listed some of the activities related to municipal operations, construction, post-construction, and industrial sources within SWMPs of entities within the watershed.

Increasing Infiltration and Reducing Runoff

The Nolan Creek Partnership considered post-construction measures which could increase infiltration as an area where activities beyond those in current SWMPs should be considered. A promotion of low impact development (LID) practices was seen as useful including demonstration projects to promote implementation and more extensive education on the benefits of LID practices.

The purpose of LID is to reduce runoff by increasing infiltration into the ground or redirecting runoff to storage for reuse at a later time. While LID may have greater upfront costs than conventional development practices, one of its promoted benefits is a reduction in infrastructure upkeep costs. Implementation of LID can create a more permanent solution for nonpoint source water quality problems, if enough are installed. Practices associated with LID include:

- Rainwater harvesting, which reduces runoff by capturing it for household or commercial use at a later point in time.
- Bio-retention, which is probably the most common LID practice, where stormwater is retained within a treatment area, such as a grass buffer strip or ponding area. Bio-retention does not prevent all runoff, but slows it down allowing more infiltration and filtering of pollutants as some pollutants, such as sediment, may settle out as runoff slows. Rain-gardens are considered a type of bio-retention with vegetation making use of the stormwater retained.
- Bioswales are stormwater conveyance systems filled with vegetation and a porous base allowing drainage. Bioswales are designed to slow runoff allowing more infiltration of the first flush of storm events and the filtering of larger events. Bioswales are often promoted as an alternative to concrete stormwater drainage systems.

Municipalities with the watershed are supportive of LID, but perceived upfront costs as a hindrance in getting developers and other to implement LID practices. The Nolan Creek Partnership supports LID and will look for ways to promote its adoption. CWA 319(h) funding, as described in Section 7, is a possibility for offsetting the costs of LID. Education on LID involving professionals, city staff, developers, business owners, and homeowners would be useful and should be promoted. Demonstration sites of LID practices would aid in promoting them as effective stormwater management measures. All of the municipalities are interested in implementing bioswales, and the City of Nolanville is actively pursuing funding for their

implementation. More details regarding specific locations for these bioswales within Nolanville and how they would be used for demonstration and monitored for effectiveness is outlined in Appendix E.

Another activity recommended by the Nolan Creek Partnership involves the promotion of Residential Cluster Development (also known as open space development) in new subdivisions by grouping residential properties on smaller lots and using the "extra land" as open space to reduce overall impervious area and increase greenspace (i.e., reduce runoff and increase infiltration). Similar to LID, this can be very effective practice in decreasing potential nonpoint source pollution, but may encounter resistance from developers as many people who move out into the countryside desire larger lots sizes rather than smaller.

WAP Management Measures:

- Support practices outlined SWMPs, particularly those associated with post-construction stormwater management in new development and redevelopment areas that increase infiltration and reduce runoff, through coordinated educational efforts.
- Specifically promote LID practices through educational workshops.
- Support funding efforts for the implementation and demonstration of LID practices by municipalities and other entities (e.g., Nolanville's implementation of bioswales).
- Promote Residential Cluster Development for new developments.

Practices that protect green spaces also provide ways to slow down runoff, thus, increasing infiltration and filtering pollutants before runoff water reaches the stream. The desire to preserve and connect green spaces throughout the watershed has been noted by stakeholders and is part of a long-term vision to connect hike and bike trails from Killeen to Belton largely following the riparian corridor of Nolan Creek/South Nolan Creek. Practices to increase infiltration tie into practices also being considered as part of flood management planning, such as detention ponds, bio-retention ponds, and bioswales. More specifics regarding recreational use and flood management are addressed in a separate section of this report.

Rural Stormwater Management

Livestock

In evaluating potential bacteria sources, livestock were identified as the largest potential source in subbasins that were predominately rural (McFarland and Adams, 2015b). Beef cattle are the primary livestock in the watershed, but sheep and goats are also prominent. While primarily a rural issue, there is also a need to target livestock owners within municipal boundaries. Livestock are excluded by city ordinances from within municipal boundaries, but annexed areas exist where livestock are present, as agricultural use of these lands has continued post-annexation. There are no Concentrated Animal Feeding Operations (CAFOs) in the watershed, but some relatively small land holdings were considered by stakeholders to have fairly high densities of livestock that should be targeted for manure management, particularly those nearer the creek, as close proximity is more likely to lead to livestock waste in the creek either through runoff or direct deposition. Education is needed to create awareness and aid with planning and implementation of livestock management practices that move or minimize the time livestock spend in or near the creek to reduce the amount of livestock waste entering the creek.

Besides educational outreach, the Nolan Creek Partnership plans to promote development of water quality management plans (WQMPs) for agricultural or silvicultural lands through the TSSWCB, which are approved through the Central Texas SWCD (https://www.tsswcb.texas.gov/programs/water-quality-management-plan). As each operation is different, each WQMP provides a site-specific plan. The plan includes appropriate items, such as land treatment practices, production practices, grazing management measures, and technologies, needed for preventing or abating pollution to aid in meeting water quality standards. Having a WQMP also allows ranchers or farmers to leverage some financial assistance programs at the state and federal levels.

The NRCS also provides conservation planning as technical assistance to private landowners and others as a voluntary program (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/).

Landowner assistance for forest and riparian management can also be obtained from the Texas A&M Forest Service (TFS) with planning efforts encompassing water resources as well as vegetation management (https://tfsweb.tamu.edu/LandownerAssistance/).

While the cost of planning through TSSWCB, NRCS, and TFS is generally free, the implementation of these plans can be expensive. For limiting bacteria, the most effective management measures target direct deposition and limiting the time livestock spend in or near the creek. This may require alternative water sources, rotational grazing options, and/or fencing. Effectiveness then depends on the willingness of landowners to put in the additional effort needed to implement these plans. While the technical assistance in developing a plan is generally free, implementation of practices outlined in a WQMP or conservation plan vary.

WAP Management Measures:

- Educate livestock owners on good management practices for maintaining healthy streams via workshops and distribution of educational resources.
- Develop awareness of the planning process for WQMPs, conservation plans, and other planning options.
- Promote development and implementation of WQMPs, conservation plans, or other conservation plans by livestock owners in the watershed.

Horses

While horses are often categorized as livestock, they are more often considered pets and, thus, presented as a separate category in the WAP. Waste management efforts, while similar to those for livestock, will need to target a different audience in dealing with horses. Horses are likely on smaller acreages than grazing beef cattle, and stables/boarding facilities should be targeted as well as individual horse owners. The same planning processes available to livestock owners are available to horse owners through WQMPs and conservation plans. Manure, even if on a smaller scale, should be managed including stockpiled manure from stalls or other areas, particularly if it is then land applied as organic fertilizer.

WAP Management Measures:

- Educate horse owners on good management practices for maintaining healthy streams via workshops and distribution of educational resources.

- Develop awareness of the planning process for WQMPs, conservation plans, and other planning options.
- Promote development and implementation of WQMPs, conservation plans, or other conservation plans by horse owners in the watershed.

Feral Hogs

While characterizing sources within the watershed, feral hogs were considered a relatively small issue with most activity noted along North Nolan Creek in wooded areas outside the targeted assessment areas. More recently extensive hog activity has been noted within the urban areas along the creek within Harker Heights. Because hogs are transitory but very prolific, the need for hog management is considered a low to moderate priority that could shift as the hog population fluctuates.

Hog reduction efforts are mainly done through shooting and trapping by private land owners. Texas Wildlife Services (https://agrilife.org/txwildlifeservices/), which is a division of Texas A&M AgriLife Extension, provides technical assistance in feral hog control. Hogs for a Cause (http://www.hogsforacause.org/) in Belton is a nonprofit feral hog capture organization that provides the meat to struggling families. While a nonprofit, Hogs for a Cause charges about $10 a head largely to recoup their costs. These hogs must be caught live for meat processing as they fall under United States Department of Agriculture (USDA) meat inspection guidelines. The Hogs for a Cause organization currently has a processor willing to work with them to process trapped hogs, and they are looking to build their own processing plant dedicated to this endeavor. For individuals wanting to trap hogs themselves, traps can cost about $500 and upwards.

WAP Management Measures:

- Educate landowners on management measures to aid in hog reduction through website and factsheets.
- Host feral hog workshops in the watershed.
- Promote management options, such as Hogs for a Cause, to help with trapping.

If feral hogs become a larger problem, the Nolan Creek Partnership, on review of the WAP, may consider coordinating trapping and hunting with Texas Wildlife Services and/or hiring a county trapper. Other watersheds have considered supporting a bounty program for feral hogs, but only in areas where feral hog populations are considered a large portion of the bacteria source problem.

Other Sources

Roosting Birds

High densities of roosting birds have been noted as a problem in the watershed mainly at two locations, on the power lines near the Home Depot in Killeen and in the H-E-B parking lot along Trimmier Road in Killeen. Both of these locations are near or along Trimmier Road Ditch, a tributary to Little Nolan Creek. While roosting birds can be a public nuisance, the property owner where the birds roost is responsible for implementing control measures.

Control methods for roosting birds, such as grackles, involve various frighten tactics to discourage roosting or the removal of roosting habitat. Grackles, starlings, and blackbirds that

are causing damage or creating a nuisance are not protected by state or federal law (Texas A&M AgriLife Extension – http://counties.agrilife.org/ector/files/2011/07/l1921_18.pdf), and Texas Wildlife Service can aid with developing a plan to deal with roosting birds. The cost can vary depending on tactics implemented and the frequency of implementation. The effectiveness of frighten tactics can be limited as they must be repeated and often varied as birds may become accustomed to any one frighten method. There also is the likelihood that these birds may just move to another nearby location, thus, moving the problem to another area rather than truly solving it.

WAP Management Measures:

- Make landowners aware of assistance available from Texas Wildlife Services on methods for decreasing attractiveness of areas to roosting.
- If a discouragement or frighten plan is developed, assist with education of the public regarding proposed tactics.

Wildlife (including waterfowl)

Deer and small wildlife mammals, such as skunks, opossums, and raccoons, are considered minor contributors to the bacteria issue in the watershed. Deer, as larger mammals, are primarily found in the more rural portions of the watershed, although riparian corridors can act as passage ways for deer into more urbanized areas. High densities of deer are also not considered a problem in this watershed based on stakeholder feedback. In dealing with smaller mammals that may congregate, particularly in municipalities if a food source is made available, when queried, this has not been considered a major problem by stakeholders. Waterfowl, particularly in the park areas along the Nolan Creek near Belton, have been noted. Signage "Do Not Feed Waterfowl" would be useful in known feeding areas. While watersheds with high densities of waterfowl were considered for removal management measures, at this time preventive measures are considered most appropriate in the Nolan Creek/South Nolan Creek watershed.

Preventative measures include educational outreach to the public on the issues associated with feeding small mammals and waterfowl. Public awareness and educational campaign on why feeding ducks and other wildlife can contribute to higher bacteria concentrations within the creek should aid in reducing and keeping waterfowl and wildlife populations at reasonable levels. Assistance is available from TPWD for outreach activities and in developing removal plans, should they become necessary.

Other preventative measures focus on landowner planning assistance programs. Similar to planning efforts for livestock, WQMPs, conservation plans, and assistance from the Texas A&M Forest Service is available to deal with wildlife management, water resources, and vegetation management. The Texas Parks and Wildlife Department also offers a number of services and permits to aid with land management related to wildlife (https://tpwd.texas.gov/huntwild/apps/).

WAP Management Measures:

- Provide educational programs to the public to discourage feeding of waterfowl and small mammals.
- Add signage "Do Not Feed Waterfowl" in known feeding locations.
- Monitor population densities to assess if further management is needed.

- If population densities are considered large enough to warrant control, consult with TPWD on options for control.
- If deemed necessary, implement population control measures.
- Promote landowner use of conservation planning for wildlife through TSSWCB, NRCS, TFS, and TPWD.

Recreational Use and Flood Management

As part of the WAP, there is an overall desire by the Nolan Creek Partnership to merge the water quality planning process with initiatives focused on recreational use, including hike and bike trails, and flood management.

Recreational Use

As the bacteria impairment is closely associated with recreational use, how the creek is used is important to its management. Recreational use of South Nolan/Nolan Creek varies from its headwaters northwest of Killeen to its confluence with the Leon River southeast of Belton. Low flows generally limit recreational use of the creek within Killeen and Harker Heights to noncontact activities, such walking or biking along trails near the creek. As flows increase, secondary contact recreation activities increase, such as fishing and wading by adults, which has been observed below US 190 in Nolanville. During periods with adequate baseflow, kayaking and canoeing occur, particularly within the City of Belton from Martin Luther King Jr Avenue to Confederate Park. For longer kayaking trips, the crossing at South Nolan Creek with Farm-to-Market 93 or Backstrom Crossing are noted as potential input points. Primary contact recreation activities, including swimming and wading by children, occur in within Nolan River, often where the river intersects with parks within Belton.

The City of Belton encourages kayaking and safe usage of Nolan Creek from within its parks. An important issue that the City of Belton has emphasized is the need for more education of the public on safe usage of the creek. This would include not only education due to elevated bacteria concentrations but also increasing water levels that occur with storm events. Flooding or even smaller increases in water levels that can create dangerous stream conditions making direct use of the creek unsafe. Within the watershed, there currently is some signage encouraging secondary recreation is displayed within Belton City Parks along the creek. The Nolan Creek Partnership will promote via additional signage and on its website and other venues information regarding water quality and water levels of Nolan Creek and safe usage of the creek.

As part of the recreational use of Nolan Creek/South Nolan Creek several hike and bike trials exist near the creek, such as the Andy K. Well Hike and Bike Trail in Killeen and the Nolan Creek Hike and Bike Trail in Belton, which connects several of the Belton parks. Harker Heights also has a trail near the creek, and Nolanville is in the planning stages for developing a trail system. An ultimate goal expressed was for a trail system connecting municipalities throughout the watershed from Killeen to Belton much of which would be along the creek. In 2016, the Bicycle and Pedestrian Advisory Committee (BPAC) was established by the Killeen-Temple Metropolitan Planning Organization (KTMPO) Transportation Planning Policy Board with the purpose of improving bicycle and walking mobility within the Killeen-Temple Region (https://ktmpo.org/planning/bike-and-pedestrian/#1455811352-1-90). The BikePed App supported through KTMPO provides a map of bike and pedestrian facilities including future

projects suggested by citizens (https://ctcog.maps.arcgis.com/apps/webappviewer/index.html?id=4585c0739c5c4b25a74f38f4d8e4e941). It is important that the Nolan Creek/South Nolan Creek WPP be coordinated with bike and pedestrian trail programs, as many of these Hike and Bike trails planned and currently in existence are near or along the creek. Trails provide areas for outreach to the public on water quality where signage could be established for educational purposes. Planning efforts for these trails should also consider protection of the riparian area along the creek, and may also increase the need for trash and pet waste stations as more individuals recreate near the creek. The Nolan Creek Partnership will support and promote the implementation of educational signage as well as pet waste stations along these trails.

Using the floodplain for parks and trails, takes this land out of development (Waller Creek in Austin example in progress, https://www.wallercreek.org/). The City of Killeen has acquired undeveloped land in the floodplain to better control management within these riparian areas. Maintenance and extension of trails and parks is further addressed within Killeen's Draft Master Plan for Parks and Recreation (https://www.slideshare.net/CityofKilleen/killeen-parks-master-plan) and within the City of Killeen Drainage Master Plan. Development pressures can make the acquisition and control of riparian areas difficult as people like to build along waterways as these are often considered aesthetically pleasing locations, but other uses may be more appropriate to aid water quality improvements and flood control. The Nolan Creek Partnership will support opportunities to protect the creek through riparian buffers that could be associated with trails.

WAP Management Measures:

- Promote safe usage of Nolan Creek/South Nolan Creek through educational information provided via website and other venues.
- Coordinate WAP activities with creek recreational activities promoted by municipalities often associated with city parks as well as through planning and maintenance of bicycle and pedestrian trails.
- Support installation of more trash and pet waste stations in areas near the creek associated with increased recreational use.
- Support implementation of educational signage within parks and along trails.
- Support development of riparian buffers as a water quality improvement measure but also as part of the trail systems associated with the creek corridor.

Flood Management

The CTCOG has received a grant through the Texas Water Development Board (TWDB)STEO to conduct a flood protection planning study for the Nolan Creek watershed. This flood protection study started in February 2017 and should conclude in August 2019. Goals of the study include developing a hydrologic model of the watershed that will be used to identify problem areas associated with flooding and mitigation alternatives including a benefit/cost analysis. Further information regarding the Nolan Creek Flood Protection Planning Study can be found on the CTCOG website at:

https://ctcog.org/regional-planning/nolan-creek-flood-protection-planning-study/

The Nolan Creek Partnership understands there is a connection between flood management and water quality management and is supportive of the Nolan Creek Flood Protection Planning

Study. Outcomes from this study will be used to inform efforts in implementing water quality management measures. This flood protection planning process will aid in determining the best locations for detention or bio-retention ponds for flood management, which will aid bacteria abatement through settling of stormwater runoff. Flood planning should also address concerns from stakeholders regarding increased peak flows that have led to an increase in streambank erosion and in essence, property loss. Upstream urbanization (more concrete) has been voiced as the cause of these increasing peak flows, so the impact of continued municipal growth on peak flows should be addressed with flood planning. Management measures associated with flood management should include opportunities for riparian restoration to reduce channel erosion often associated with higher peak flows.

As part of flood management, 17 small lakes or reservoirs exist in the watershed (Figure 2-4). These small lakes and reservoirs aid with flood management. Impoundment also improves water quality by reducing sediment and other pollutants through settling and with bacteria, allowing more time for decay to occur. Indications are that these small water bodies do not discharge into the creek except during large storm events (Wolfe, 2014), but aging of these structures is a concern. Thirteen of these reservoirs were built in the 1950s and 60s as flood control structures by the Soil Conservation Service (SCS, now NRCS), and all these flood control reservoirs are under the control of local sponsors who have responsibility for operation and maintenance. Other small reservoirs or lakes are privately built structures. As these structures fill with sediment, their benefits for flood control and in mitigating water quality decrease (Featherston, 2009). Because of downstream urban development, these structures need rehabilitation in order to meet current dam safety criteria. Rehabilitation of the dams for these reservoirs will also provide additional flood protection to downstream areas. The Nolan Creek Partnership, thus, supports assessment and rehabilitation, as needed, of all these structures.

Bell County WCID No. 6 operates and maintains the 13 SCS reservoirs in the watershed (Figure 2-4). In 2007, SCS #15 was rehabilitated with federal funding in part provided through NRCS. The match cost-share of 35 percent was provided by the WCID No. 6 as $400,000 cash and the rest in in-kind services represented by 40,000 cubic yards of topsoil for the auxiliary spillway (Featherston, 2009). Assuming 65 percent funding from the federal government, overall rehabilitation costs for SCS #15 were over one million dollars. Many SCS flood control reservoirs have private sponsors making the costs of rehabilitation a significant barrier. As a taxing entity, WCID No. 6 has the ability to obtain notable amounts of cash to aid with rehabilitation efforts. Even when funding is available, it still takes time for rehabilitation to occur due to the need for technical expertise and planning. The WCID No. 6 personnel indicate that they are working to rehabilitate SCS #12 and planning efforts are under consideration for SCS #2, #3, and #5a with about a five year planning horizon.

WAP Management Measures:

- Support ongoing flood planning and, as part of adaptive management, support and, as appropriate, integrate outcomes from the flood planning process, particularly the development of bioswales, detention or bio-retention ponds for flood management, into the WAP.
- Provide opportunities for riparian and stream channel restoration and education.
- Support ongoing assessment, operation, and maintenance efforts associated with small lakes and flood control reservoirs throughout the watershed.

Microbial Source Tracking

On various occasions stakeholders have expressed frustration in defining control measures for bacteria when they do not clearly know the source. How can we decrease bacteria if we do not know the source? How can we develop a plan when we do not know what we are after? While nonpoint source pollution impacting Nolan Creek is from a multitude of sources, the use of Microbial Source Tracking (MST) would aid in better targeting the nonpoint sources needing management.

To aid in better focusing management measures, the stakeholder group recommends MST be implemented in the watershed as part of the management measures. Using MST would help identify sources of bacteria (human, pets, wildlife, or livestock) in various subbasins. These data would then be used as an adaptive management tool, in that the new information provided through MST may reprioritize implementation measures. Costs for MST are variable depending on the number of samples analyzed and the precision desired in estimating relative sources. A rough cost of $250,000 is estimated for MST, which would be in addition to the costs associated with general effectiveness monitoring.

Management Measures:

- Review other MST projects conducted in Texas to aid in understanding how to get the most useful information from an MST Study.
- Develop funding for MST.Design and implement MST study.
- Analyze and present MST results and evaluate management measures with MST findings.

Bacteria Reductions

Bacteria load reductions will vary greatly depending on the number, location, and how well management measures are implemented. While production potential is fairly easy to quantify (see Table 3-3), actual contributions of bacteria to the creek from various sources are difficult to quantify, unless directly deposited, as transport and decay alter the amount entering the creek. To estimate the management effort needed to meet water quality goals, reduction estimates must still be developed despite limitations in knowing actual impacts per activity. These anticipated reductions are estimated below using production rates (as noted in Table 3-3) adjusted for proximity following reduction calculation methods as presented in the Navasota River WPP (TWRI, 2017). Within the Nolan Creek/South Nolan Creek watershed, reductions amounts and primary sources vary from upstream to downstream with land use as shown in Section 3 with LDCs (Table 3-3) and SELECT maps presented in Section 4. Reduction efforts needed to meet the water quality standard of 126 MPN/100 mL for *E. coli*, thus, must vary depending on location within the watershed. The following focuses on reductions needed to meet the water quality target for bacteria under moderate or low flow conditions for the four stations evaluated using the LDC approach (Figure 3-1), as moderate to low flows represent the ambient water quality conditions under which routine monitoring general occurs for assessment purposes.

For station 18828 located at the crossing of South Nolan Creek with 38th Street in Killeen, no reductions are indicated based on LDC development for moderate or low flows (Figure 3-3 and Table 3-3). While measured data compared to the LDCs in Section 3 are based on fairly recently

collected samples (May 2013 through June 2015), land use has changed somewhat above station 18828. Mickey's Dog Park opened in June 2015 and is located above station 18828. Also, the urban population has grown about 12 percent for the watershed as a whole from 2010 to 2016. Within Killeen, population growth has been about 11 percent, and the homeless population in Killeen has notable increased in recent years with much of the homeless activity noted in the drainage area above or near station 18828. While reductions were not indicated as needed based on previous data for low and moderate flows, efforts should still focus in this area, to make sure this portion of the river does not increase above target levels. The new dog park is a great asset to Killeen and provides an opportunity and focus area for educating pet owners on the hazards of pet waste to water quality. As a rough estimate assuming only 25 percent of the bacteria produced reaches the creek, just the daily waste from 25 dogs could potentially raise bacteria levels at station 11928 above target levels.

Assumptions for Dogs:

- 2.50×10^6 bacteria production rate (Table 4-2)
- 0.25 proximity factor

Moving downstream to station 11913 at Roy Reynolds Road along the border between Killeen and Harker Heights, reductions noted in Table 3-3 are higher for low flows than moderate flow, thus, will be used as the target level for estimating reduction needs. Above Roy Reynolds Road, besides Mickey's Dog Park, there are several other parks making dog waste a target source. Similar to the estimates for station 18828 (and assuming no reductions upstream and 25 percent of bacteria produced reaches the creek), controlling the daily waste from 128 dogs in this area could potentially reduce bacteria loads to target levels.

We know that dog waste is not the only source in this region of the watershed. The drainage area between stations 18828 and 11913 is complex in that beside parks, some of the open land area has been identified as annexed land that is still being used for livestock grazing. While livestock numbers are limited, if cattle have near or direct access to the creek, this could be a large contributing factor. Based on *E. coli* production rates (see Table 4-2), one cow is in essence the equivalent of 20 dogs, so it would take only 6 cows to have the same impact as 128 dogs assuming only 25 percent of the bacteria produced is transported to the creek. The development of a WQMP for livestock owners within this portion of the watershed, even with relatively small herd sizes, could have a large impact on stream water quality, particularly if the livestock are located close to the creek or a tributary. The practices associated with a WQMP will vary depending on the operation, finances, and willingness of the landowner to adopt, but fencing cattle from the creek and providing alternative water facilities have been shown to decrease bacteria contributions from cattle 37 to 85 percent (TWRI, 2017).

Assumptions for Cattle:

- 2.10×10^8 bacteria production rate (Table 4-2)
- 0.25 proximity factor

Other contributing factors above station 11913, include urban stormwater runoff, which is largely addressed through MS4 permits and SWMPs. The WWTFs which discharge into the

creek above this location (Bell County WCID 1 Main Plant and Plant 2 combined) represent constant inputs (Figure 3-1 and Table 3-2). These WWTF discharges are largely in compliance with permit limits with average daily discharges generally well below 126 MPN/100 mL (see Figure 5-1). Illicit discharges related to SSOs have been an issue at times in the watershed above station 11913, but concerted efforts by the City of Killeen have been made to address SSOs, particularly within the Long Branch and Little Nolan Creek drainage basins, to limit their occurrence. The drainage of Little Nolan Creek does converge with South Nolan Creek just above station 11913, and the drainage area of Little Nolan Creek does still have a large number of annexed OSSFs not yet connected to the central sewer system within Killeen (Figures 4-13 and 4-14). In evaluating these OSSFs as potential sources of bacteria above station 11913, one failing OSSF discharging untreated effluent could easily contribute bacteria loadings more than 3.5 times the allowable loading for meeting target bacteria levels assuming a proximity factor of only 5 percent of bacteria produced reaching the creek.

Assumptions for OSSFs:

- 5.00×10^6 bacteria production rate (Table 4-2)
- 60 gallons water used per person per day
- 3,785.2 mL/gallon
- 3 estimated people per household
- 0.05 proximity factor

Moving further down, it is assumed that upstream reduction efforts will translate into some downstream decreases in *E. coli* concentrations, but nonpoint source contributions between station 11913 and station 11910 at US 90 should still be addressed. Above station 11910, the Harker Heights WWTF is the only point source discharge. Assuming the full permitted discharge and permit *E. coli* levels of 126 MPN/100 mL as a daily average, the Harker Heights WWTF on the high end might contribute up to 14 percent of the bacteria loading at Station 11910 under baseflow conditions. Near station 11910, urban runoff from the eastern portion of Nolanville occurs as well as from portions of Harker Heights with pets and urban stormwater runoff as the major contributing sources to consider based on SELECT results of potential sources. The watershed does become more rural in this region, so load reductions from livestock and feral hogs may also be considered, but likely a lower priority. Feral hogs, while not a major problem in the watershed, have become more apparent along the creek even in the more urban areas within Harker Heights. Trapping of hogs would aid in decreasing loadings but would need to be a continuing effort, as hogs reproduce prolifically and are quite transient, particularly along riparian corridors. The impact from hogs can be quite large when they are present as feral hogs often move in large groups. Trapping of the equivalent of about 260 hogs would be needed to meet the load reductions at station 11910, so likely would have a limited impact unless large populations are noted in this area.

Assumptions for Feral Hogs:

- 1.38×10^9 bacteria production rate (Table 4-2)
- 0.25 proximity factor

The most downstream station for LDCs was 11905 located at Backstrom Crossing. The drainage area between stations 11905 and 11910 is more rural. Besides livestock, a source of concern noted by stakeholders was the expansion of rural subdivisions in this area, which will increase OSSFs. Bell County Health Department considers the newer OSSFs more reliable and less likely to fail than older systems, but stakeholders did like the idea of promoting installation of decentralized OSSFs in new rural subdivisions rather than individual OSSFs as a way of decreasing even further the likelihood of contributions from an ill maintained OSSF. As noted above, the potential bacteria contributions from one OSSF with a "hard" failure discharging untreated waste could easily lead to exceedance of the water quality standard.

The WCID 1 Plant 3 (South Plant), located downstream of station 11910, plans to start directing 1.8 to 2.2 MDG of its wastewater discharge from Nolan Creek to Trimmier Creek by the end of 2018 (Figure 3-1). Because the average daily *E. coli* concentrations associated with the WCID 1 Plant 3 are generally quite low (average 1.6 MPN/100 mL for Jan. 2016 – Apr. 2018) the impact of the change in discharge is expected to have a very limited impact (< 1 percent of reductions needed under moderate flows) on bacteria loadings to South Nolan Creek below station 11910.

Even further downstream within the City of Belton, while not considered with LDCs, increases in bacteria are occurring at the local level that need to be addressed. There are a number of parks along the creek within Belton making dogs a priority source. Ducks may also be adding notable to the bacteria loading and feeding should be discouraged to keep this source from growing. Otherwise, efforts should continue to address potential urban stormwater runoff contributions as well as rural contributions from livestock and OSSFs outside the city limits of Belton.

While there are lots of assumptions regarding transport of bacteria and the effectiveness of various management measures, implementation activities focusing on the primary sources within each region should meet reduction needs to meet the target goal of 126 MPN/100 mL for ambient conditions.

Associated Nutrient Reductions

As nutrient criteria for streams emerge within Texas, a larger focus may be needed in reducing nutrient contributions. Nutrients within Nolan Creek largely are contributed from point sources related to WWTF discharges (McFarland and Adams, 2015a). Implementing greater nutrient control from these WWTFs will be quite costly. Estimated costs for nutrient control, particularly for phosphorus, will vary depending on the reduction limit set with estimated capital costs of one million dollars or more for each facility (see http://t-nn.tarleton.edu/docs/nolan_creek/January%2016,%202014/Nolan-Creek---StatewideNutrientStandards-011614.pdf).

Many of the practices defined for reducing bacteria will also aid in reducing nutrient contributions to Nolan Creek from nonpoint sources. If more is needed to address nonpoint source nutrient contributions, a specific focus in urban areas would be to reduce use of lawn fertilizers by homeowners and commercial users, such as golf courses. Management practices may include:

- Provide educational outreach to homeowners, golf courses, and landscape operations on proper application and amounts of fertilizer for lawn needs.
- Encourage use of fertilizer containing only nitrogen, no phosphorus.
- Encourage development of nutrient management plans for use of fertilizers on agricultural lands.

Similarly for rural areas, nutrient management from nonpoint sources should focus on reducing the fertilizer applied, whether commercial or organic, to the nutrients needed by the pasture or cropping system. Cropland and improved pasture comprise only about three percent of the watershed area in Nolan Creek. Most of the rural area is rangeland or forest, which is not normally fertilized, except through direct deposition of organic fertilizer via livestock and wildlife. Within rural areas, producers should be encouraged to work with NRCS, the TSSWCB, and local SWCD in nutrient management planning as part of WQMPs and conservation plans.

Implementation of practices or technologies, such as wetlands or floating treatment wetlands, focused on instream nutrient reduction might be considered if more intensive nutrient control is required.

SECTION 6

Educational Outreach

Educational outreach will be a part of all management measures, but for many measures, educational efforts can be grouped into regional, urban, and rural focus areas. One item specific to education is marketing. The stakeholder group indicated that different communication strategies may be needed for different management practices, particularly in targeting younger individuals. Items, such as brochures, fliers, factsheets, participation with informational booths at local events, and newsletters, reach only a portion of the target audience and even websites do not necessarily reach the technologically savvy. Use of a variety of social media techniques may be needed to address the educational component of the WAP. At a minimum, the watershed coordinator, noted in the next section under needed assistance for the Nolan Creek/South Nolan Creek watershed, should go through social media training to learn how to best target educational messages. If funding allows, a marketing expert or firm might be hired to aid in developing a strategized media outreach program.

Regional Programs

Regional programs focus on the watershed as a whole and include activities, such as maintaining a website for the Nolan Creek WPP for posting newsletters, educational fact sheets, training information, monitoring data, and other relevant information. A goal would be to link the educational component of this website with other pertinent websites providing information already developed, such as EPA's stormwater (https://www.epa.gov/npdes/npdes-stormwater-program) and nonpoint source (https://www.epa.gov/nps) programs, the information provided by various SWMPs in the watershed, and the CTCOG flood management planning and hike/bike trail information as well as other programs noted below.

Cen-Tex Sustainability Partnership

The Cen-Tex Sustainability Partnership serves as a forum to develop and implement regional sustainability efforts within the Central Texas region to improve the overall quality of life and economic vitality its citizens. Members include Fort Hood and the Cities of Copperas Cove, Gatesville, Harker Heights, Killeen, Belton, Nolanville and Lampasas. Cen-Tex promotes educational outreach through programs to youth in area schools and participation in events, such as Earth Fest, Eco Harvest, and GIS Day, held within the region.

- Cen-Tex Sustainability Partnership http://www.centexsustains.org/education.html

Texas Watershed Stewards

The Texas Watershed Steward program implemented through a partnership between Texas A&M AgriLife Extension Service and TSSWCB provides science-based, watershed education to help citizens identify and take action to address local water quality impairments. Texas Watershed Stewards learn about the nature and function of watersheds, potential impairments, and strategies for watershed protection. A Texas Watershed Stewards Program was hosted in the Nolan Creek watershed on September 19, 2013, to encourage stakeholder participation in the

watershed planning process. The program was open to all watershed residents including homeowners, business owners, agricultural producers, decision-makers, community leaders, and other citizens. The Nolan Creek Partnership found success in this program, and with cooperation from Texas A&M AgriLife Extension Service would like to provide the opportunity for this program to be presented again in the watershed at least once within the next three years and again within seven to ten years. Costs for presentation of this program are largely underwritten by TSSWCB as a program sponsor.

- Texas A&M AgriLife Extension Service and TSSWCB https://tws.tamu.edu/

Texas Stream Team

The Texas Stream Team is a volunteer water quality monitoring program coordinated through the Meadows Center for Water and the Environment at Texas State in San Marcos, Texas. The Texas Stream Team program trains volunteers in water quality monitoring and quality assurance procedures, so collected data may be used to augment professionally collected data. The Texas Stream Team was established in 1991 and is administered through a cooperative partnership between Texas State University, TCEQ, and EPA with assistance from other partners and sponsors. Five Texas Stream Team monitoring stations exist in the watershed, but commitments to monitoring at these five locations have varied with the most recent data from 2015 as noted on the Texas Stream Team website when checked in November 2017. The Nolan Creek Partnership would like to encourage more volunteers by facilitating training sessions in the watershed and also using data collected by volunteers to help better target sources of bacteria within the watershed. While training is often provided free of charge via the Texas Stream Team program, sponsors are solicited to aid with the cost of kits.

- Meadows Center for Water and the Environment – Texas Stream Team http://www.meadowscenter.txstate.edu/Service/TexasStreamTeam.html
    - Costs: Water Quality Monitoring Kits – Standard Kit about $500 each; Advanced Kit for Nitrate, Phosphorus & Turbidity about $600; *E. coli* Monitoring Equipment about $220 each (Total $1,320 per volunteer for monitoring kits)

On-Site Sewage Facilities

In a survey of potential bacteria and nutrient sources in the Nolan Creek/South Nolan Creek watershed, OSSFs often referred to as septic systems, were identified as a potential source (McFarland and Adams, 2015b). The analysis of monitoring data and land-use information further targeted areas along Little Nolan Creek within the City of Killeen where many residences are not yet connected to the municipal sewer collection system (McFarland and Adams, 2015b; Nett and Flowers, 2008). Rural residences outside of sewer collection areas, particularly those nearest the creek, were also considered potential sources as the soils in the area are not well suited for OSSFs (Huckabee, et al., 1977). Efforts discussed below are educational components that are on-going or that the Nolan Creek Partnership can help provide to stakeholders on proper maintenance and repair of OSSFs.

OSSF Informational Campaign

Texas A&M AgriLife Extension and many other agencies have developed extensive educational programs geared towards homeowners with OSSFs. The Nolan Creek Partnership will adapt if needed and distribute existing technical guidance for owning and operating OSSFs. Distribution

of this information should target those with OSSFs through direct mailings, service providers for OSSFs, and the Bell County Health Inspectors office, as the responsible entity for permitting and inspection of OSSFs. Other distribution mechanisms will also be considered as marketing for all management practices is developed.

Cost Estimate: Mailings an estimated 2,200 households with OSSFs ($2,000)

The Nolan Creek Partnership website will link to online information available from the following:

- Texas A&M AgriLife Extension Service on On-Site Sewage Facilities – https://ossf.tamu.edu/ and
- EPA –https://www.epa.gov/septic

OSSF Maintenance Workshops

The Nolan Creek Partnership plans to work with Texas A&M AgriLife Extension to host a one-day, educational workshop focused on the operation of aerobic and anaerobic septic systems including proper maintenance and repair at least once per year. Besides workshop delivery on maintenance targeting those who use OSSFs, Texas A&M AgriLife Extension also provides programs specifically for installers and maintenance providers that should also be delivered in the watershed at least once in the first three years. These workshops would focus primarily on those within rural areas of the watershed, as the cities within their MS4 stormwater management plans have outreach efforts focused on OSSFs. The cost of workshop delivery is often underwritten by other water quality programs promoting proper OSSF maintenance at the state level. If not underwritten, costs of sponsoring such a workshop are estimated at about $3,500.

Online Onsite Wastewater Treatment and Reuse Course will be promoted on the Nolan Creek Partnership website.

- Texas A&M AgriLife Extension Service on On-Site Sewage Facilities – https://water.tamu.edu/events-classes-training/

Riparian and Stream Ecosystem Education Program

The Riparian and Stream Ecosystem Education Program will focus primarily on landowners along the creek, but also solicit participation from city/county personnel and developers. This program has been developed by the Texas Water Resources Institute (TWRI) with funding from EPA and TSSWCB and includes a large number of partners (e.g., TPWD, Texas Riparian Association, NRCS, the Nueces River Authority, Texas A&M AgriLife Research and Extension, and the Texas Tech University Llano River Field Station). The Nolan Creek Partnership will work with TWRI and the Texas Riparian Association to coordinate delivery of a program on Riparian Proper Functioning Condition at least once every three years. Through this program, the Nolan Creek Partnership hopes to connect riparian landowners with the Texas Riparian Association as a venue for learning more about the technical and financial resources available for improving management of their riparian lands. Riparian degradation is a major threat to stream health through its negative impacts on water quality and stream habitat. Proper management, protection, and restoration of riparian areas will help decrease bacteria, nutrient, and sediment loadings from nonpoint source runoff by allowing the floodplain to act as a buffer before runoff

reaches the creek. The Riparian and Stream Ecosystem Education program will increase stakeholder awareness, understanding, and knowledge about the nature and function of riparian zones and the best management practices (BMPs) that can protect riparian areas, while minimizing nonpoint source pollution.

Cost: Delivery of Riparian and Stream Ecosystem Program has often been underwritten by program sponsors. Free delivery of this program is contingent on continued sponsored funding. More recent programs are charging $100 per person for attendance.

- Texas Riparian Association – Riparian Program http://texasriparian.org/riparian-education-program/ and http://texasriparian.org/trainings/

Urban Programs

The Nolan Creek Partnership through the Watershed Coordinator will collaborate with local cities and the county in the development and distribution of education and outreach materials focusing on urban nonpoint source pollution. As noted earlier, many of these urban programs and materials are associated with MS4 permits, so the Nolan Creek Partnership will coordinate with SWMP educational efforts in these activities (see Appendix F). Examples of activities that the Nolan Creek Partnership would promote and expand upon include advertising and support of community stream cleanup events, efforts to control pet waste, and hazardous waste cleanup days. These urban programs will enable the Nolan Creek Partnership to reach residents, visitors, businesses, as well as city/county personnel and developers.

An example of educational outreach already occurring regarding safe use of the creek is the webpage on the Belton City website on Nolan Creek (http://www.beltontexas.gov/departments/parks_and_recreation/nolan_creek.php). This webpage includes access to rain gages and stream elevation monitors at locations along the creek from Killeen to Belton allowing individuals to view current water levels as well as the impact of recent rains on stream conditions. The Belton website also includes a page dealing with Frequently Asked Questions about Nolan Creek (http://www.beltontexas.gov/departments/parks_and_recreation/faqs_about_nolan_creek.php). Many of these questions focus on access for tubing or kayaking but also the safety of recreating in Nolan Creek. For water quality information, the Belton Nolan Creek website also includes links to data from TCEQ and the Nolan Creek WPP. The Nolan Creek WPP website would reciprocate with links to the City of Belton website on Nolan Creek.

Sewer Lines – Private Infrastructure

A primary focus identified for education dealing with human waste was the lateral lines linking individual homes to the main WWTF collection system. The Nolan Creek WAP will expand on efforts already being conducted under MS4 permit SWMPs through the Nolan Creek WPP website as well as other educational avenues. This is an area where how best to market the information still needs to be defined, but the focus would be on the following:

- Education of private property owners on responsibilities regarding lateral lines
- Education of owners and renters on how to maintain clear lateral lines

- Education of owners and renters on how to identify leakage or blockage problems with lateral lines for wastewater located on private property and what to do when problems occur

Texas Waterway Cleanup Program

The Nolan Creek Partnership plans to coordinate with Keep Texas Beautiful to organize yearly a creek cleanup within the watershed. The creek cleanup will be open to all stakeholders, and local civic groups will be invited to participate. The Watershed Coordinator will also promote and participate in other creek cleanup events as a way to connect stakeholders to the creek and the watershed as well as providing a conduit for distributing educational information.

Low Impact Development

The Watershed Coordinator should plan for at least one workshop/training on LID within the watershed at least once every three years. For example, several demonstration projects for LID practices have been designed and installed at the Texas AgriLife Research and Extension Center in Dallas including permeable pavements, bioretention, rainwater harvesting, green roofs, and detention ponds. These demonstration projects provide examples of how LID can be integrated into the design of new developments or retrofitted to existing area. This educational outreach may involve travel to the Texas AgriLife Research and Extension Center in Dallas or other locations to view demonstration sites or coordinating speakers or workshops locally on LID.

Urban Riparian and Stream Restoration Training

Urban riparian and stream restoration training through the Texas Riparian Association would aid landowners, municipalities and other entities within the watershed in better understanding how to maintain and restore natural stream functions. Individuals, particularly those involved with municipal development, should be encouraged to attend. These training courses focus on urban stream systems and impacts development can have on stream degradation including an overview comparing traditional and natural restoration techniques. Basic training is generally one-day course and held throughout Texas near large urban centers. A more advance three-day courses is offered in Dallas.

Cost: Registration cost for the Urban Riparian and Stream Restoration Training are estimated at $100 per person for the one-day course. Registration costs for the three-day course were not available.

- Texas Riparian Association – Riparian Program http://texasriparian.org/riparian-education-program/ and http://texasriparian.org/trainings/

Domestic Pet Waste

Pet Waste Management

Pet waste has been identified in many watersheds as a major contributing source of bacteria, particularly in urban areas. Municipalities in the watershed have developed programs geared towards pet owners regarding proper pet waste management, but consensus was that more needs to be done. A large amount of educational information is available regarding the impacts of pet waste on water quality from EPA and other resources. The Nolan Creek Partnership will work with existing programs to help develop and distribute existing materials about the effects of pet waste on water quality through newsletters and other venues. The Nolan Creek Partnership will

also work to develop a watershed-wide pet waste campaign to encourage folks to pick up pet waste.

Pet Stations

The Nolan Creek Partnership will encourage municipalities within the watershed to add "pet stations" at local parks along Nolan Creek and South Nolan Creek. The "pet station" contains all the elements necessary to maximize clean up success with waste pick up baggies as well as a trash receptacle. A watershed friendly sign could be attached to the pet waste station noting pet waste as a contributing source of bacteria in the watershed. These pet waste stations require continuous maintenance, so engagement of municipalities will be a necessity.

Wildlife Waste

While not considered a major source of bacteria in the watershed, waterfowl and other wildlife can become a problem source if population levels are not kept under control. Working with TPWD, educational outreach will include information on why the public should be discouraged from feeding waterfowl and small mammals. Signage in parks to discourage wildlife feeding should be adopted by municipalities.

Home Chemical & Hazardous Waste Collection Events

Several entities host HHW events within or near the watershed that provide respective residents a place to properly dispose of hazardous chemicals. All too commonly typical household chemicals, such as fertilizers, pesticides, herbicides, insecticides, and cleaning supplies are improperly disposed. When improperly disposed of, these chemicals and hazardous waste can eventually make their way into local waterways (Nolan/South Nolan Creek) through stormwater runoff. The Home Chemical & Hazardous Waste Collection Events provide an easy and safe method for the proper disposal of the more harmful household products. The Nolan Creek Partnership will help promote such events as part of its outreach activities and aid in providing information on how to appropriately deal with hazardous waste through its website and other venues.

Agricultural Programs

There is an abundance of material already developed that focuses on the control of bacteria and nutrients from agricultural sources. The Nolan Creek Partnership will coordinate with the county, NRCS, TSSWCB, Texas A&M AgriLife Extension, and other agencies to modify and distribute education and outreach materials that target the rural stakeholders and livestock owners in the watershed. Examples of activities that the Nolan Creek Partnership will encourage include nutrient management, soil and water testing, and livestock grazing management; all items currently addressed by Texas A&M AgriLife Extension. The Nolan Creek Partnership will also promote and host agricultural programs to encourage action by rural and urban livestock owners in appropriate management of animal waste.

Lone Star Healthy Streams Program

The Lone Star Healthy Streams (LSHS) program focuses on educating rural livestock owners on practices to reduce bacteria in Texas water bodies through best management practices for livestock. The LSHS program was developed by Texas A&M AgriLife Extension Service and the TWRI. Presentations/workshops can be arranged upon request or the program can be

accessed through a series of online courses at: https://water.tamu.edu/events-classes-training/ . These presentations/workshops are designed to target audiences for beef cattle, dairy cattle, feral hogs, horses, and poultry. For the Nolan Creek watershed, beef cattle and horses would be the primary focus and potentially feral hogs, should the hog problem increase. Through the Lone Star Healthy Stream program, resources are provided that specifically address BMPs for reducing bacteria from livestock, such as waste utilization, filter strips, and access control (http://lshs.tamu.edu/bmps/). The Nolan Creek Partnership would encourage stakeholders to access these on-line educational modules through brochures, fliers, newsletters, and other awareness and informational materials.

- Texas A&M AgriLife Extension Service LSHS Program https://water.tamu.edu/water-quality/lone-star-healthy-streams-program-lshs/

Feral Hog Management Workshop

The Nolan Creek/South Nolan Creek watershed is primarily urban and feral hogs are not considered a major problem or source of bacteria in this watershed. However, it has been expressed by stakeholders that in the more rural areas, particularly along North Nolan Creek, feral hogs can be a problem. More recently, hog damage has been noted along the creek within the city limits of Harker Heights. The Nolan Creek Partnership, in conjunction with Texas A&M AgriLife Extension and other appropriate agencies will make available educational materials on hog management. Hog management is a significant issue in some of the surrounding watersheds, such as the Lampasas and Leon River watersheds that are more rural, and as workshops on Feral Hog Management are presented for these other watersheds, the Nolan Creek Partnership will help to promote these as well as conduct a workshop specific to the watershed at least once every three years. These Feral Hog Workshops present information on feral hog biology, effects feral hogs have on water quality, trap design as well as pertinent laws and regulations. Costs for Feral Hog Workshops can be variable depending on current support from statewide programs.

Online information on feral hog control is also available from the following:

- Texas A&M AgriLife Extension – Coping with Feral Hogs https://feralhogs.tamu.edu/ and Feral Hogs http://articles.extension.org/feral_hogs .
- TPWD – Feral Hogs https://tpwd.texas.gov/huntwild/wild/nuisance/feral_hogs/

Table 6-1 Summary of proposed educational outreach activities for throughout the watershed.

Education or Outreach Activity	Responsible for Delivery	Number to be Implemented			Estimated Cost	Goal
		Years 1-3	Years 4-6	Years 7-10		
Nolan Creek WPP - Awareness and Informational Materials						
Website, other Social Media, and email	Watershed Coordinator[1]	Maintained throughout	Maintained throughout	Maintained throughout	About $250/yr to host	Provide a base for electronically available educational materials and outreach to stakeholders throughout the watershed
Fact Sheet (General for the WPP)	Watershed Coordinator	1 per yr	1 per yr	1 per yr	About $40/ fact sheet (100 copies)	Distribute at least 100 copies per year via public locations, such as libraries and city/county offices, and make electronically available
Newsletters	Watershed Coordinator	2 per yr	2 per yr	2 per yr	$0 Electronic only	Updates once every six months
Brochures	Watershed Coordinator	1 per yr	1 per yr	1 per yr	About $40 each (100 copies)	Distribute at least 100 copies per year via public locations, such as libraries and city/county offices, and make electronically available
Fliers	Watershed Coordinator	4 per yr	4 per yr	4 per yr	About $20 each (100 copies)	Distribute at least 100 copies per year via public locations, such as libraries and city/county offices, and make electronically available

Education or Outreach Activity	Responsible for Delivery	Number to be Implemented			Estimated Cost	Goal
		Years 1-3	Years 4-6	Years 7-10		
Displays at Local Events	Watershed Coordinator	4 per yr	4 per yr	4 per yr	$500 to set up initial display and then $100/yr for updates	Watershed Coordinator should participate in at least 4 events per year
Hiring of Public Relations Expertise for Development of Outreach Campaign	Municipalities with Watershed Coordinator	1			$10,000	Use Public Relations expertise to help develop outreach program
Regional Educational Programs						
Texas Watershed Stewards	Texas A&M AgriLife Extension Service	1	0	1	Delivery cost underwritten but sponsor for lunch for up to 50 participants (about $600)	One in first three years and another in years 7-10
Texas Stream Team	Meadows Center for Water and the Environment	1 per yr	1 per yr	1 per yr	Kits about $1,320/volunteer	Recruit 10 volunteers initially and then at least 2 per year to account for turnover
OSSF Maintenance Workshops for Users	Texas A&M AgriLife Extension Service	1 per yr	1 per yr	1 per yr	About $3,500/workshop and about $3,000 for direct mailings to those on OSSFs	Conduct one workshop per year with at least 20 attendees/workshop
OSSF Maintenance Workshops for Installers & Maintenance	Texas A&M AgriLife Extension Service	1	1	1	About $3,500/workshop	Conduct one workshop every three years with at least 5 attendees/workshop

Education or Outreach Activity	Responsible for Delivery	Number to be Implemented			Estimated Cost	Goal
		Years 1-3	Years 4-6	Years 7-10		
OSSF Information Campaign	Watershed Coordinator, Municipalities & Bell County	Link to available electronic information on website & include with workshop mailings to those on OSSFs			Include with workshop mailing (about $1,000 for copies of information)	Reach at least 50% of OSSF users with mailings
Riparian and Stream Ecosystem Education Program	Texas Riparian Association – Riparian Program	1	1	1	Cost $100 per person unless underwritten by program sponsors	Conduct one workshop every three years with at least 15 attendees/workshop
Urban Riparian and Stream Restoration Training	Texas Riparian Association – Riparian Program	5 attendees	5 attendees	5 attendees	Cost $100 per person	Have at least five individuals per year attend a workshop annually
Urban Programs						
Sewer Lines - Private Infrastructure Educational Campaign	Municipalities with Watershed Coordinator	Maintained throughout	Maintained throughout	Maintained throughout	Cost largely covered as time of watershed coordinator, plus additional $5,000 per year for campaign	Link to electronic information available dealing SWMPs & support relevant activities
Texas Waterway Cleanups	Keep Texas Beautiful	1 per yr	1 per yr	1 per yr	About $2,000 per event, but often sponsored	Participate in at least one creek clean up per year

Education or Outreach Activity	Responsible for Delivery	Number to be Implemented			Estimated Cost	Goal
		Years 1-3	Years 4-6	Years 7-10		
LID Workshops	Texas A&M AgriLife Extension (or other LID experts)	1	1	1	Depends on delivery method and if travel to Dallas is needed.	Sponsor at least one workshop every three years
Urban Riparian and Stream Restoration Training	Texas Riparian Association – Riparian Program	1	1	1	Cost for registration about $100 per person for 1-day course	Encourage attendance by municipalities and others to attend nearby courses
Pet Waste Management Educational Campaign	Municipalities with Watershed Coordinator	Maintained throughout	Maintained throughout	Maintained throughout	Cost largely covered as time of watershed coordinator	Link to electronic information available with SWMPs & support relevant activities
Pet Waste Stations and Signage	Municipalities with Watershed Coordinator	1	1	1	Stations about $260 each, maintenance about $85/station per yr, signage about $250/sign	Add three stations per year throughout the watershed
Don't Feed Wildlife Education	Municipalities	1			Signage in parks near creek, $250/sign	Add three signs in first three years and educational materials provided through electronic media
HHW Events	Municipalities, CTCOG & Bell County	1 per yr	1 per yr	1 per yr	About $12,500 per event, but often sponsored	Participate in at least one HHW event per year

Education or Outreach Activity	Responsible for Delivery	Number to be Implemented			Estimated Cost	Goal
		Years 1-3	Years 4-6	Years 7-10		
Support SWMP Educational programs	Municipalities, Fort Hood & Bell County	Maintained throughout	Maintained throughout	Maintained throughout	Cost largely covered as time of watershed coordinator	Link to electronic information available with SWMPs & support relevant activities
Agricultural Programs						
Lone Star Healthy Streams Program (Cattle)	Texas A&M AgriLife Extension Service LSHS Program	1	1	1	Cost underwritten by program sponsors	Conduct one workshop every three years with at least 15 attendees/workshop
Lone Star Healthy Streams Program (Horses)	Texas A&M AgriLife Extension Service LSHS Program	1	1	1	Cost underwritten by program sponsors	Conduct one workshop every three years with at least 15 attendees/workshop
Feral Hog Management Workshops	Texas A&M AgriLife Extension Service	1	1	1	Advertise electronically, cost variable depending on program support	One every three years
Feral Hog Education	Watershed Coordinator	Maintained throughout	Maintained throughout	Maintained throughout	Time for watershed coordinator	Make available already existing educational materials through website and other electronic media

1. Cost of Watershed Coordinator estimated at $70,000 per year.

SECTION 7

Financial and Technical Assistance

Watershed Coordinator

To coordinate activities within the Nolan Creek WPP, the Nolan Creek Partnership recommends hiring a locally-based Watershed Coordinator. Primary Duties of the Watershed Coordinator would be as follows:

- Work with the county, cities, local boards, and businesses to coordinate implementation of management measures.
- Coordinate educational outreach activities by
    - Developing publications (newspaper, newsletter, factsheets) and website content to promote and communicate watershed efforts
    - Interacting with appropriate state and federal agencies to set up workshops
    - Promoting and participating in creek cleanup and HHW activities and, as appropriate, organizing such events
- Engage state and federal agencies and organizations, as appropriate, in introducing needed technical and financial resources to stakeholder groups.
- Aid in developing grants to obtain financial resources to implement educational and management practices.
- Track and document implementation efforts to assess progress toward established goals.
- Assist in developing a water quality monitoring effectiveness program, including MST, and participate with monitoring and data management, as needed.
- Evaluate water quality data to monitor progress towards instream improvements.
- Conduct regular stakeholder meetings to provide updates on progress and seek input on activities and assess the need for new approaches.

Cost – Salary $35,000 to $50,000 plus about 32% fringe (total $46,200 to $66,000/year) with an additional $5,000 per year estimated for travel and general expenses. Source of funding likely through municipalities with financial assistance through the CWA 319 program (CWA 319 funding needs 40% match from non-federal dollars).

Technical Assistance

Most management measures will require some level of technical assistance to properly implement. A variety of technical resources are available, many providing planning assistance free of charge, through state and federal agencies. Several of the resources listed below are also listed as educational resources. The Watershed Coordinator for the WPP should be capable of facilitating technical assistance with these entities. Of note, programs listed are subject to change, particularly with variations in state and federal funding.

Wastewater Treatment Facilities

- TCEQ – Help for Wastewater Treatment Plant Owners and Operators (https://www.tceq.texas.gov/assistance/water/wastewater/help-for-wastewater-treatment-plant-owners-and-operators)
- EPA – Municipal Wastewater (https://www.epa.gov/npdes/municipal-wastewater)
- Brazos River Authority (BRA) – operates Temple-Belton WWTF and can provide technical assistance to other operations in the area (http://www.brazos.org/About-Us/Water-Quality/Water-Wastewater-Treatment)
- Municipalities, WCID1 & WCID 3

Sewer Line Infrastructure

- Municipalities – Public Works Departments
- TCEQ – Sanitary Sewer Overflow Initiative (https://www.tceq.texas.gov/compliance/investigation/ssoinitiative)
- EPA – Municipal Wastewater (https://www.epa.gov/npdes/municipal-wastewater)

OSSFs

- Bell County Health Department – On-Site Sewer Facilities Information – Inspections and Permits (http://www.bellcountyhealth.org/environmental_health_and_food_protection/on-site_sewer_facilities/index.php)
- Texas AgriLife – Onsite Waste Water Treatment Systems (https://water.tamu.edu/water-quality/onsite-waste-water-treatment-systems/)
- TCEQ – On-Site Sewage Facilities (Septic Systems) (https://www.tceq.texas.gov/permitting/ossf)
- EPA – Septic Systems (Onsite/Decentralized Systems) (https://www.epa.gov/septic
- Clearwater Groundwater Conservation District (http://www.cuwcd.org/)
- Texas Groundwater Protection Committee (http://www.tgpc.state.tx.us/water-wells/)

Pet Waste

- Municipalities
- Existing Pet Waste Campaigns – Examples:
    - City of Austin, Texas, Scoop the Poop (http://www.austintexas.gov/department/scoop-the-poop)
    - New Hampshire Department of Environmental Services, Pet Waste Outreach Campaign (https://www.des.nh.gov/organization/divisions/water/wmb/coastal/scoop_the_poop.htm)
    - Metropolitan North Georgia Water Planning District (http://cleanwatercampaign.org/protect-our-water/pet-waste/)
    - Pet Poo Skiddoo, Pet Waste Removal (https://www.petpooskiddoo.com/blog/10-bizarre-campaigns-pushing-people-to-pick-up-dog-poop/)

Illegal Dumping

- TCEQ – "Don't Mess with Texas Water": A Way to Report Illegal Dumping (https://www.tceq.texas.gov/p2/dont-mess-with-texas-water-a-way-to-report-illegal-dumping#get-involved)
- Bell County - Illicit Discharge Detection and Elimination (http://www.bellcountytx.com/departments/engineer_2/illicit_discharges.php) and County Engineer's Office at (254) 933-5275
- Municipalities

Homeless

- TCEQ Brownfields Site Assessment Program – Could potentially be used to facilitate the cleanup and redevelopment of areas where homeless encampments have become a hazard to the environment (https://www.tceq.texas.gov/remediation/bsa/Benefits.html
- Homeless shelters and charitable organizations working with the homeless within the watershed, such as Families in Crisis and the Central Texas Homeless Alliance.
- Municipalities

Urban Stormwater Management

- EPA – National Pollutant Discharge Elimination System (NPDES), Stormwater Discharges from Municipal Sources (https://www.epa.gov/npdes/stormwater-discharges-municipal-sources
- TCEQ – Municipal Separate Storm Sewer System (MS4) Discharges: Am I Regulated? (https://www.tceq.texas.gov/permitting/stormwater/ms4/WQ_ms4_AIR.html)
- TPWD for all wildlife related management strategies – Hill County Wildlife District, Bell County (https://tpwd.texas.gov/landwater/land/habitats/hillcountry/regulatory/?county=bell)
- Texas AgriLife Extension – Low Impact Development (https://tcwp.tamu.edu/land-use/low-impact-development/)
- TCEQ – Statewide: Low Impact Development Workshops and Documents (https://www.tceq.texas.gov/waterquality/nonpoint-source/projects/statewide-low-impact-development-workshops)
- Municipalities

Rural Stormwater Management

- NRCS – Conservation Planning (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/)
- USDA Belton Service Center, 1605 N Main St, Belton, TX, 76513-1944; Phone (254) 939-7808 ext 3 (https://offices.sc.egov.usda.gov/locator/app?type=ref&state=48&county=027&agency=nrcs)
- TSSWCB – Water Quality Management Plan (https://www.tsswcb.texas.gov/programs/water-quality-management-plan), Dublin Regional Office 611 East Blackjack, Dublin, TX 76446-2321; Phone 254-445-4814
- SWCD – Central Texas SWCD, PO Box 1832, Temple, TS 76503-1832; Phone (254) 718-5296; email: centraltexas@swcd.texas.gov

- Texas A&M Forest Service – Contact Us (http://texasforestservice.tamu.edu/content/article.aspx?id=19988)
- TPWD – Hill County Wildlife District, Bell County (https://tpwd.texas.gov/landwater/land/habitats/hillcountry/regulatory/?county=bell)
- Texas A&M AgriLife – Stormwater Management (https://water.tamu.edu/water-management-irrigation/stormwater-management/)
- Cen-Tex Sustainability Partnership (http://www.centexsustains.org/education.html)

Roosting Birds

- TPWD – Hill County Wildlife District, Bell County (https://tpwd.texas.gov/landwater/land/habitats/hillcountry/regulatory/?county=bell)
- Texas Wildlife Services – Roosting Birds (https://agrilife.org/txwildlifeservices/species-information-and-publications/birds/roosting-birds/)

Wildlife (including waterfowl)

- TPWD for all wildlife related management strategies – Hill County Wildlife District, Bell County (https://tpwd.texas.gov/landwater/land/habitats/hillcountry/regulatory/?county=bell)
- Texas Wildlife Services (https://agrilife.org/txwildlifeservices/)

Recreational Use

- TPWD – Recreational Grants (https://tpwd.texas.gov/business/grants/recreation-grants)
- City of Killeen – Parks and Recreation (http://www.killeentexas.gov/index.php?section=27)
- City of Harker Heights – Parks and Recreation (http://www.ci.harker-heights.tx.us/index.php/2011-11-22-17-14-10/parks-and-recreation)
- City of Nolanville – City Park Master Park Plan (http://ci.nolanville.tx.us/page/city.park)
- City of Belton – Parks and Recreation (http://www.beltontexas.gov/departments/parks_and_recreation/index.php)

Flood Management

- CTCOG – Nolan Creek Flood Protection Planning Study (https://ctcog.org/regional-planning/nolan-creek-flood-protection-planning-study/)
- Texas Floodplain Management Association (training) – (http://www.tfma.org/events/event_list.asp)
- NRCS – Watershed Protection and Flood Prevention Program (https://www.nrcs.usda.gov/wps/portal/nrcs/main/tx/programs/planning/wpfp/) provides assistance with flood control dam rehabilitation (example: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/tx/programs/planning/wpfp/?cid=nrcs144p2_002969)
- TSSWCB – Flood Control Program (https://www.tsswcb.texas.gov/programs/flood-control-program)
- Texas Riparian Association – Riparian Resources (http://texasriparian.org/)

Microbial Source Tracking

- TWRI – Texas Bacterial Source Tracking Program (http://texasbst.tamu.edu/)

- United States Geological Survey (USGS) Microbial Source-Tracking and Detection Techniques (https://water.usgs.gov/owq/microbial.html) and Selction and
- EPA - Using Microbial Source Tracking to Support Total Maximum Daily Load (TMDL) Development and Implementation (https://www.epa.gov/tmdl/using-microbial-source-tracking-support-tmdl-development-and-implementation)

Instream Effectiveness Monitoring

- TCEQ – Clean Rivers Program (https://www.tceq.texas.gov/waterquality/clean-rivers)
- Brazos River Authority (BRA) – facilitates monitoring with TCEQ within the Brazos River Basin via the Texas Clean Rivers Program and works with WPPs for water quality improvement (http://www.brazos.org/About-Us/Water-Quality)
- The Meadows Center for Water and the Environment – Texas Stream Team (http://www.meadowscenter.txstate.edu/Service/TexasStreamTeam.html)

Financial Assistance

While watershed municipalities, Fort Hood, and Bell County will finance or perform many of these management measures, particularly those associated with MS4 permits as on-going activities, often budgets are already stretched thin, so financial assistance would aid in implementation of the measures outlined in this WAP. Currently, governmental entities within the watershed have not made solid financial commitments to implementation of the WPP beyond activities already occurring under MS4 permits, as it takes time to plan and work new activities and expenses into budgets set by fiscal year. There is also a need to determine how some of these costs may be split among entities as the watershed covers several governmental jurisdictions. One suggestion was to consider things such as contribution area, population density, and impact in developing a cost-share allogrithm among entities in the watershed. Broad estimates of needed finances to implement this WPP are provided at the end of the section. While funding can seem daunting, there are several sources of financial assistance, mainly from federal and state programs, that can help. Many of these potentail funding sources, which could supplement county and muncipal sources, are listed below by agency along with the types of management measures that might be funded under each, which is also summarized at the end of this section (Table 7.2).

Although costs are difficult to truly estimate until implementation is engaged, estimates per management strategy are provided below for major activities (Table 7-1). These estimates include the education-outreach component as well as the structural items, such as repair or replacement of OSSFs or lateral lines to the central wastewater collection system, needed for these activities. While these costs seem large, the financial resources noted earlier in this section are available to assist in meeting these costs. There are also on-going programs within municipalities, Fort Hood and Bell County that may facilitate implementation of these activities, thus, reducing costs. Some of these have already been identified, such as those specifically associated with MS4 permits. Best use of resources is the goal, but some additional financial resources will be needed, much of which will need to come from local funding sources.

Table 7-2 Estimated costs of major activities by management strategy.

Measure	Activities	Estimated per Unit Costs	Unit	Estimated Number per Timeframe				Comments
				Years 1-3	Years 4-6	Years 7-10	Total Costs	
Watershed Coordinator	Overall Coordination	$70,000	per year	3	3	4	$700,000	Alternatives may involve a committee structure similar to CENTEX for managing coordination of WPP
	Outreach Materials (fliers, brochures, website, etc.)	$510	per year	3	3	4	$5,100	
	Mailings	$4,000	per year	3	3	4	$40,000	
	Hiring of Public Relations firm to develop outreach strategy	$10,000	once	1			$10,000	
WWTF	Tracking voluntary reporting of bacteria in discharges	Not applicable (NA)	NA	NA	NA	NA	NA	Cost covered with Watershed Coordinator
Sewer Lines	Repair or replacement of leaky lateral lines	$1,650	per household	10	20	20	$82,500	Cost range from $300 to $3,000; mid-range value used for estimate ($1,650)
OSSFs	Repair of failing OSSF	$3,000	per household	10	20	20	$150,000	Cost range from $1,000 to $5,000; mid-range value used for estimate ($3,000)
	Replacement failing OSSF	$7,500	per household	5	10	10	$187,500	Cost range from $5,000 to $10,000; mid-range value used for estimate ($7,500)

Measure	Activities	Estimated per Unit Costs	Unit	Estimated Number per Timeframe				Comments
				Years 1-3	Years 4-6	Years 7-10	Total Costs	
	Connecting to centralized sewer system from OSSF	$3,000	per household	5	10	10	$75,000	
	Decommission of OSSFs	$2,000	per household	5	10	10	$50,000	Cost range from $300 to $3,000; mid-range value used for estimate ($1,650)
	Education Homeowners	$3,500	per workshop	3	3	3	$31,500	
	Education Installer/Service Providers	$3,500	per workshop	1	1	1	$10,500	
Pet Waste	Additional pet waste stations	$345	per station	9	9	9	$9,315	Waste station and annual maintenance
Illegal Dumping	Creek cleanup events	$2,000	per event	3	3	3	$18,000	
	HHW Events	$12,500	per event	NA	NA	NA	NA	Already sponsored under on-going programs
Homeless	To be determined (TBD)	TBD	TBD	TBD	TBD	TBD	TBD	To be determined and added to plan at a later date
Urban Stormwater	Implementation MS4 permit SWMPs	On-going	NA	NA	NA	NA	NA	Covered largely by activities in SWMPs
	Bioswales (Nolanville)	$217,000		1			$217,000	See Appendix E for details
Rural Stormwater	WQMPs for livestock and horse owners	$15,000	per operation	4	4	4	$180,000	$15,000 represents maximum available per TSSWCB cost share
Feral Hogs	Hog trapping	$10	per hog	50	50	50	$1,500	Amount charged by Hogs for a Cause

Measure	Activities	Estimated per Unit Costs	Unit	Estimated Number per Timeframe				Comments
				Years 1-3	Years 4-6	Years 7-10	Total Costs	
Roosting Birds	TBA	TBD	TBD	TBD	TBD	TBD	TBD	Control plan will need to be developed before costs can be estimated
Wildlife	Do not feed campaign, signs in parks	$250	each	3	0	0	$750	Education campaign covered under Watershed Coordinator outreach activities
Recreational Use	Promotion of safe usage	NA	NA	NA	NA	NA	NA	Covered under Watershed Coordinator outreach activities
Flood Management	TBA	TBD	TBD	TBD	TBD	TBD	TBD	Flood planning occurring in tandem with WPP under separate project
Microbial Source Tracking	Assess sources	$250,000	per study	1			$250,000	To be conducted within first three years of plan
Stream Monitoring (costs)	Monitoring for evaluating effectiveness in reaching instream water quality goals	$100,000	per year	2	3	3	$800,000	See Section 9 for details. Estimated costs based on 10 stations with monthly monitoring for bacteria, chlorophyll-a, nutrients and total suspended solids.
							$2,818,665	Overall total

EPA

CWA §319 Nonpoint Source Grant Program (1)

The CWA §319 Nonpoint Source program provides grant funding through TSSWCB and TCEQ from EPA to implement specific projects that control and abate nonpoint source pollution. The TSSWCB focuses on projects aimed at agricultural and silvicultural nonpoint source pollution and the TCEQ focuses on projects that target urban nonpoint source pollution. Management measures that might be addressed with CWA §319 funding include support of a Watershed Coordinator as well as implementation of some management practices and educational outreach activities. Funding through the CWA §319 requires a 40 percent nonfederal match and funding cannot be used to support permitted activities, such as those specifically outlined within SWMPs under MS4 permits or direct discharge permits associated with WWTFs. For example, CWA §319 funding could be used to assist with the removal of OSSFs within a municipality but could not fund the connecting line to the central wastewater collection system. Another example is that CWA §319 funding could be used for educational outreach, such as for pet waste, which is more frequent, uses a different venue, or covers a broader area than addressed through SWMPs associated with MS4 permits. The TCEQ and/or TSSWCB should be contacted regarding appropriate use of CWA §319 prior to applying to make sure planned activities are an appropriate use of this funding.

- EPA https://www.epa.gov/lakes/clean-water-act-section-319
- TCEQ http://www.tceq.texas.gov/waterquality/nonpoint-source/grants/grant-pgm.html
- TSSWCB http://www.tsswcb.texas.gov/managementprogram

Environmental Education Grants (2)

Under the Environmental Education (EE) grants program, EPA seeks to support environmental education projects that promote environmental awareness and stewardship and help provide people with the skills to take responsible actions to protect the environment. This grant program provides financial support for projects that design, demonstrate, and/or disseminate environmental education practices, methods, or techniques.

- EPA https://www.epa.gov/education/environmental-education-ee-grants

TCEQ

Supplemental Environmental Projects (SEPs) (3)

As part of a settlement for an enforcement action, TCEQ may approve environmental projects as an offset to assessed penalties. For local governments, compliance SEPs may include repair on structures or equipment related to the cause of the violation or remediation efforts, such as cleanup of a spill. Custom SEPs are open to a variety of respondents and can include projects, such as collection events for tires, HHW, electronics and/or large solid waste items; cleanup of illegal dump sites; erosion control projects along a creek; or extending first-time sewer service to low income residents utilizing faulty septic systems.

- TCEQ http://www.tceq.texas.gov/legal/sep/

Texas Clean Rivers Program (4)

The Texas Clean Rivers Program (CRP) is a partnership between TCEQ and regional water authorities that conducts statewide water quality monitoring and assessment. The Nolan

Creek/South Nolan Creek watershed is in the Brazos Basin with the BRA as the TCEQ partner. The CRP program is fee-funded through permits with most fees allocated to monitoring, quality assurance, and data management functions of the program. While this program does not provide grants or loans, its resources can be targeted to aid with effectiveness monitoring in the Nolan Creek/South Nolan Creek watershed to assess improvement in water quality conditions as management measures are implemented. Input on monitoring is solicited through the Brazos River Steering Committee, which meets annually allowing stakeholder involvement setting goals and priorities for development and allocation of CRP resources.

- TCEQ http://www.tceq.texas.gov/waterquality/clean-rivers/ TCEQ,
- BRA https://www.brazos.org/About-Us/Water-Quality/Clean-Rivers-Program

Texas Department of Agriculture

Community Development Block Grant (CDBG) (5)

The Texas CDBG Community Development Fund provides grants to rural Texas cities (under 50,000 in population) and counties (non-metropolitan population under 200,000), which are not eligible for direct CDBG funding from Housing and Urban Development. The Texas CDBG program provides for basic infrastructure projects such as water/wastewater facilities, street improvements, and drainage. Grants are competitive with applications accepted biennially.

- Texas Department of Agriculture (TDA) http://www.texasagriculture.gov/GrantsServices/RuralEconomicDevelopment/RuralCommunityDevelopmentBlockGrant(CDBG).aspx
- CTCOG – https://ctcog.org/regional-planning/technical-assistance/

Texas Capital Fund (6)

The Texas Capital Fund Infrastructure/Real Estate Programs provide financial resources to non-entitlement communities. Funds from the infrastructure program can be utilized for public infrastructure, such as stormwater drainage, water and sewer lines, needed to assist a business. Funds from the real estate program are for real estate development to assist a business. Both programs focus on new business development and expansions that commit to creating and/or retaining permanent jobs, primarily for low and moderate-income persons.

Non-entitlement cities are located predominately in rural areas and are cities with populations less than 50,000 thousand persons; cities that are not designated as a central city of a metropolitan statistical area; and cites that are not participating in urban county programs. Non-entitlement counties are also predominately rural in nature and are counties that generally have fewer than 200,000 persons in the non-entitlement cities and unincorporated areas located in the county. Businesses or individuals may not directly submit applications.

- Texas Department of Agriculture http://www.texasagriculture.gov/GrantsServices/RuralEconomicDevelopment/RuralCommunityDevelopmentBlockGrant(CDBG)/CDBGResources/Applications/INFRARE.aspx and http://www.texasagriculture.gov/GrantsServices/RuralEconomicDevelopment/TexasCapitalFund.aspx

TPWD

Texas Farm & Ranch Lands Conservation Program (7)

The Texas Farm & Ranch Lands Conservation Program (F&RLCP), established by Senate Bill 1273 in 2005, provides grants to landowners to support responsible stewardship and conservation of working lands by generating interest and awareness in easement programs and other conservation options that aid in conserving the ecological and economic value of these lands. Originally under the Texas General Land Office, this program effective January 1, 2016, is now administered through the TWPD.

- TPWD https://tpwd.texas.gov/landwater/land/private/farm-and-ranch/

Landowner Incentive Program (8)

The Texas Landowner Incentive Program (LIP) is a collaborative effort between TPWD Wildlife and Inland Fisheries Divisions to meet the needs of private, non-federal landowners wishing to enact good conservation practices on their lands for the benefit of healthy terrestrial and aquatic ecosystems. Partnerships with the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program, National Fish and Wildlife Foundation, and others fund LIP. Funding through LIP is competitive with highest priority given to projects expected to directly benefit Endangered Species Act (ESA)-listed species and their habitats. Special emphasis is placed on projects that benefit freshwater mussel species of conservation concern and pollinator species.

- TPWD https://tpwd.texas.gov/landwater/land/private/lip/

National Recreational Trails Fund (9)

The TPWD administers the National Recreational Trails Fund (RTF) in Texas under the approval of the Federal Highway Administration. This federally funded program receives its funding from a portion of federal gas taxes paid on fuel used in non-highway recreational vehicles. The reimbursable grants can be up to 80% of project cost with a maximum of $200,000 for non-motorized trail grants and a maximum award of $400,000 for motorized (off-highway vehicle) trail grants. Funds can be spent on both motorized and non-motorized recreational trail projects such as the construction of new recreational trails, to improve existing trails, to develop trailheads or trailside facilities, and to acquire trail corridors.

- TPWD https://tpwd.texas.gov/business/grants/recreation-grants/recreational-trails-grants

Local Park Grant Program (10)

The Local Park Grant Program administered by TPWD consists of five individual programs that assist local units of government with the acquisition and/or development of public recreation areas and facilities throughout the State of Texas. The Program provides 50% matching grants on a reimbursement basis to eligible applicants. All grant assisted sites must be dedicated as parkland in perpetuity, properly maintained and open to the public.

- TPWD https://tpwd.texas.gov/business/grants/recreation-grants/about-local-parks-grants

TSSWCB

Water Quality Management Plan Program (11)

A WQMP is a site-specific plan for land improvement measures developed through SWCDs for agricultural and silvicultural lands. A WQMP provides farmers and ranchers a voluntary opportunity to achieve a level of nonpoint source water pollution prevention or abatement consistent with state water quality standards. Through a partnership with SWCDs, the TSSWCB, and NRCS, free technical assistance is provided to landowners to develop a WQMP. Financial assistance is available from TSSWCB to assist landowners in implementing certain conservation practices in WQMPs. The maximum allowable amount of cost-share funds per operating unit for implementation of WQMPs is $15,000 (https://www.tsswcb.texas.gov/sites/default/files/files/programs/water-quality-management-plan/WQMP_Rules_Chp_523_Effect_7-7-2013.pdf).

- TSSWCB http://www.tsswcb.texas.gov/en/wqmp

Flood Control Program (12)

This TSSWCB program provides state dollars to flood control dam sponsors for operation and maintenance, structural repair, matching funds from federal rehabilitation projects or Emergency Watershed Protection Program repairs, and/or engineering services.

- TSSWCB https://www.tsswcb.texas.gov/programs/flood-control-program

TWDB

Clean Water State Revolving Fund Loan Program (13)

Authorized by the Clean Water Act with funds managed by the TWDB via EPA, the Clean Water State Revolving Fund (CWSRF) Loan Program provides low-cost financial assistance for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure (https://www.epa.gov/cwsrf and http://www.twdb.texas.gov/financial/programs/CWSRF/). The CWSRF program traditionally have been used for upgrading WWTFs and collection systems in that it can provide the significant funding often needed for these large infrastructure projects. On a smaller scale, CWSRF funding can assist with connecting OSSFs to centralized sewer systems. In dealing with nonpoint source abatement and stormwater drainage, the CWSRF can also be used for "soft" structures, such as ponds, bioswales, and green infrastructure as well as "hard" drainage structures, such as pipes and concrete channels. Other types of eligible activities include acquisition, protection and/or rehabilitation of natural waterways and implementation of LID or other stormwater best managnement practices. Eligible applicants for the CWSRF include cities, counties, districts, river authorities, designated management agencies, authorized Indian tribal organizations, and public and private entities proposing nonpoint source or estuary management projects. For entities without a dedicated source of revenue to repay loans, sponsorship may be a strategy to consider for less traditional types of water quality improvement projects (see EPA and USDA Forest Service National Urban Forest Technology & Science Delivery Team webinar https://www.epa.gov/cwsrf/cwsrf-webinars).

- TWDB http://www.twdb.texas.gov/financial/programs/cwsrf/

Economically Distressed Area Program (14)
Funding through Economically Distressed Area Program (EDAP) is designed to provide assistance to economically distressed areas where water or wastewater services do not exist or systems do not meet minimum state standards. This potentially could be a source of funding in considering improvements for connections to the wastewater collection system within municipalities or improvement of systems within county subdivisions for economically disadvantaged neighborhoods within the watershed. There are several special requirements associated with EDAP funding, most notably that the median household income be less than 75 percent of the median state household income and that the area was established as a subdivision prior to June 1, 2005. Areas would need to be carefully targeted and TWDB should be consulted to make sure the full listing of special requirements is met prior to pursuing this funding. Funding through EDAP is available in the form of a grant or a combination grant/loan for qualified areas needing water and wastewater infrastructure services or improvements.

- TWDB http://www.twdb.state.tx.us/assistance/assistance_main.asp TWDB

Agricultural Water Conservation Loan Program (15)
The Agricultural Water Conservation Loan (AWCL) Program provides low-interest, fixed-rate loans to state agencies and political subdivisions for water conservation projects. These funds may also provide pass-through loans to individuals for water conservation projects. The AWCL program also provides a linked deposit loan program for individuals to access TWDB funds through participating local and state depository banks and farm credit institutions.

- TWDB http://www.twdb.texas.gov/financial/programs/AWCL/index.asp

USDA Farm Service Agency
Conservation Reserve Program (16)
The Conservation Reserve Program is a land conservation program managed by the Farm Service Agency where in exchange for a yearly rental payment, farmers agree to remove environmentally sensitive land from agricultural production. Eligibility is limited to cropland or certain marginal pastureland suitable for riparian buffer of similar water quality purposes.

- USDA Farm Service Agency http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp and https://www.fsa.usda.gov/programs-and-services/conservation-programs/prospective-participants/index

USDA-NRCS
The NRCS offers a variety of financial assistance programs to landowners and agricultural producers through the 2014 Farm Bill. General information on USDA-NRCS financial assistance programs can be found at the link below. More details are provided for programs that would be eligible to producers in the Nolan Creek/South Nolan Creek watershed.

- USDA-NRCS https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/

Environmental Quality Incentives Program (17)
The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that offers financial and technical assistance to agricultural producers in addressing specific land use issues. Contracts through EQIP provide financial assistance to implement conservation practices. Funding through EQIP may be used to help implement practices defined in a WQMP or conservation plan.

- USDA-NRCS
  https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

Conservation Innovation Grants (18)
Conservation Innovation Grants (CIG) are competitive grants to develop the tools, technologies, and strategies for public and private sector innovation in resource conservation. Producers involved with CIG must be EQIP eligible and grantee must leverage federal funding with at least matching funds.

- USDA-NRCS
  https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/

Conservation Stewardship Program (19)
The Conservation Stewardship Program (CSP) offers payments to maintain existing conservation practices. Priorities for funding are based on the operation type and number of resource concerns that are meeting the stewardship level at the time of application and payments needed to implement additional or enhanced conservation activities.

- USDA-NRCS
  https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/csp/?cid=nrcseprd1288524

Watershed and Flood Prevention Operations Program (20)
The NRCS can assist through the Watershed and Flood Prevention Operations (WFPO) Program with funding the operations of projects to aid with watershed and flood prevention. Prior to requesting funding, the sponsor must work with NRCS to develop an approved watershed plan. Funding and priorities through this program can vary, so NRCS should be contacted regarding plan development and funding options.

- USDA- NRCS
  https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/

USDA-Rural Development
Single Family Housing Repair Loans and Grants (21)
Also known as the Section 504 Home Repair program, this program provides loans to very low incomes homeowners for repairs or improvements to remove health and safety hazard. Grants are available to low-income elderly over 62 and unable to repay a repair loan. These home repair grants and loans may be a potential funding source for OSSFs.

- USDA-Rural Development https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants
    - Texas Housing Program Contact (243) 742-9770 or RA.TXTempleHSG.RDmailbox@tx.usda.gov

US Department of Health & Human Services

Targeted Homeless Assistance Programs (22)

The US Department of Health & Human Services (HHS) provides a variety of assistance programs designed specifically for assisting individuals or families experiencing homelessness. These include assistance with housing, health care, job training, and other supportive needs that might be considered in addressing the homelessness problem within the watershed area.

Supportive Services: Non-targeted or Mainstream Programs (23)

Supportive services under HHS focus more on community grants to assist low income individuals including the homeless and include programs such as Community Mental Health Service Block Grants, Family Violence Prevention and Services Grant Program, and Temporary Assistance for Needy Families.

- US Department of HHS – https://www.hhs.gov/programs/social-services/homelessness/grants/index.html#mainstream

Table 7-2 Summary of potential financial assistance providers from state and federal agencies beyond governmental resources within the watershed.

Agency	Program (Ref. No.)	Management Strategy														
		WWTF	Sewer Lines	OSSFs	Home-less	Pet Waste	Illegal Dump-ing	Urban Storm-water	Rural Storm-water	Roost-ing Birds	Wild-life	Recre-ational Use	Flood Mgt	MST	Stream Monitor-ing	Water-shed Coor-dinator
EPA	CWA 319 (1)			x		x	x	x	x	x	x			x	x	x
EPA	EE Grants (2)		x	x		x	x	x	x		x					x
TCEQ	SEPs (3)	x	x	x				x								
TCEQ	CRP (4)														x	
TDA	CDBG (5)	x	x					x								
TDA	Texas Capital Fund (6)	x	x					x								
TPWD	F&RLCP (7)								x		x		x			
TPWD	LIP (8)								x		x		x			
TPWD	RTF (9)											x				
TPWD	Local Parks (10)											x				
TSSWCB	WQMPs (11)								x				x			
TSSWCB	Flood Control (12)												x			
TWDB	CWSRF (13)	x	x	x				x								
TWDB	EDAP (14)	x	x	x												

Agency	Program (Ref. No.)	Management Strategy														
		WWTF	Sewer Lines	OSSFs	Home-less	Pet Waste	Illegal Dump-ing	Urban Storm-water	Rural Storm-water	Roost-ing Birds	Wild-life	Recre-ational Use	Flood Mgt	MST	Stream Monitor-ing	Water-shed Coor-dinator
TWDB	AWCL (15)								x							
USDA-FSA	Conser-vation Reserve Program (16)								x				x			
USDA-NRCS	EQIP (17)								x				x			
USDA-NRCS	CIG (18)								x							
USDA-NRCS	CSP (19)								x				x			
USDA-NRCS	WFPO (20)								x				x			
USDA-Rural Develop-ment	Sect 504 (21)		x	x												
US HSS	Targeted Homeless Supportive Services (22)				x											
US HSS	Supportive Services: Non-targeted or Mainstream Programs (23)				x											

SECTION 8

Proposed Schedule for Management Measures

Implementation of management measures within the Nolan Creek/South Nolan Creek watershed will occur incrementally with higher priority item (human waste sources and pet waste) as the primary focus initially (Table 8-1). The highest priority will be hiring a Watershed Coordinator to help make all these activities happen. An adaptive management approach is recommended with an evaluation at the end of years three, six, and ten to assess if priorities should be changed, particularly if new information arises through monitoring or MST efforts, and as specific management measures are defined for dealing with bacteria contributions from the homeless.

Table 8-1 Outline for implementation of management activities.

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
Overall WPP	Nolan Creek Partnership	Develop funding and hire a watershed coordinator	Year 1	High	About $70,000 per year	1	High, responsible for coordinating all WAP activities
WWTFs	Watershed Coordinator and WWTFs	Track reported bacteria concentrations associated with WWTF discharges and compare with instream water quality	Once every six months report on website. Annual report to WPP in public meeting.	High	Covered under Watershed Coordinator		Low, as keeping bacteria concentrations below limits already required by permit and generally occurs
Sewer Line Infrastructure - Public	Watershed Coordinator in coordination with municipalities	Track reported unauthorized discharges within the watershed by coordinating with municipalities regarding any water quality noncompliance notifications	Once every six months report on website. Annual report to WPP in public meeting.	High	Covered under Watershed Coordinator		Low, as these are unauthorized discharges, but may denote problems and significant contributions that need to be addressed
Sewer Line Infrastructure - Private	Private Landowners in cooperation	Educate private property owners on responsibilities	Focus in years 1-3	High	To be determined (cost	2 & 3	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	with Municipalities and Watershed Coordinator	regarding lateral lines			dependent on approach)		
	Private Landowners in cooperation with Municipalities and Watershed Coordinator	Educate owners and renters on how to maintain clear lateral lines	Focus in years 1-3	High		2 & 3	Moderate
	Private Landowners in cooperation with Municipalities and Watershed Coordinator	Educate owners and renters on how to identify leakage or blockage problems with lateral lines for wastewater located on private property and what to do when problems occur	Focus in years 1-3	High		2 & 3	Moderate
	Private Landowners in cooperation with Municipalities and Watershed Coordinator	Develop and implement a voluntary inspection program of lateral lines on private property focusing on high density	Focus in years 4-6	Medium	Personnel to develop & implement program		Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		housing/population areas					
	Private Landowners in cooperation with Municipalities and Watershed Coordinator	Develop a financial assistance program for maintenance, repairs and/or replacement of lateral lines	Focus in years 1-6	High	Estimated $100 to $3,000 for repairs and/or replacement of lateral lines per connection	5, 6, 13, 14 & 21	Moderate
OSSFs	Watershed Coordinator in conjunction with municipalities and BCHD	Locate OSSFs, particularly those close to the creek	Ongoing	Moderate	Personnel time		Moderate
	Municipalities	Maintain and update an inventory of OSSFs within CCNs that are still in use and those that have been connected to the centralized wastewater collection system and share OSSF maps/databases with Watershed	Ongoing	High	Personnel time to coordinate, some already being done by municipalities		Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		Coordinator and other entities in the watershed					
	Nolan Creek Partnership working with Bell County	Encourage installation of decentralized OSSFs in new subdivisions rather than installing individual OSSFs with each house	Focus in years 4-6	Medium	Unknown		Low
	Municipalities and BCHD	Target connecting OSSFs within municipal boundaries to the centralized sewer system	Ongoing	High	Personnel time		Moderate
	Private landowners, Municipalities and Watershed Coordinator	Aid in identifying and providing financial assistance for connection of households to the centralized sewer system and removal of decommissioned OSSFs	Focus in years 1-3	High	Estimated OSSF replacement $5,000 to $10,000, repairs $1,000 to $5,000, and decommission about $2,000	1, 5, 6, 13, 14 & 21	Moderate
	Nolan Creek Partnership working with Bell County	Promote installation of decentralized OSSFs in new rural subdivisions rather	Focus in years 4-6	Medium	Unknown		Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		than individual OSSFs.					
	Nolan Creek Partnership & Bell County	Develop and provide financial assistance program for those with OSSF compliance issues to aid in repairing or replacing failing systems.	Focus in years 1-6	High	Estimated OSSF replacement $5,000 to $10,000, repairs $1,000 to $5,000	1, 5, 6, 13, 14 & 21	Moderate
	Nolan Creek Partnership & Bell County	Develop & support on-going media efforts to educate homeowners & renters on proper maintenance and use of OSSFs	Focus in years 1-3	High	Largely covered under other media campaign or on-going efforts	1 & 2	Moderate
	Nolan Creek Partnership in conjunction with Texas A&M AgriLife Extension	Sponsor OSSF workshops/trainings for homeowners	One per year for first 10 years	High	About $3,500 per workshop	1 & 2	Moderate
	Nolan Creek Partnership in conjunction	Sponsor OSSF workshops/trainings for installers and	About one every three years	High	About $3,500 per workshop	1 & 2	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	with Texas A&M AgriLife Extension	maintenance providers					
Pet Waste	Nolan Creek Partnership with Municipalities	Support and expand public outreach and educational programs encouraging proper disposal of pet waste	Focus in years 1-3	High	Covered under other activities using newsletters, website information, and other "traditional" education avenues	1 & 2	High
	Nolan Creek Partnership with Municipalities	For the entire watershed area, develop a pet waste pick-up campaign	Focus in years 1-3	High	Additional $5,000 per year for educational campaign & time from Watershed Coordinator	1 & 2	Moderate
	Nolan Creek Partnership with Municipalities	Support the use and provide additional pet waste stations in public areas within the watershed	Focus in years 1-3	High	About $260/station & $85/yr/station maintenance per station		Moderate
Illegal Dumping	Nolan Creek Partnership, TCEQ & TxDOT	Implement signage at major highway crossing on how to	Focus in years 4-6	Medium	Unknown	1 & 2	Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		report illegal dumping					
	Nolan Creek Partnership	Promote information on website and other venues on how and who to report illegal dumping	Focus in years 4-6	Medium	Largely covered under other media efforts	1 & 2	Low
	Nolan Creek Partnership	Support use of cameras to document illegal dumping	Focus in years 4-6	Medium	None		Low
	Nolan Creek Partnership with Municipalities	Support and aid creek cleanup events planned by other entities and sponsor at least one separate creek cleanup event per year	Focus in years 1 -10	High	About $2,000 per event (supplies)	1 & 2	Moderate
	Nolan Creek Partnership with Municipalities	Aid implementation of an aerial assessment prior to waterway cleanups	Focus in years 1 -10	High	Unknown	1 & 2	Moderate
	Nolan Creek Partnership	Promote available options for HHW disposal and planned HHW events through	Ongoing	Medium	Part of duties associated with Watershed Coordinator, informational		Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		newsletters, website, and other outreach venues			material combined with other activities		
	Nolan Creek Partnership	Use HHW and creek cleanup events as an opportunity for educational outreach to reduce illegal dumping	Ongoing	Medium	Time of Watershed Coordinator to participate in events		Low
	Nolan Creek Partnership	Promote educational information on proper trash and dead animal disposal through newsletters, website, and other outreach venues	Ongoing	Medium	Part of duties associated with Watershed Coordinator, informational material combined with other activities	1 & 2	Low
Homeless	Nolan Creek Partnership with Municipalities & Other Entities	Work with municipalities and other organizations in defining management measures that address the bacteria contributions from homeless population	First three years	High	Limited to planning but costs will increase as specific measures are defined for implementation	22 & 23	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
Increasing Infiltration and Reducing Runoff	Nolan Creek Partnership	Support practices outlined SWMPs, particularly those associated with post-construction stormwater management in new development and redevelopment areas that increase infiltration and reduce runoff, through coordinated educational efforts	Ongoing	Medium	Limited to time from watershed coordinator		Moderate to Low
	Nolan Creek Partnership in conjunction with municipalities, Texas A&M AgriLife Extension & TCEQ	Specifically promote LID practices through educational workshops	At least one workshop every three years and development of demonstrations site(s) as funding allows	Medium	To be determined; may in part be funded through city and county sources	1 & 2	Moderate to Low
	Nolan Creek Partnership in conjunction with municipalities and Bell County	Support funding efforts for the implementation and demonstration of LID practices by municipalities and other entities	Ongoing	Medium	Limited to time from watershed coordinator; actual implementation may be funded through city,	1, 3, 5, 6 & 13	Moderate to Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
					county or other sources		
	Bell County	Promote Residential Cluster Development for new developments	Ongoing	Medium	Unknown		Low
Livestock	Nolan Creek Partnership in conjunction with Texas A&M AgriLife Extension, TSSWCB, & NRCS	Educate livestock producers on good management practices for maintaining healthy streams via workshops and distribution of educational resources.	Conduct one workshop every three years with at least 15 attendees/workshop	Medium	Costs generally underwritten	1 & 2	Moderate
	Nolan Creek Partnership in conjunction with Texas A&M AgriLife Extension, TSSWCB, & NRCS	Develop awareness of the planning process for WQMPs, conservation plans, and other planning options	Done through workshops and other educational materials	Medium	Covered under other activities		Moderate
	Nolan Creek Partnership in conjunction with Texas A&M	Promote development of WQMPs, conservation plans, or other	On-going	Medium	Vary depending on plan (Under TSSWCB, maximum.	16, 17, 18, 19 & 20	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	AgriLife Extension, TSSWCB, & NRCS	conservation plans by livestock owners in the watershed (goal 5 WQMPs per year)			allowable amount of cost-share funds per operating unit $15,000)		
Horses	Nolan Creek Partnership in conjunction with Texas A&M AgriLife Extension, TSSWCB, & NRCS	Educate horse owners on good management practices for maintaining healthy streams via workshops and distribution of educational resources.	Conduct one workshop every three years with at least 15 attendees/workshop	Medium	Costs generally underwritten	1 & 2	Moderate
	Nolan Creek Partnership in conjunction with Texas A&M AgriLife Extension, TSSWCB, & NRCS	Develop awareness of the planning process for WQMPs and conservation plans	Done through workshops and other educational materials	Medium	Covered under other activities	1 & 2	Moderate
	Nolan Creek Partnership in conjunction with Texas A&M	Promote develop of WQMPs and/or conservation plans by horse owners in	On-going	Medium	Vary depending on plan (Under TSSWCB, maximum.	16, 17, 18, 19 & 20	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	AgriLife Extension, TSSWCB, & NRCS	the watershed (goal 2 WQMPs per year)			allowable amount of cost-share funds per operating unit $15,000)		
Feral Hogs	Nolan Creek Partnership in conjunction with Texas Wildlife Services	Educate landowners on management measures to aid in hog reduction	Make available already existing educational materials through website and other electronic media and advertise workshops in adjoining watersheds	Low	Limited to time from watershed coordinator	1 & 2	Low
	Nolan Creek Partnership in conjunction with Texas Wildlife Services	Host feral hog workshops in the watershed	One every three years	Low	Variable	1 & 2	Low
	Nolan Creek Partnership	Promote management options, such as Hogs for a Cause, to help with trapping of hogs	On-going	Low	Limited to time from watershed coordinator	1 & 2	Low
Roosting Birds	Nolan Creek Partnership in conjunction with Texas	Make landowners aware of assistance available from Texas Wildlife Services on	Focus in years 7-10	Low	Limited to time from watershed coordinator	1	Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	Wildlife Services	methods for decreasing attractiveness of areas to roosting					
	Private Landowners in cooperation with Municipalities and Watershed Coordinator	If a discouragement or frighten plan is developed, assist with education of the public regarding proposed tactics	Focus in years 7-10	Low	Limited to time from watershed coordinator	1	Low (although may to moderate to high at specific location)
Wildlife	Nolan Creek Partnership in conjunction TPWD	Provide educational materials to the public to discourage feeding of waterfowl and small mammals via website	On-going	Medium	Limited to time from watershed coordinator	1	Low (although may to moderate at specific location)
	Municipalities	Add signage "Do Not Feed Waterfowl" in known feeding locations	First three years	Medium	Costs about $250/sign		Low (although may to moderate at specific location)
	Nolan Creek Partnership in conjunction TPWD	Monitor population densities to assess if further management is needed	On-going	Low	Limited to time from watershed coordinator	1	Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	Nolan Creek Partnership in conjunction TPWD	If population densities are considered large enough to warrant control, consult with TPWD on options for control	Focus in years 7-10	Low	Limited to time from watershed coordinator	1	Low
	Nolan Creek Partnership in conjunction TPWD	If deemed necessary, implement population control measures	Focus in years 7-10	Low	To be determined		Unknown, depends on density
	Nolan Creek Partnership in conjunction with TSSWCB, NRCS, TFS, and TPWD	Promote landowner use of conservation planning for wildlife through TSSWCB, NRCS, TFS, and TPWD.	On-going	Low	Limited to time from watershed coordinator to promote	1	Low
Recreational Activities	Nolan Creek Partnership with Municipalities & CTCOG	Promote safe usage of Nolan Creek/South Nolan Creek through educational information provided via website and other venues	Years 1-10	High	Limited to time from watershed coordinator to promote	1	Low

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	Nolan Creek Partnership with Municipalities & CTCOG	Coordinate WAP activities with creek recreational activities promoted by municipalities often associated with city parks as well as through planning and maintenance of bicycle and pedestrian trails	Ongoing	High	Limited to time from watershed coordinator	1	Low to Moderate
	Municipalities with Nolan Creek Partnership	Support installation of more trash and pet waste stations in areas near the creek associated with increased recreational use (goal 3 added station per year)	Years 1 - 10	Medium	Stations about $650 each, maintenance about $100/station per yr, signage about $250/sign	1 & 2	Moderate
	Nolan Creek Partnership with Municipalities & CTCOG	Support implementation of educational signage within parks and along trails (goal three signs in first three years)	Years 1-3	Medium	Signage about $250/sign	1 & 2	Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
	Nolan Creek Partnership with Municipalities & CTCOG	Support of the development of riparian buffers as part of trail systems associated with the creek corridor	Ongoing	Medium	Limited to time from watershed coordinator	9 & 10	Low to Moderate
Flood Management	Municipalities, Bell County & CTCOG	Support ongoing flood planning and as part of adaptive management, particularly recommendations for development of bioswales, detention or bio-retention ponds for flood management	Ongoing	Medium	Limited to time from watershed coordinator	1, 7, 8, 11, 12, 16, 17, 19 & 20	Low to Moderate
	Municipalities, Bell County & CTCOG	Provide opportunities for riparian and stream channel restoration and education	Ongoing	Medium	Limited to time from watershed coordinator	1, 7, 8, 11, 12, 16, 17, 19 & 20	Low to Moderate
	WCID No. 6, Municipalities, & Central Texas SWCD	Support ongoing assessment, operation and maintenance efforts associated with small lakes and	Ongoing	Medium	Limited to time from watershed coordinator	12 & 20	Low to Moderate

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
		flood control reservoirs within the watershed					
Microbial Source Tracking	Nolan Creek Partnership with Municipalities	Review other MST projects conducted in Texas to aid in understanding how to get the most useful information from an MST Study	Focus in years 1-3	High	Limited to time from watershed coordinator interacting with municipalities	1	Low
	Nolan Creek Partnership with Municipalities	Develop funding for MST	Focus in years 1-3	High	Limited to time from watershed coordinator interacting with municipalities	1	Low
	Nolan Creek Partnership with Municipalities	Design & implement MST study	Focus in years 4-6	Medium	About $250,000	1	Low
	Nolan Creek Partnership with Municipalities	Analyze MST results and evaluate management measures with MST findings	Focus in years 7-10	Medium	Limited to time from watershed coordinator interacting with the Nolan Creek Partnership	1	Moderate to High

Area	Responsible Party	Activity or Management Measure	Timeframe	Priority	Estimated Cost	Potential Funding Opportunity[1]	Anticipated Reductions[2]
Nutrient Reduction Efforts	Nolan Creek Partnership with Municipalities	Provide educational to homeowners, golf courses, and landscape operations on fertilizer application	On-going through website and other electronic media	Low	Limited with linkage to existing materials and programs	1 & 2	Low
	Nolan Creek Partnership with Municipalities	Encourage use of fertilizer containing only nitrogen and no phosphorus for lawn care	On-going through website and other electronic media	Low	Limited with linkage to existing materials and programs	1 & 2	Low
	Nolan Creek Partnership in conjunction with AgriLife Extension, TSSWCB, & NRCS	Encourage development of nutrient management plans for use of fertilizers on agricultural lands	On-going in relation to WQMPs, conservation plans and other land planning efforts	Low	Costs related to implementation under other land management activities	16, 17, 18, 19 & 20	Low

1. Number refers to possible funding opportunities listed in Table 7.1
2. Anticipated reductions related to bacteria except for nutrient reduction efforts.

SECTION 9

Monitoring Success

Adaptive Implementation

For a successful WPP, implemented management measures should be tracked and periodically evaluated to determine what efforts are actually occurring and to what extent and impact these efforts are having on water quality. This allows for adaptive management or modification of management activities if progress is not going as anticipated or new information arises, as may be provided through MST potentially refocusing priorities for source control. Adaptive management also allows for new management measure to be introduced into the plan that may not have been considered or available when the plan was developed. Within the proposed implementation schedule (Section 8), an overall evaluation of management measures is suggested to occur at the end of years three, six, and ten.

Monitoring Plan

As part of effectiveness monitoring and adaptive management for the watershed, routine monthly monitoring is proposed at a minimum of six stations, although ten or more would be preferred. If limited to six, the following stations should be included:

- 18828 located on South Nolan Creek at 38th Street in Killeen,
- 21437 located on Little Nolan Creek off US 190 in Killeen,
- 11913 located on South Nolan Creek at Roy Reynolds Road in Killeen,
- 11908 located on South Nolan Creek at Levi Crossing below Nolanville,
- 11905 located on South Nolan Creek at Backstrom Crossing, and
- 14237 located on Nolan Creek in Yettie Polk Park in Belton.

These six stations represent stations with historical data for comparison of trends and also includes the three stations (18828, 11913, and 11905) used for LDC analyses in assessing needed reductions (see Figure 9-1). Station 21437 represents monitoring on Little Nolan Creek, a tributary noted as impaired (AU 1218C). Station 11908 is proposed because it represents a location where trash and debris often accumulates, particularly after high flow events, and is a known area for illegal dumping. Monitoring at station 11908 should also reflect changes associated with BMPs, such as bioswales, that the City of Nolanville is interested in implementing. Station 14237, while outside the impaired assessment units, represents an area with long-term data under TCEQ's Clean Rivers Program and a location near where contact recreational activities are known to occur within Nolan Creek.

Additional monitoring, if implemented, should focus on stations with historical data for trends analysis (see Figure 9-1), monitoring within tributaries to better isolate sources, and/or new stations focused on targeting sources via MST or evaluating improvements related to the implementation of specific management measures.

Monthly monitoring parameters should include at a minimum *E. coli* and flow to assess changes in the impairment status. Additional parameters based on concerns for nutrients should include chlorophyll-a, nitrite-nitrate-nitrogen, orthophosphate-phosphorus, total phosphorus, total Kjeldahl nitrogen, and total suspended solids.

Microbial Source Tracking

As outlined as a management measure in Section 5, MST is proposed to better define the major sources in different portions of the watershed to aid in prioritizing management measures. The use of MST will identify if bacteria are primarily from human, pets, wildlife, or livestock in various portions of the watershed. These data, ideally would be collected in conjunction with the routine monitoring, and used as an adaptive management tool, in reprioritizing or potentially defining new implementation measures.

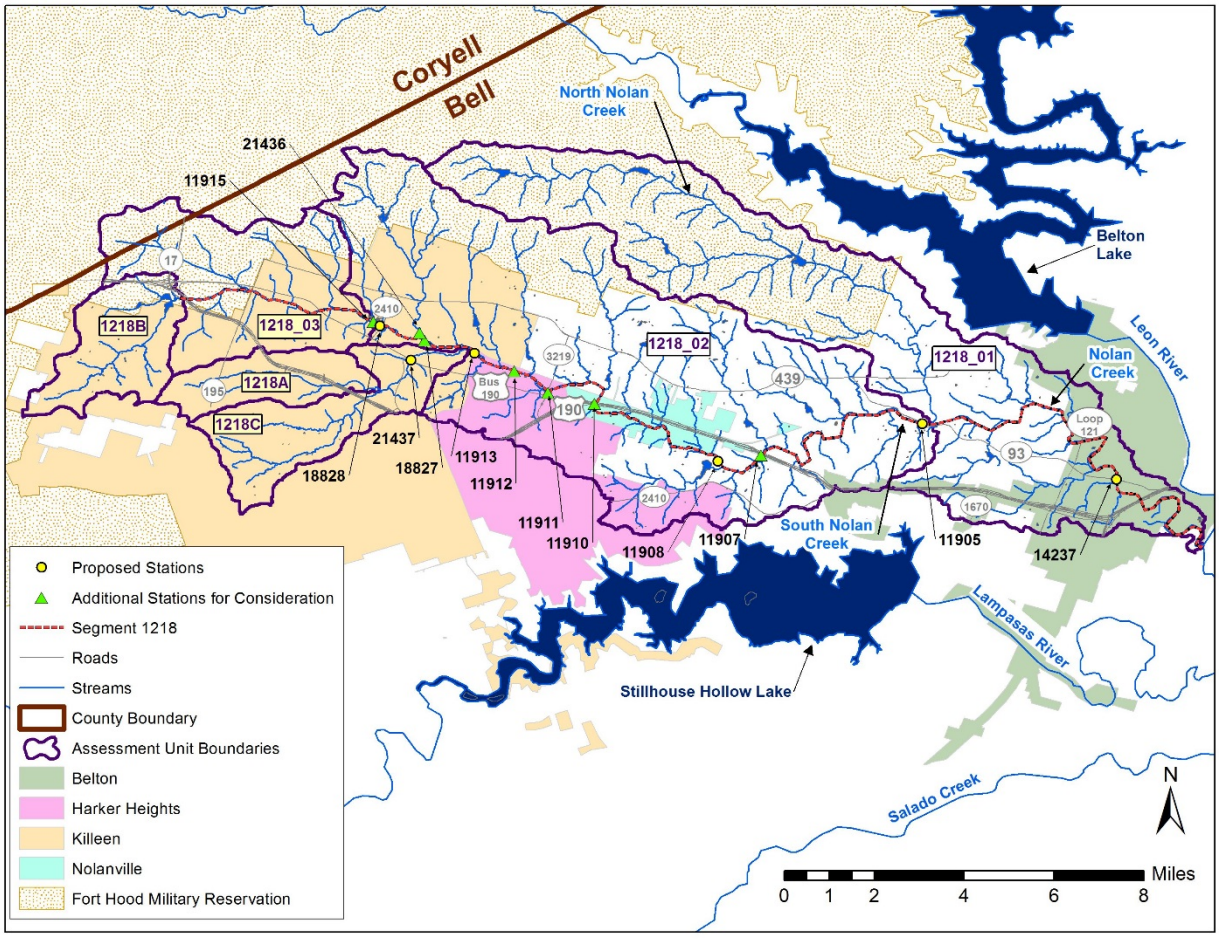

Figure 9-1 Proposed primary and secondary monitoring stations for evaluating effectiveness of the Nolan Creek/South Nolan Creek WPP.

Effectiveness Evaluation

The data collected from these stations would be made available for updated assessment evaluations for Nolan Creek/South Nolan Creek, which the goal of delisting the impaired segments within the watershed. Data will be overlaid on developed LDCs as a measure of effectiveness, and trend evaluations will be used to evaluate changes over time. Flow measurements will be an important component of these trend evaluations to allow adjustment for changes in flow conditions between monitoring periods.

The goal of the Partnership is to decrease in the *E. coli* geometric mean concentration to or below the criterion for contact recreation of 126 MPN/100 mL. For nutrients, average values should be at or below screening levels established for nitrate of 1.95 mg/L and total phosphorus of 0.69 mg/L. With monthly monitoring, samples should be fairly evenly spaced temporally between months allowing for an annual evaluation of trends. Besides mean comparisons and trends analysis, sample values will also be overlain on LDCs to evaluate the influence of flow in post-implementation monitoring. The goal is for target levels for bacteria to be reached within 10 years. At the end of years three, six, and ten, progress by the WPP should be evaluated with regard to implementation of management practices with regard to impacts on water quality to determine progress towards this goal.

References

AVMA, American Veterinary Medical Association. 2012. U.S. Pet Ownership & Demographics Sourcebook. Online at: https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx (link verified May 2, 2018).

AVSWAT. 2006. ArcView SWAT released July 2006 for SWAT2005 by the Texas AgriLife Blackland Research and Extension Center in collaboration with the USDA-ARS Grassland Soil and Water Research Lab in Temple, Texas. Online at: http://swat.tamu.edu/software/avswat/ (link verified May 2, 2018).

Benham, B.L., C. Baffaut, R.W. Zeckoski, K.R. Mankin, Y.A. Pachepsky, A.M. Sadeghi, K.M. Brannan, M.L. Soupir, and M.J. Habersack. 2006. Modeling bacteria fate and transport in watersheds to support TMDLs. Transactions of the American Society of Agricultural Engineers 49(4):987-1002.

Bonta, J.V. 2002. Framework for Estimating TMDLs with Minimal Data, pp. 6-12. In: Proceedings American Society of Agricultural Engineers Conference, Watershed Management to Meet Emerging TMDL Regulations. Fort Worth, TX.

Bonta, J.V., and B. R. Cleland. 2003. Incorporating natural variability, uncertainty and risk into water quality evaluations using duration curves. Journal of the American Water Resources Association 39:1481-1496.

Borel, K.E., R. Karthikeyan, P.K. Smith, L. Gregory, and R. Srinivasan. 2012. Estimating daily potential *E. coli* loads in rural Texas watersheds using Spatially Explicit Load Enrichment Calculation Tool (SELECT). Texas Water Journal 3(1):42-58.

Brazos River Authority, and Espey Consultants. 2010. Lake Granbury Watershed Protection Plan. Prepared for the U.S. Environmental Protection Agency and the Texas Commission on Environmental Quality. Developed by the Lake Granbury Watershed Protection Plan Stakeholders Committee. Available at: https://www.brazos.org/About-Us/Water-Quality/Watershed-Protection-Plans/Lake-Granbury-WPP/WPP-Final-Report (link verified May 2, 2018).

Cleland, B.R. 2003. TMDL Development From the "Bottom Up" -- Part III: Duration Curves and Wet-Weather Assessments. National TMDL Science and Policy 2003 Water Environment Federation Specialty Conference. Chicago, IL.

Cleland, B.R. 2002. TMDL Development From the "Bottom Up" – Part II: Using Duration Curves to Connect the Pieces. National TMDL Science and Policy 2002 Water Environment Federation Specialty Conference. Phoenix, AZ.

Di Luzio, M., Srinivasan R., Arnold J.G. 2004. A GIS-Coupled Hydrological Model System for the Watershed Assessment of Agricultural Nonpoint and Point Sources of Pollution. Transactions in GIS, 8(1): 113-136.

Di Luzio, M., R. Srinivasan, J.G. Arnold , and S.L. Neitsch. 2002. Soil and Water Assessment Tool. ArcView GIS Interface Manual: Version 2000. Grassland Soil and Water Research Lab Report 02-03 and Blacklands Research Center Report 02-07, Temple, Texas, Published by Texas Water Resources Institute TR-193, College Station, Texas.

Doyle, M.P., and M.C. Erickson. 2006. Closing the door on the fecal coliform assay. Microbe 1(4):162-163.

EPA, Environmental Protection Agency. 2001. Protocol for Developing Pathogen TMDLs, first edition. EPA, Office of Water, Washington, D.C. EPA 841-R-00-002.

EPA, Environmental Protection Agency. 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. EPA Watershed Branch, Office of Wetlands, Oceans and Watersheds, Washington, D.C. EPA 841-B-07-006, August 2007.

EPA, Environmental Protection Agency. 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. EPA Office of Water, Nonpoint Source Control Branch, Washington, D.C. EPA 841-B-08-002 (March 2008) Available at: http://www.epa.gov/polluted-runoff-nonpoint-source-pollution/handbook-developing-watershed-plans-restore-and-protect (Link verified May 2, 2018).

Featherston, J.W. 2009. Search for the Elusive 35%: A Sponsor Dilemma. Talk presented at the 11th National Watershed Conference, May 17-20, 2009 in Wichita, Kansas, by James W. Featherston, Agricultural Economist, USDA-NRCS, Temple, Texas. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/?&cid=nrcs143_009714 (Link verified May 2, 2018).

George, P.G., R.E. Mace, and R. Petrossian. 2011. Aquifers of Texas. Texas Water Development Board, Report 380, Austin, Texas.

Griffith, G., Bryce, S., Omernik, J., and Rogers, A. 2007. Ecoregions of Texas. Project Report to the Texas Commission on Environmental Quality, Austin, Texas, AS-199 (12/07).

Hone, J. 1988. Feral pig rooting in a mountain forest and woodland: Distribution, abundance and relationship with environmental variables. Australia J. of Ecol. 13:393-400.

Huckabee, J.W. Jr., D.R. Thompson, J.C. Wyrick, and E.G. Pavlat. 1977. Soil Survey of Bell County. United States Department of Agriculture, Soil Conservation Service I cooperation with the Texas Agricultural Experiment Station. USDA-SCS, Washington, D.C.

Johnson, S.L., T. Whiteaker, and D.R. Maidment. 2009. A tool for automated load duration curve creation. Journal of the American Water Resources Association 45(3):654-663.

Ling, W., M. McFarland, D. Magin, L. Warrick, and A. Wendt. 2012. Geronimo and Alligator Creeks Watershed Protection Plan. Prepared for the Geronimo and Alligator Creeks Partnership, August 2012. Online at: http://www.geronimocreek.org/Plan.aspx (link verified May 2, 2018).

McCuen, R.H. 1982. A Guide to Hydrologic Analysis Using SCS Methods. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

McFarland, A., and T. Adams. 2016a. Characterizing Water Quality within Nolan Creek/South Nolan Creek. Prepared for the Nolan Creek Partnership and the Texas Commission on Environmental Quality in cooperation with the Environmental Protection Agency by the Texas Institute for Applied Environmental Research and the City of Killeen via a Clean Water Act Section 319 grant (TR1508). Available at: http://t-nn.tarleton.edu/docs/nolan_creek/publications/Nolan_Monitoring_Report(revDec2015)FINAL.pdf (link verified May 2, 2018).

McFarland, A., and T. Adams. 2016b. Characterizing Potential Pollutant Loads to Nolan Creek/South Nolan Creek. Prepared for the Nolan Creek Partnership and the Texas Commission on Environmental Quality in cooperation with the Environmental Protection Agency by the Texas Institute for Applied Environmental Research and the City of Killeen via a Clean Water Act Section 319 grant (TR1507). Available at: http://t-nn.tarleton.edu/docs/nolan_creek/publications/Nolan_LDC_SELECT_Report(18Feb2016)FINAL.pdf (link verified May 2, 2018).

McFarland, A., and T. Adams. 2015a. Data Inventory for the Nolan Creek/South Nolan Creek Watershed Segment 1218. Prepared for the Nolan Creek Partnership and the Texas Commission on Environmental Quality in cooperation with the Environmental Protection Agency by the Texas Institute for Applied Environmental Research and the City of Killeen via a Clean Water Act Section 319 grant (TR1409). Available at: http://t-nn.tarleton.edu/docs/nolan_creek/publications/Nolan_Data_Inventory_Report(revDec2015)FINAL.pdf (link verified May 2, 2018).

McFarland, A., and T. Adams. 2015b. Survey of Potential Bacteria and Nutrient Sources in the Nolan Creek/South Nolan Creek Watershed. Prepared for the Nolan Creek Partnership and the Texas Commission on Environmental Quality in cooperation with the Environmental Protection Agency by the Texas Institute for Applied Environmental Research and the City of Killeen via a Clean Water Act Section 319 grant (TR1410). Available at: http://t-nn.tarleton.edu/docs/nolan_creek/publications/SourceSurvey_Report_(revDec2015)FINAL.pdf (link verified May 2, 2018).

Morrison, M.A., and J.V. Bonta. 2008. Development of Duration-Curve Based Methods for Quantifying Variability and Change in Watershed Hydrology and Water Quality. U.S. EPA Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH, EPA/600/R-08/065, May 2008.

NCDC, National Climatic Data Center. 2018. Climate Data Online: Monthly and Daily Summaries. Available at: http://www.ncdc.noaa.gov/cdo-web/ (data accessed September 2015 and updated January 2018, link verified May 2, 2018).

NCDC, National Climatic Data Center. 2014. Climate Data Online: Normal Monthly 1981 to 2010. Available at: http://www.ncdc.noaa.gov/cdo-web/ (data accessed October 2014, link verified May 2, 2018).

Nett, J.P., and J.D. Flowers. 2008. Assessment and Targeting of Bacterial Sources in the South Nolan Creek Watershed. Prepared for the Texas Commission on Environmental Quality by the City of Killeen and Jacobs Carter Burgess, Inc.

Orton, R.B. 1977. Climate, pp. 72-73. In: Soil Survey of Bell County. United States Department of Agriculture, Soil Conservation Service in cooperation with the Texas Agricultural Experiment Station. USDA-SCS, Washington, D.C.

PBS&J. 2000. Final Report, Predicting Effects of Urban Development on Water quality in the Cities of New Braunfels, San Marcos, Seguin and Victoria. Prepared in cooperation with the Guadalupe-Blanco River Authority and the Texas Natural Resource Conservation Commission. Online at: http://www.gbra.org/documents/crp/studies/urbandevelopmentstudy.pdf (link verified May 2, 2018).

Parsons Water & Infrastructure Inc. and the Brazos River Authority. 2015. Watershed Protection Plan for the Leon River Below Proctor Lake and Above Belton Lake. Prepared for the Stakeholders of the Leon River Watershed by Parson, the Texas State Soil & Water Conservation Board, the Brazos River Authority, and US Environmental Protection Agency through a Clean Water Act Section 319(h) grant. Available at: http://leonriver.tamu.edu/media/1110/final-leon-wpp.pdf (Link verified May 2, 2018).

Prcin, L., R. Srinivasan, and P. Casebolt. 2013. The Lampasas River Watershed Protection Plan. Prepared for the Lampasas River Watershed Partnership by Texas A&M AgriLife, the Texas State Soil & Water Conservation Board, and US Environmental Protection Agency through a Clean Water Act Section 319(h) grant. Available at: http://www.lampasasriver.org/media/72931/lampasas-river-wpp_june-2013.pdf (Link verified May 2, 2018).

Reed, Stowe, and Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility Systems in Texas. Prepared by Reed, Stowe & Yanke, LLC, Austin, Texas for the Texas On-Site Wastewater Treatment Research Council (September 2001).

SCS, Soil Conservation Service. 1986. Urban Hydrology for Small Watershed. United States Department of Agriculture, Natural Resource Conservation Service, Conservation Engineering Division, Technical Release 55, June 1986. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf (Link verified June 14, 2018).

Tate, J. 1984. Techniques in controlling wild hogs in Great Smoky Mountains National Park; Proceedings of a workshop National Park Service Research/Resources Manage. Report SER-72, Nov. 1984.

Taylor, R. 2003. The Feral Hog in Texas. Texas Parks and Wildlife, W7000-195 (9/03), Austin, TX. Available at https://tpwd.texas.gov/huntwild/wild/nuisance/feral_hogs/ (link verified May 2, 2018).

Teague, A., R. Karthikeyan, M. Babbar-Sebens, R. Srinivasan, and R.A. Persyn. 2009. Spatially explicit load enrichment calculation tool to identify potential E. coli sources in watersheds. Transactions of the American Society of Agricultural and Biological Engineers 52(4):1109-1120.

Texas Demographic Center, 2018. Estimates of the Total Populations of Counties and Places in Texas for July 1, 2016 and January 1, 2017. Population Estimates and Projections Program, Texas Demographic Center, The University of Texas at San Antonio, June 2018. Online at: http://demographics.texas.gov/Resources/TPEPP/Estimates/2016/2016_txpopest_method.pdf (link verified September 24, 2018).

TCEQ, Texas Commission on Environmental Quality. 2018. Recreational Use Attainability Analyses. TCEQ, Austin, TX. Online at: https://www.tceq.texas.gov/waterquality/standards/ruaas/index (link verified May 2, 2018).

TCEQ, Texas Commission on Environmental Quality. 2015a. 22014 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). Online at: https://www.tceq.texas.gov/waterquality/assessment/14twqi/14txir (link verified May 2, 2018).

TCEQ, Texas Commission on Environmental Quality. 2015b. 2014 Guidance for Assessing and Reporting Surface Water Quality in Texas. TCEQ, Austin, TX (June 2015). Online at: https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_guidance.pdf (link verified May 2, 2018).

TPWD (Texas Parks and Wildlife Department). 2012. WL. 127R WTD Federal Aid Report Charts and Tables. TPWD, Austin, TX.

TWRI, Texas Water Resources Institute. 2017. Navasota River Below Lake Limestone Watershed Protection Plan, developed by the Navasota River Watershed Partnership in conjunction with TWRI, Texas A&M AgriLife Research, and the Texas A&M Department of Soil and Crop Sciences through funding provided by the Texas State Soil and Water Conservation Board State Nonpoint Source Grant program. TWRI Technical Report 497, College Station, TX.

USCB, United States Census Bureau. 2010. Census 2010 Data, Washington D.C. Available at: https://www.census.gov/programs-surveys/decennial-census/decade.2010.html (data accessed July 2015; link verified May 2, 2018).

USDA-NASS, U.S. Department of Agriculture-National Agriculture Statistics Service. 2014. 2012 Census Volume 1, Chapter 2: County Level Data, Texas. Available at http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/ (link verified May 2, 2018).

USDA-NRCS, United States Department of Agriculture Natural Resources Conservation Service. 2005. Soil Data Mart, SSURGO version 2.2. Available online at http://websoilsurvey.nrcs.usda.gov/ (data accessed September 2014; link verified May 2, 2018).

USDA-SCS, United States Department of Agriculture Natural Resources Conservation Service. 1993. U.S. Department of Agriculture Handbook 18. Soil Survey Manual - Chapter 6 Interpretations. Soil Survey Division Staff, Washington, D.C.

USGS, United States Geological Survey. 2014. Multi-Resolution Land Characteristics (MRLC) Consortium National Land Cover Database 2011. Available at http://www.mrlc.gov/nlcd11_data.php (data accessed August 2014, link verified May 2, 2018).

USGS, U.S. Geological Survey. 1984. Summary of Available Data: USGS 08102600 Nolan Ck at Belton, TX. Available at: http://waterdata.usgs.gov/nwis/nwisman/?site_no=08102600&agency_cd=USGS (data accessed October 2014, link verified May 2, 2018).

Vidon, P., L.P. Tedesco, J. Wilson, M.A. Campbell, L.R. Casey, and M. Gray. 2008. Direct and indirect hydrological controls on E. coli concentration and loading in Midwestern streams. Journal of Environmental Quality 37:1761-1768.

Winemiller, K., D. Scott, S. Shafer, J. Baker, and A. Braden. 2010. Preliminary Results of a Recreational Use Attainability Analysis of 31 Streams in the Brazos River Basin. Texas A&M University, College Station, Texas. Online at: http://www.tceq.texas.gov/assets/public/waterquality/standards/ruaa/brazos1/RUAA%20Report%20Brazos%20River%20Basin.pdf (link verified May 2, 2018).

Wolfe, J. 2014. Nolan Creek Flow: Potential Changes Related to Upstream Influence. Report prepared for the City of Belton but the Texas A&M AgriLife Research, Blackland Research and Extension Center, Water Science Laboratory. Online at: https://blackland.tamu.edu/files/2017/10/Nolan_Creek_Low_Flow_Assessment_BREC_Final.pdf (link verified May 2, 2018).

Appendix A

Nutrient LDCs

Nutrient LDCs are shown for nitrate (Figures A-1 – A-4), orthophosphate-phosphorus (ortho-P) (Figures A-5 – A-8), and total-P (Figures A-9 – A-12). Nutrients were compared to screening levels of 1.95 mg/L nitrate, 0.37 mg/L ortho-P, and 0.69 mg/L total-P for calculating allowable loadings, which are presented in pounds (lbs) per day. The percent reductions estimated to meet screening levels are indicated in Table A-1 – A-3. Unlike bacteria, lower reductions for nutrients are needed under higher flow regimes, indicating primarily point source or dry weather loadings. Only at station 18828, the most upstream location monitored, were screening levels met, but then only under high flow conditions. Reductions in nutrient concentrations were 58 to 87 percent during moderate to low flow conditions and 0 to 56 percent during high flow conditions.

Of note, in developing the LDCs for nutrients, most of the wet-weather or high flow samples represented flow-weighted samples collected during storm events. The flow associated with these samples represented an average flow over the time period of sample collection. This average flow for each flow-weighted storm sample was calculated based on reported stage data and derived stage-discharge relationships for each storm monitoring station, which are presented in the monitoring data report for this project.

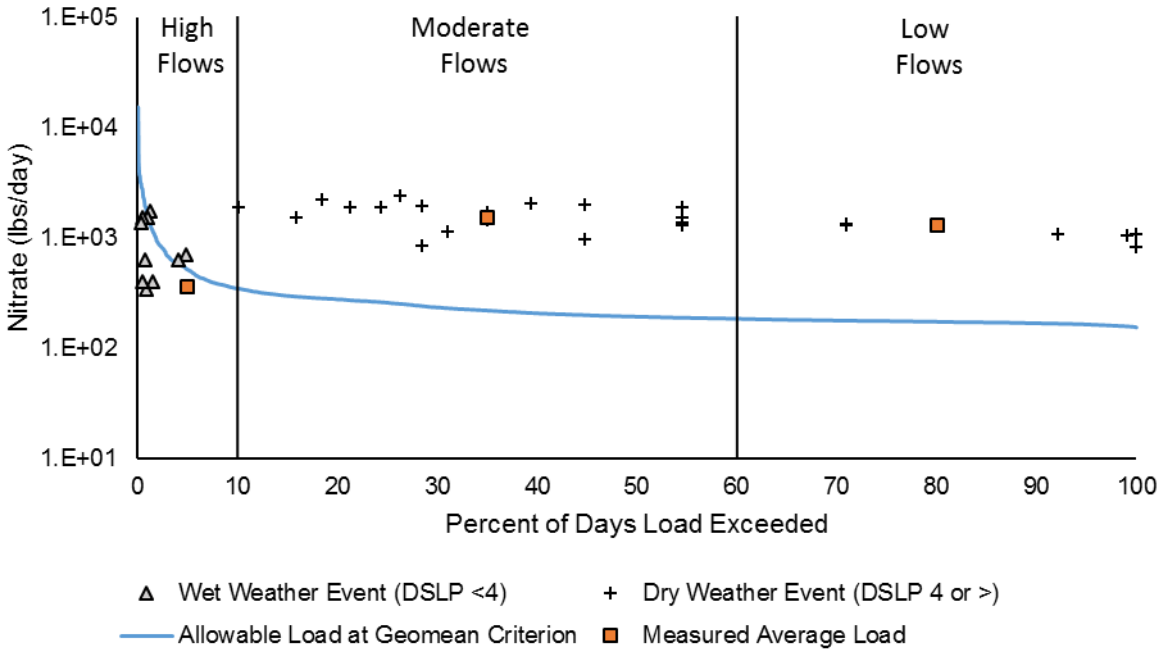

Figure A-1 Nitrate load duration curve for station 18828, South Nolan Creek at 38th Street

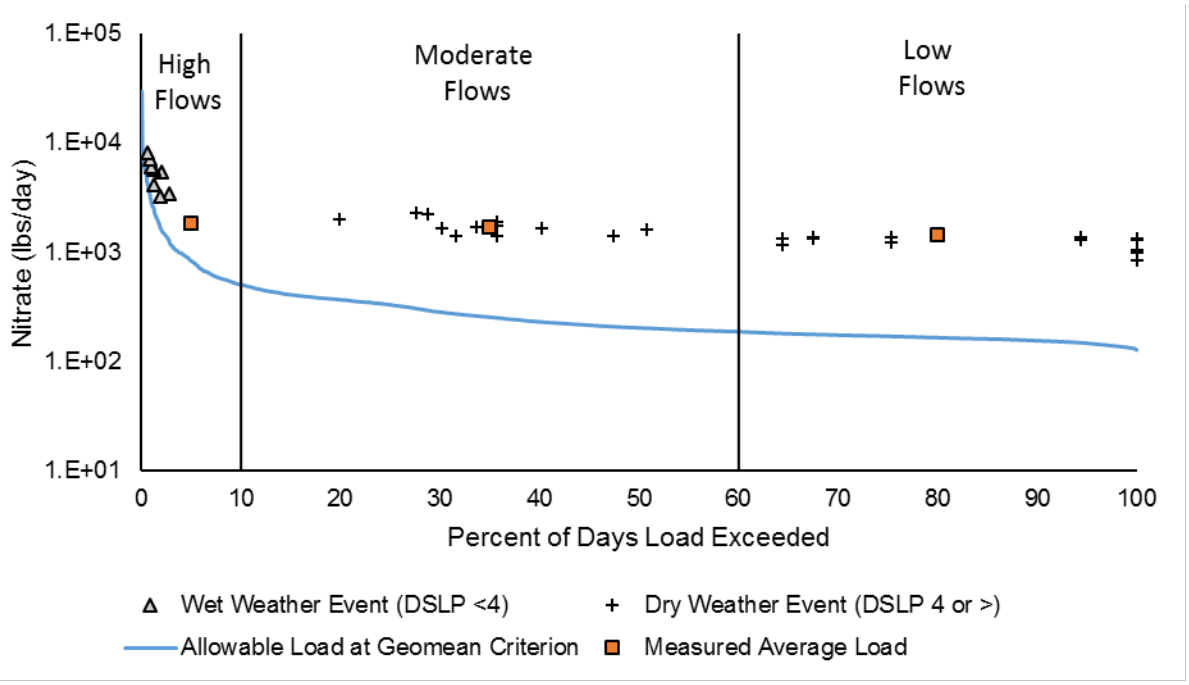

Figure A-2 Nitrate load duration curve for station 11913, South Nolan Creek at Roy Reynolds Road.

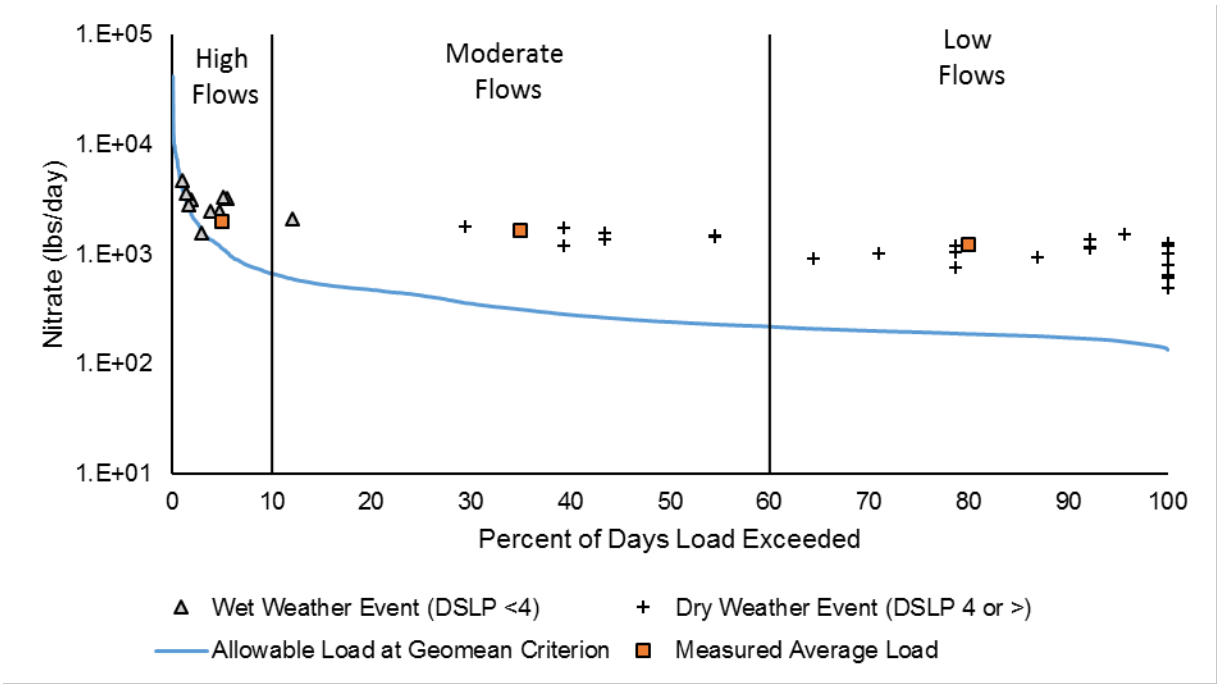

Figure A-3 Nitrate load duration curve for station 11910, Nolan Creek at US 190.

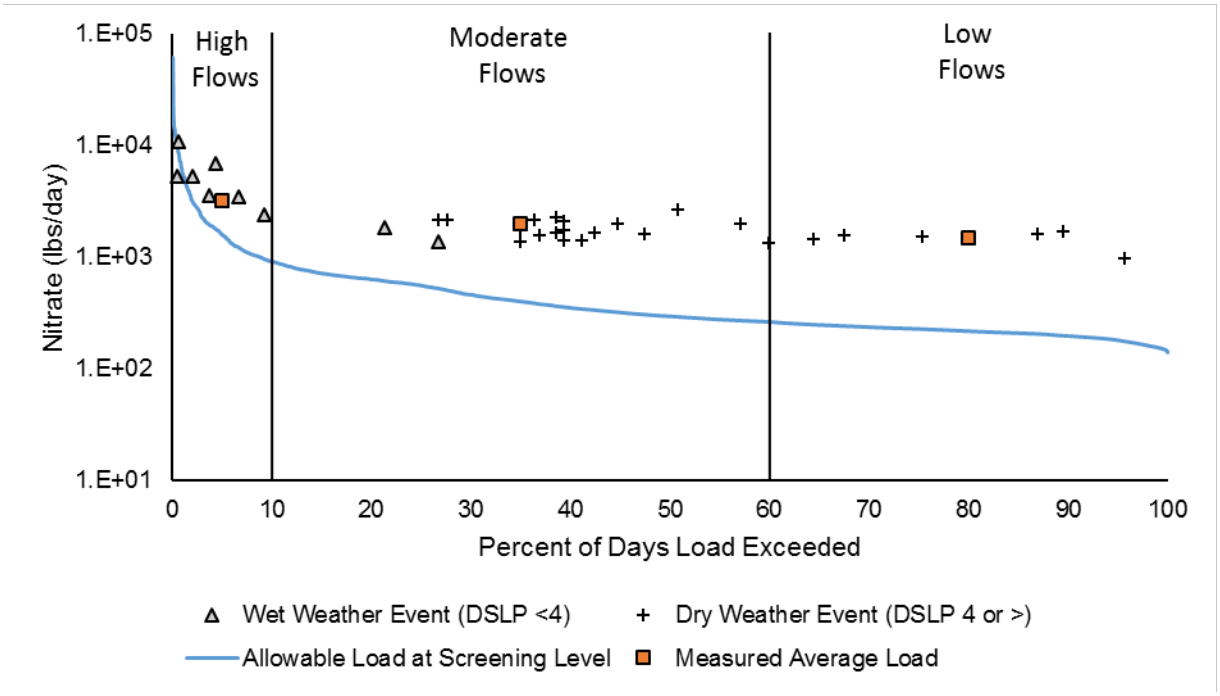

Figure A-4 Nitrate load duration curve for station 11905, Nolan Creek at Backstrom Crossing.

Table A-1 Average concentration of measured nitrate by flow regime and estimated percent reductions needed to meet screening level of 1.95 mg/L nitrate for four stations along Nolan Creek/South Nolan Creek. Zero percent reductions indicate the screening level is already met and reductions are not necessary.

Station	High Flows (0-10%)		Moderate Flows (10-60%)		Low Flows 60-100%)	
	Average Nitrate (mg/L)	Percent Reduction	Average Nitrate (mg/L)	Percent Reduction	Average Nitrate (mg/L)	Percent Reduction
18828	1.31	0%	13.5	86%	14.7	87%
11913	4.46	56%	13.0	85%	13.0	85%
11910	3.41	43%	10.4	81%	12.7	85%
11905	4.08	52%	9.65	80%	13.1	85%

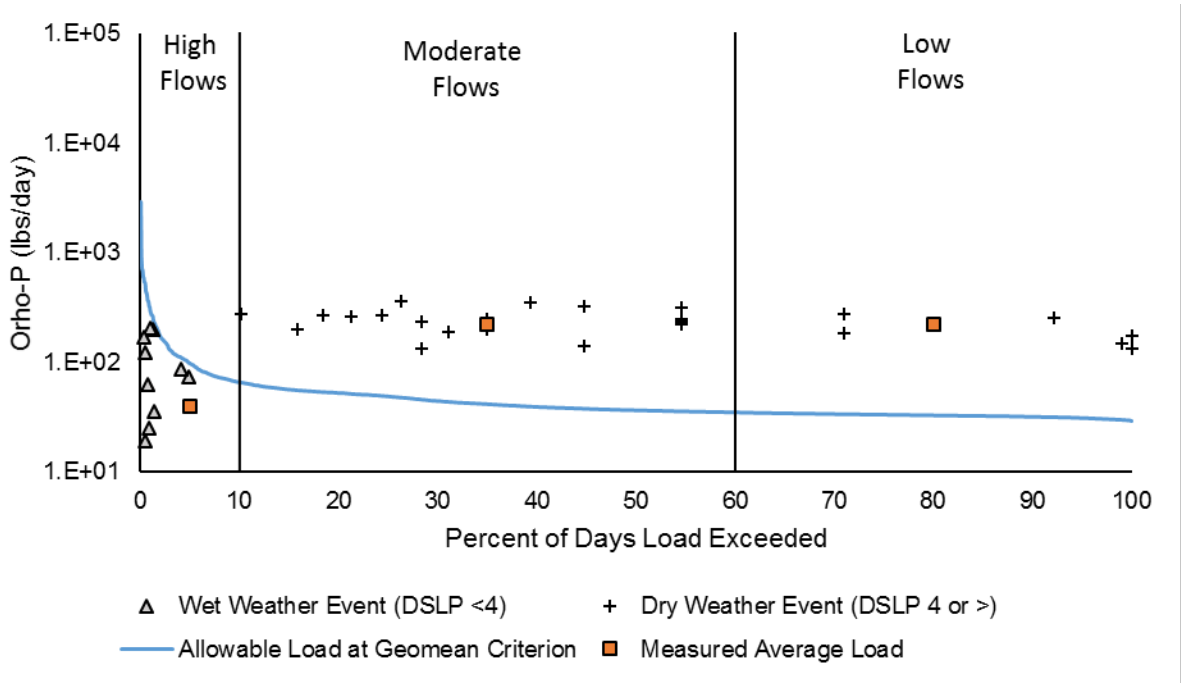

Figure A-5 Ortho-P load duration curve for station 18828, South Nolan Creek at 38th Street

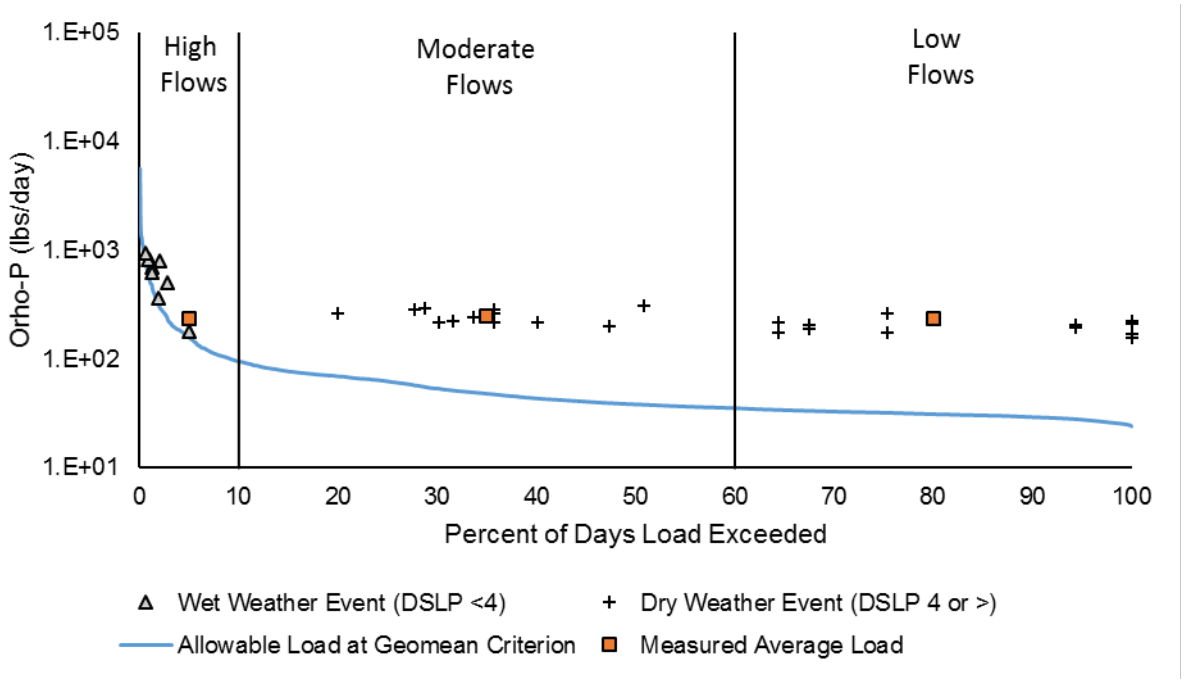

Figure A-6 Ortho-P load duration curve for station 11913, South Nolan Creek at Roy Reynolds Road.

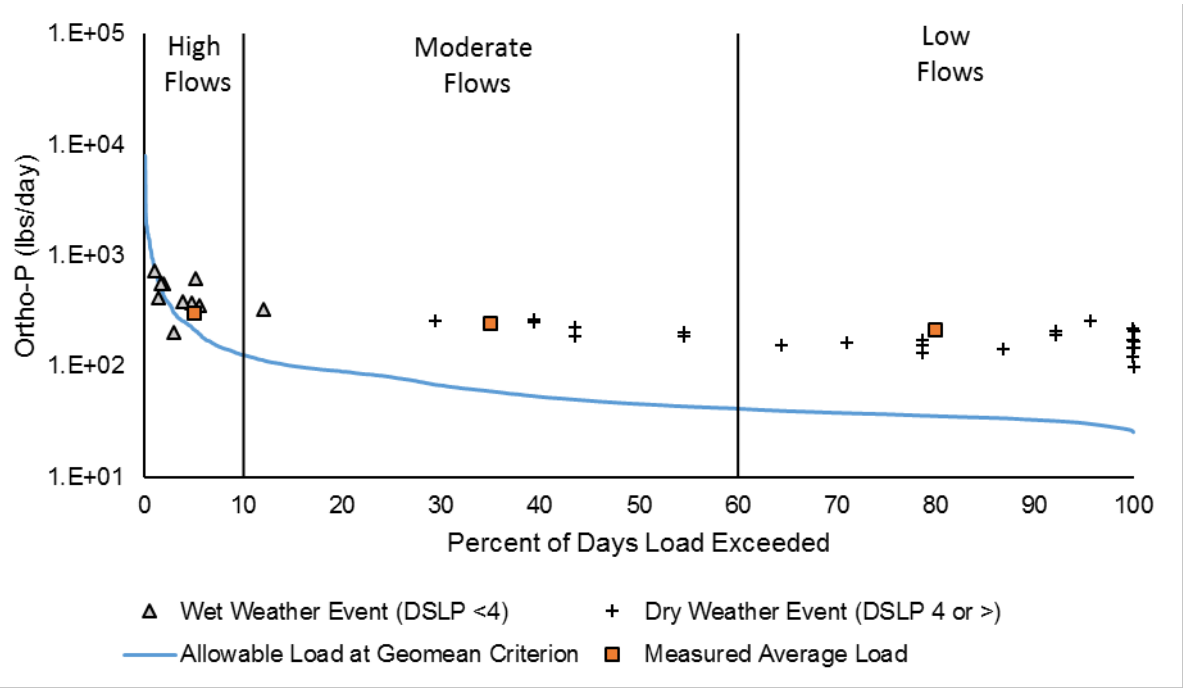

Figure A-7 Ortho-P load duration curve for station 11910, Nolan Creek at US 190.

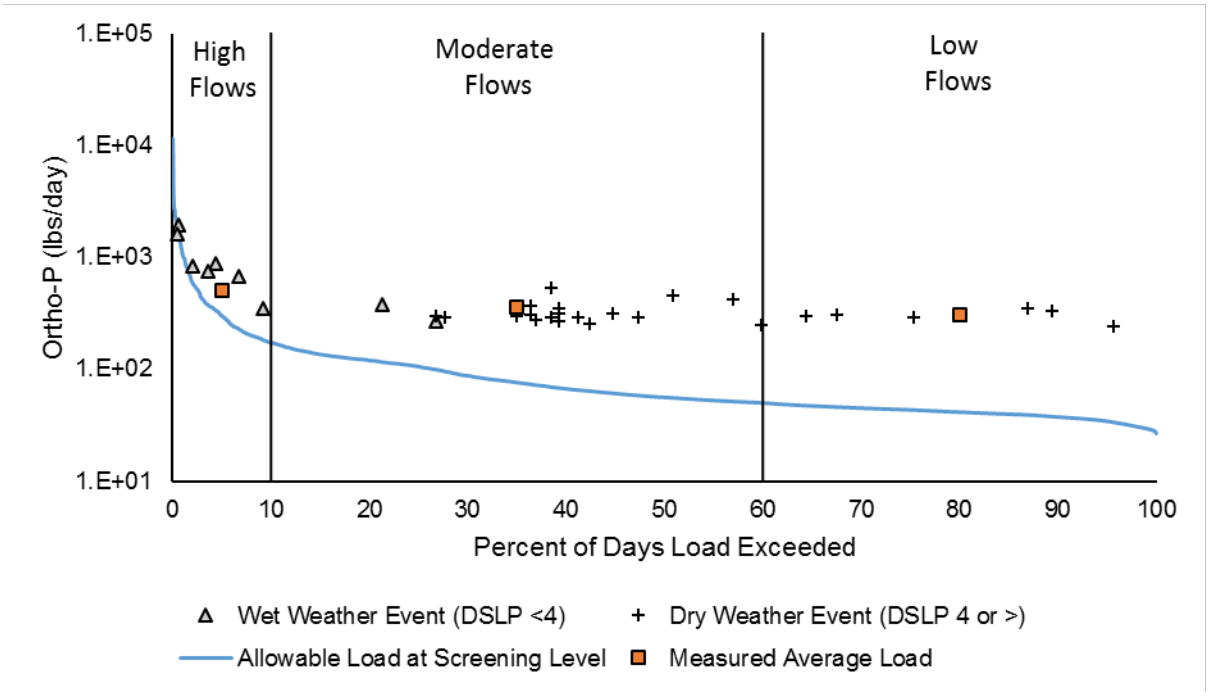

Figure A-8 Ortho-P load duration curve for station 11905, Nolan Creek at Backstrom Crossing.

Table A-2 Average concentration of measured ortho-P by flow regime and estimated percent reductions needed to meet screening level of 0.37 mg/L ortho-P for four stations along Nolan Creek/South Nolan Creek. Zero percent reductions indicate the screening level is already met and reductions are not necessary.

Station	High Flows (0-10%)		Moderate Flows (10-60%)		Low Flows 60-100%)	
	Average Ortho-P (mg/L)	Percent Reduction	Average Ortho-P (mg/L)	Percent Reduction	Average Ortho-P (mg/L)	Percent Reduction
18828	0.15	0%	1.99	81%	2.51	85%
11913	0.57	36%	1.89	80%	2.73	86%
11910	0.52	28%	1.55	76%	2.22	83%
11905	0.65	43%	1.74	79%	2.71	86%

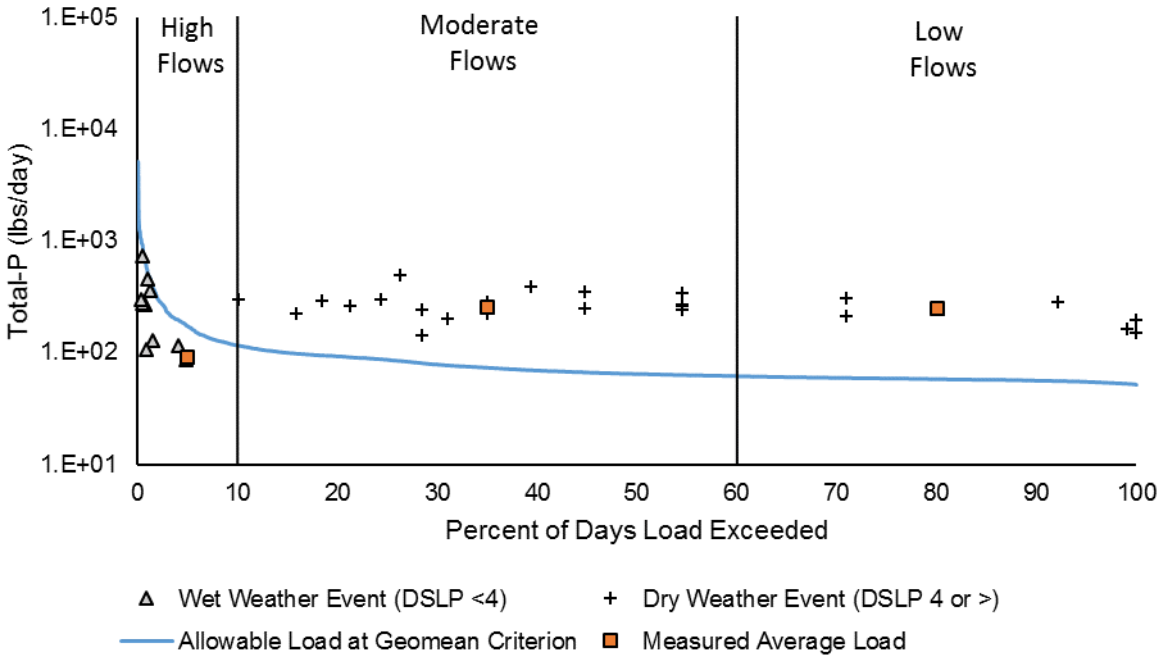

Figure A-9 Total-P load duration curve for station 18828, South Nolan Creek at 38th Street

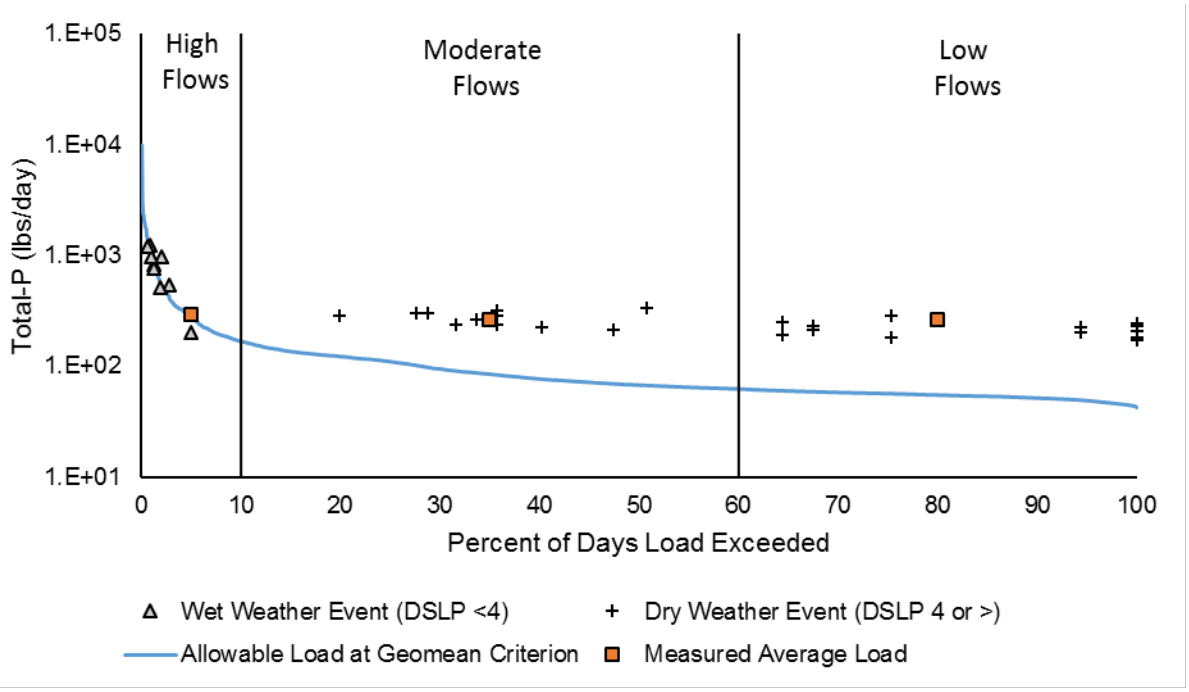

Figure A-10 Total-P load duration curve for station 11913, South Nolan Creek at Roy Reynolds Road.

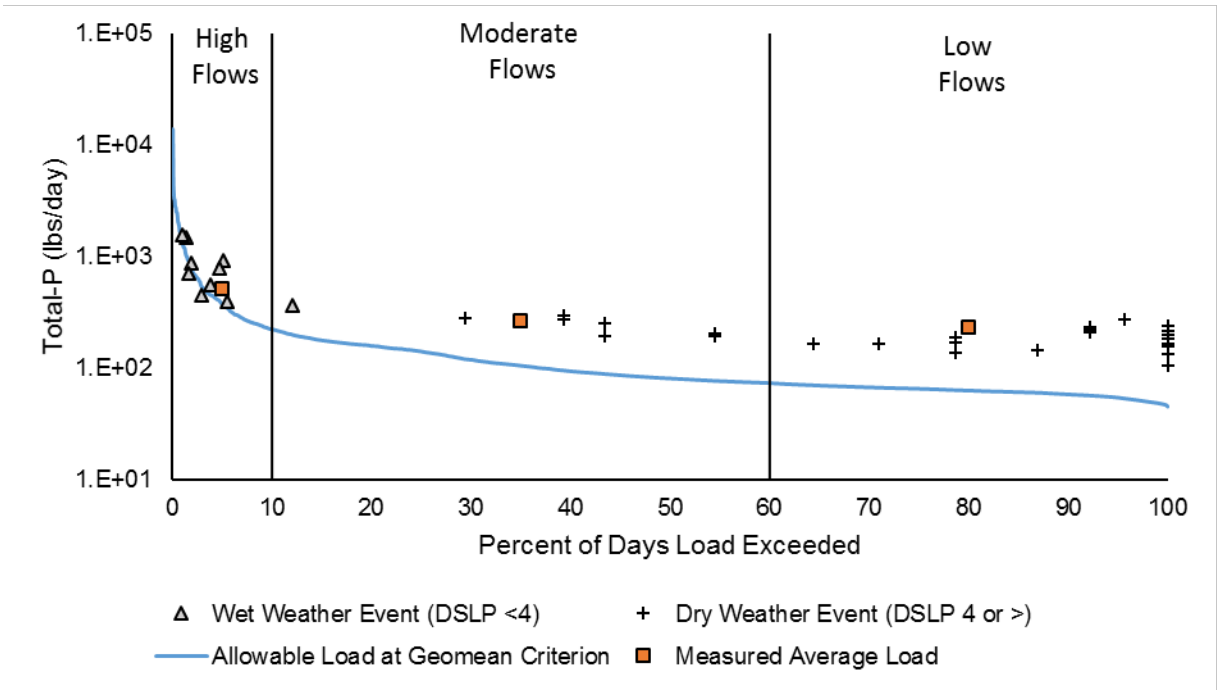

Figure A-11 Total-P load duration curve for station 11910, Nolan Creek at US 190.

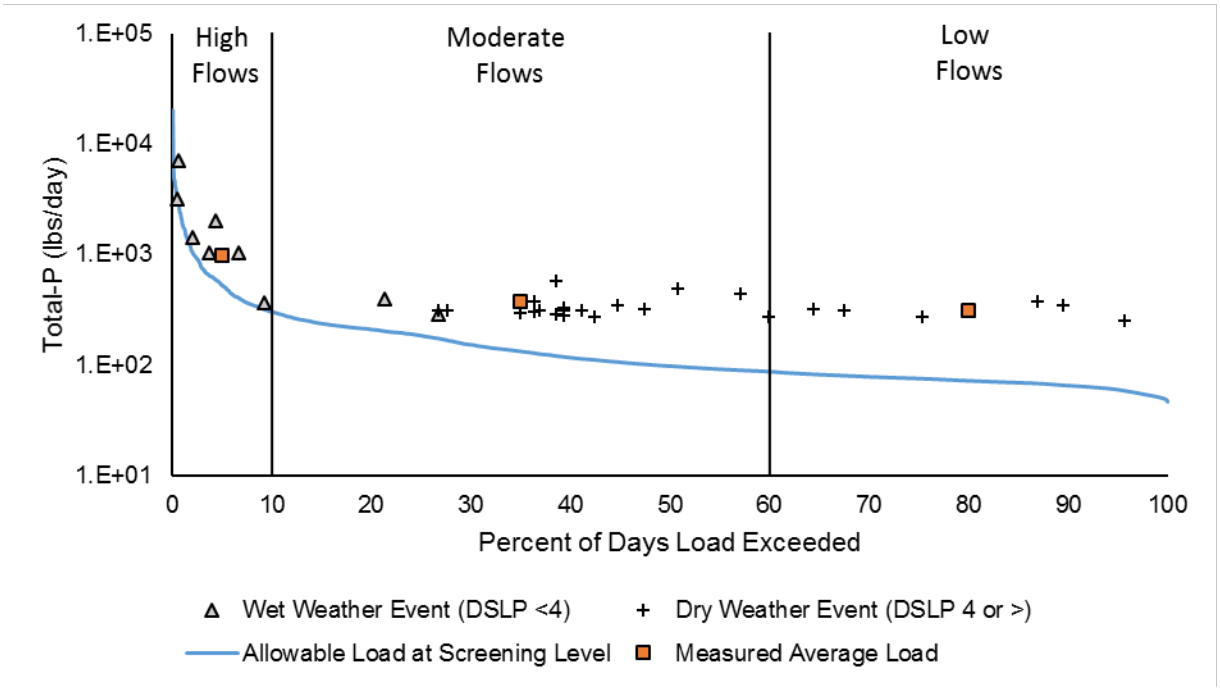

Figure A-12 Total-P load duration curve for station 11905, Nolan Creek at Backstrom Crossing.

Table A-3 Average concentration of measured total-P by flow regime and estimated percent reductions needed to meet screening level of 0.69 mg/L total-P for four stations along Nolan Creek/South Nolan Creek. Zero percent reductions indicate the screening level is already met and reductions are not necessary.

Station	High Flows (0-10%)		Moderate Flows (10-60%)		Low Flows 60-100%)	
	Average Total-P (mg/L)	Percent Reduction	Average Total-P (mg/L)	Percent Reduction	Average Total-P (mg/L)	Percent Reduction
18828	0.33	0%	2.28	70%	2.78	75%
11913	0.71	3%	2.03	66%	2.99	77%
11910	0.88	22%	1.65	58%	2.38	71%
11905	1.25	45%	1.84	62%	2.83	76%

Appendix B

SELECT Estimates of Potential Loadings

Table B-1 SELECT estimates of potential loadings by subbasin and source for Nolan Creek/South Nolan Creek.

Subbasin	Cattle (cfu/day)	Sheep & Goats (cfu/day)	Horses (cfu/day)	Deer (cfu/day	Feral Hogs (cfu/day)	Pets (cfu/day)	OSSFs (cfu/day)	WWTF (cfu/day)	Urban Stormwater (cfu/day)	Total (cfu/day)
1	2.13E+12	2.28E+11	9.55E+08	1.98E+09	1.11E+11	0.00E+00	0.00E+00	0.00E+00	3.78E+11	2.85E+12
2	2.59E+12	3.83E+11	1.16E+09	3.72E+09	2.67E+11	0.00E+00	0.00E+00	0.00E+00	3.64E+03	3.25E+12
3	2.65E+12	5.53E+11	1.19E+09	5.91E+09	4.46E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.65E+12
4	4.23E+12	3.41E+11	1.90E+09	2.48E+09	2.41E+11	0.00E+00	0.00E+00	0.00E+00	7.23E+05	4.81E+12
5	2.07E+12	4.62E+11	9.28E+08	5.00E+09	2.84E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.82E+12
6	1.82E+12	1.64E+11	8.17E+08	1.26E+09	1.31E+11	1.07E+12	1.99E+00	0.00E+00	1.10E+12	4.28E+12
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E+11	0.00E+00	0.00E+00	2.65E+13	2.70E+13
8	0.00E+00	1.38E+09	0.00E+00	2.21E+07	0.00E+00	2.01E+12	6.08E-08	0.00E+00	4.08E+12	6.09E+12
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E+12	6.08E-08	0.00E+00	1.22E+13	1.44E+13
10	4.84E+11	4.71E+10	2.17E+08	3.89E+08	5.48E+10	2.16E+12	1.98E+00	4.29E+08	2.12E+12	4.87E+12
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.55E+11	9.11E-08	0.00E+00	1.05E+13	1.15E+13
12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E+12	2.21E-04	0.00E+00	1.56E+13	1.70E+13
13	2.37E+12	4.89E+11	1.06E+09	5.21E+09	2.82E+11	0.00E+00	0.00E+00	0.00E+00	4.17E+06	3.15E+12
14	7.33E+09	2.64E+08	3.29E+06	0.00E+00	0.00E+00	2.54E+12	2.65E-04	0.00E+00	1.92E+12	4.46E+12
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E+12	0.00E+00	1.14E+11	5.57E+12	7.00E+12
16	5.49E+12	5.88E+11	2.47E+09	5.06E+09	4.11E+11	8.62E+11	9.30E+08	1.43E+08	2.47E+09	7.36E+12
17	5.15E+12	4.36E+11	2.31E+09	3.20E+09	3.12E+11	8.34E+10	1.84E+04	0.00E+00	8.25E+05	5.98E+12
18	1.46E+12	1.48E+11	6.55E+08	1.20E+09	9.37E+10	1.42E+12	1.15E+01	0.00E+00	6.58E+11	3.78E+12
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E+12	1.10E-04	0.00E+00	2.70E+12	4.37E+12
20	3.08E+12	3.61E+11	1.38E+09	3.19E+09	1.65E+11	1.91E+11	3.23E+04	0.00E+00	7.77E+09	3.81E+12
21	2.67E+12	3.72E+11	1.20E+09	3.57E+09	2.61E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E+12

Subbasin	Cattle (cfu/day)	Sheep & Goats (cfu/day)	Horses (cfu/day)	Deer (cfu/day	Feral Hogs (cfu/day)	Pets (cfu/day)	OSSFs (cfu/day)	WWTF (cfu/day)	Urban Stormwater (cfu/day)	Total (cfu/day)
22	1.25E+11	6.66E+09	5.60E+07	3.16E+07	0.00E+00	6.78E+12	3.58E+04	0.00E+00	1.48E+13	2.18E+13
23	1.06E+11	6.00E+09	4.78E+07	2.53E+07	0.00E+00	2.31E+12	5.80E-04	1.43E+10	6.78E+12	9.21E+12
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.73E+12	5.82E+01	0.00E+00	2.83E+13	3.41E+13
25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E+12	2.98E+00	0.00E+00	3.91E+12	5.29E+12
26	6.84E+12	3.00E+11	3.07E+09	6.87E+08	1.68E+11	3.36E+11	3.31E+07	0.00E+00	8.07E+10	7.73E+12
27	6.20E+12	6.24E+11	2.79E+09	5.16E+09	4.08E+11	1.49E+11	1.13E+05	0.00E+00	1.49E+09	7.39E+12
28	4.92E+12	2.11E+11	2.21E+09	4.43E+08	1.67E+11	3.02E+11	1.25E+10	0.00E+00	3.73E+09	5.62E+12
29	9.06E+12	4.27E+11	4.07E+09	1.33E+09	3.60E+11	1.15E+11	1.99E+06	0.00E+00	1.96E+09	9.97E+12
30	7.46E+12	4.18E+11	3.35E+09	1.91E+09	3.32E+11	7.57E+10	5.55E+08	0.00E+00	9.70E+09	8.30E+12
31	7.36E+12	3.27E+11	3.31E+09	7.91E+08	2.42E+11	9.83E+10	2.51E+04	0.00E+00	1.50E+09	8.03E+12
32	5.14E+12	3.39E+11	2.31E+09	1.97E+09	2.40E+11	6.80E+10	1.60E+04	0.00E+00	9.23E+08	5.80E+12
33	5.80E+12	2.59E+11	2.60E+09	6.55E+08	2.36E+11	2.35E+11	1.41E+07	0.00E+00	9.03E+09	6.54E+12
34	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E+12	4.54E+03	0.00E+00	6.43E+12	9.48E+12
35	4.63E+12	1.96E+11	2.08E+09	3.51E+08	1.71E+11	1.67E+12	4.75E+10	2.86E+10	8.93E+11	7.63E+12
36	3.67E+12	2.15E+11	1.65E+09	1.06E+09	2.63E+11	9.73E+10	2.87E+04	0.00E+00	1.61E+08	4.25E+12
37	8.42E+12	4.40E+11	3.78E+09	1.81E+09	3.81E+11	2.81E+11	6.01E+04	0.00E+00	8.72E+09	9.54E+12
38	4.71E+12	2.07E+11	2.12E+09	4.84E+08	1.74E+11	6.93E+11	1.09E+11	3.22E+09	3.81E+11	6.28E+12
39	4.35E+12	2.30E+11	1.95E+09	9.43E+08	2.27E+11	1.32E+12	3.09E+10	0.00E+00	8.15E+10	6.25E+12
40	2.42E+12	1.75E+11	1.09E+09	1.14E+09	1.45E+11	1.61E+11	2.37E+07	0.00E+00	2.88E+10	2.93E+12
41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E+12	5.07E+09	0.00E+00	3.17E+12	5.20E+12
42	4.18E+12	2.49E+11	1.88E+09	1.24E+09	2.26E+11	1.32E+11	6.35E+06	0.00E+00	2.51E+10	4.82E+12
43	5.10E+12	1.99E+11	2.29E+09	2.02E+08	1.89E+11	1.59E+12	7.51E+09	0.00E+00	9.93E+10	7.18E+12
44	3.90E+12	2.19E+11	1.75E+09	1.00E+09	1.22E+11	6.72E+11	1.74E+08	0.00E+00	2.00E+11	5.11E+12
45	3.12E+11	2.05E+10	1.40E+08	1.20E+08	2.49E+10	9.25E+11	2.02E+02	4.77E+10	2.75E+12	4.08E+12

Table B-2 Percent of potential loadings by source within subbasins for Nolan Creek/South Nolan Creek.

Subbasin	Cattle	Sheep & Goats	Horses	Deer	Feral Hogs	Pets	OSSFs	WWTF	Urban Stormwater
1	74.72%	7.99%	0.03%	0.07%	3.90%	0.00%	0.00%	0.00%	13.28%
2	79.82%	11.81%	0.04%	0.11%	8.21%	0.00%	0.00%	0.00%	0.00%
3	72.44%	15.14%	0.03%	0.16%	12.22%	0.00%	0.00%	0.00%	0.00%
4	87.81%	7.09%	0.04%	0.05%	5.01%	0.00%	0.00%	0.00%	0.00%
5	73.33%	16.38%	0.03%	0.18%	10.07%	0.00%	0.00%	0.00%	0.00%
6	42.48%	3.83%	0.02%	0.03%	3.05%	24.92%	0.00%	0.00%	25.67%
7	0.00%	0.00%	0.00%	0.00%	0.00%	1.88%	0.00%	0.00%	98.12%
8	0.00%	0.02%	0.00%	0.00%	0.00%	32.97%	0.00%	0.00%	67.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	15.38%	0.00%	0.00%	84.62%
10	9.94%	0.97%	0.00%	0.01%	1.13%	44.37%	0.00%	0.01%	43.57%
11	0.00%	0.00%	0.00%	0.00%	0.00%	8.32%	0.00%	0.00%	91.68%
12	0.00%	0.00%	0.00%	0.00%	0.00%	8.09%	0.00%	0.00%	91.91%
13	75.30%	15.55%	0.03%	0.17%	8.95%	0.00%	0.00%	0.00%	0.00%
14	0.16%	0.01%	0.00%	0.00%	0.00%	56.86%	0.00%	0.00%	42.97%
15	0.00%	0.00%	0.00%	0.00%	0.00%	18.89%	0.00%	1.63%	79.48%
16	74.58%	7.98%	0.03%	0.07%	5.59%	11.70%	0.01%	0.00%	0.03%
17	86.02%	7.28%	0.04%	0.05%	5.21%	1.39%	0.00%	0.00%	0.00%
18	38.60%	3.92%	0.02%	0.03%	2.48%	37.51%	0.00%	0.00%	17.43%
19	0.00%	0.00%	0.00%	0.00%	0.00%	38.14%	0.00%	0.00%	61.86%
20	80.82%	9.49%	0.04%	0.08%	4.34%	5.02%	0.00%	0.00%	0.20%
21	80.75%	11.23%	0.04%	0.11%	7.87%	0.00%	0.00%	0.00%	0.00%
22	0.57%	0.03%	0.00%	0.00%	0.00%	31.17%	0.00%	0.00%	68.22%
23	1.15%	0.07%	0.00%	0.00%	0.00%	25.05%	0.00%	0.16%	73.58%
24	0.00%	0.00%	0.00%	0.00%	0.00%	16.83%	0.00%	0.00%	83.17%
25	0.00%	0.00%	0.00%	0.00%	0.00%	26.10%	0.00%	0.00%	73.90%

Subbasin	Cattle	Sheep & Goats	Horses	Deer	Feral Hogs	Pets	OSSFs	WWTF	Urban Stormwater
26	88.52%	3.87%	0.04%	0.01%	2.17%	4.34%	0.00%	0.00%	1.04%
27	83.90%	8.45%	0.04%	0.07%	5.51%	2.02%	0.00%	0.00%	0.02%
28	87.57%	3.76%	0.04%	0.01%	2.97%	5.37%	0.22%	0.00%	0.07%
29	90.89%	4.28%	0.04%	0.01%	3.61%	1.15%	0.00%	0.00%	0.02%
30	89.86%	5.04%	0.04%	0.02%	4.00%	0.91%	0.01%	0.00%	0.12%
31	91.63%	4.07%	0.04%	0.01%	3.01%	1.22%	0.00%	0.00%	0.02%
32	88.75%	5.84%	0.04%	0.03%	4.15%	1.17%	0.00%	0.00%	0.02%
33	88.66%	3.95%	0.04%	0.01%	3.61%	3.59%	0.00%	0.00%	0.14%
34	0.00%	0.00%	0.00%	0.00%	0.00%	32.22%	0.00%	0.00%	67.78%
35	60.65%	2.57%	0.03%	0.00%	2.24%	21.82%	0.62%	0.37%	11.70%
36	86.40%	5.06%	0.04%	0.02%	6.18%	2.29%	0.00%	0.00%	0.00%
37	88.29%	4.62%	0.04%	0.02%	3.99%	2.95%	0.00%	0.00%	0.09%
38	75.01%	3.30%	0.03%	0.01%	2.77%	11.03%	1.73%	0.05%	6.06%
39	69.65%	3.68%	0.03%	0.02%	3.63%	21.18%	0.49%	0.00%	1.31%
40	82.53%	5.97%	0.04%	0.04%	4.94%	5.50%	0.00%	0.00%	0.98%
41	0.00%	0.00%	0.00%	0.00%	0.00%	38.84%	0.10%	0.00%	61.07%
42	86.81%	5.17%	0.04%	0.03%	4.69%	2.75%	0.00%	0.00%	0.52%
43	70.95%	2.77%	0.03%	0.00%	2.64%	22.13%	0.10%	0.00%	1.38%
44	76.22%	4.29%	0.03%	0.02%	2.39%	13.14%	0.00%	0.00%	3.91%
45	7.63%	0.50%	0.00%	0.00%	0.61%	22.65%	0.00%	1.17%	67.44%

Appendix C

Public Sewer Line Infrastructure

Management of the public infrastructure of the sewer line infrastructure includes items, such as maintenance of the collection system, illicit discharge and elimination programs, procedures for dealing with discharges and spill, as well as program to minimize sewer overflows and blockages. These items related to the public infrastructure of the sewer system are largely addressed via SWMPs associated with each community. A summary of ongoing or planned activities related to the public infrastructure of the sewer system is presented below from SWMPs and other sources.

Collection System Maintenance

Inspection activities to detect leaks and identify rehabilitation needs for sewer lines are ongoing for municipalities within the Nolan Creek/South Nolan Creek watershed. Leak detection is largely coordinated within SWMPs of each community in dealing with IDDE.

For example in July 2017, the Killeen City Council approved an updated evaluation of its Water and Wastewater Master Plan, which was last drafted in 2012. This analysis of Killeen's infrastructure will update and layout needed capital improvements and repairs. Work is ongoing to rehabilitate and replace wastewater mainlines within Killeen. As part of Killeen's SWMP, a goal is to clean 35,000 ft/yr and television video (TV) inspect 12,000 ft/yr of sewer lines to aid in eliminating sanitary system overflows (SSOs).

Illicit Discharge Detection and Elimination Programs

Illicit Discharge Detection and Elimination programs focus on the detective work needed to hunt down and correct illicit connections. This involves understanding the sewage collection system, but also the stormwater drainage as it leads to the creek. As part of the MS4 general permit, each entity is required to submit a SWMP that specifically addresses IDDE. Requirements in part include mapping storm drainage outfalls in relation to surface waters; developing an IDDE program for detecting, investigating, and eliminating illicit discharges; and educating and training municipal staff. Dry weather screening is also an important tool implemented or in development within SWMPs of several of these entities.

Stormwater ordinances for illicit discharges already exist for the cities of Belton, Harker Heights, and Killeen. The City of Nolanville within its SWMP has set a target date of 2019 for adopting a city ordinance for illicit discharges.

Procedures for Tracking, Responding and Removing Illicit Discharges and Spills

As part of their SWMPs, specific procedures for tracking, responding, and removing illicit discharges and spills have been developed by each municipality. These includes things such as dry weather screening and response training of personnel.

In addressing illicit discharges, each MS4 entity has public reporting and response procedures for complaints noted as follows:

- **Killeen** (SWMP) – Drainage Utility Response line (254) 501-7629, 24-hr hotline for reporting stormwater drainage issues. The Water and Sewer Department in Killeen deals with wastewater lines. The City of Killeen has a specific number for reporting leaks, sewer blockages, and overflows as (254) 501-6500 [alternate number (254) 501-6310] noted on their webpage at (http://www.killeentexas.gov/index.php?section=125).
- **Fort Hood** (SWMP) – Through the Fort Hood municipal stormwater program, illicit discharges may be reported via email through its website by clicking on the "Please Don't Feed the Storm Drain" logo at http://www.hood.army.mil/dpw/Environmental/Municipal%20storm%20water.aspx.
- **Harker Heights** (SWMP) – The City of Harker Heights Public Works Department has regular hours and after hours duty phone numbers as well as stormwater hotline noted on its website (http://www.ci.harker-heights.tx.us/index.php/public-works). These numbers are provided below.
    - Regular hours (254) 953-5649
    - After Hours Emergency Numbers
        - Water Leaks (254) 681-6779
        - Sewer Stops (254) 702-4893
        - Street, Drainage & Sanitation (254) 319-4996
    - Stormwater Hotline
        - Regular Hours (254) 953-5649
        - Holidays, weekends & after 5 pm weekdays (254) 319-4996
- **Nolanville** (SWMP) – The City of Nolanville provides an illegal dumping notification link on City of Nolanville's website for all "concerns" at http://ci.nolanville.tx.us/page/Report_Concerns.
- **Belton** (SWMP) – Within the City of Belton, the Public Works Department can be contacted at (254) 933-5823 regarding illegal dumping or discharges.
- **Bell County** (SWMP) – For illegal dumping, the Bell County Engineer's Office should be contacted at (254) 933-5275.

Programs to Minimize Sewer System Overflows from Blockage

Municipalities are also actively working to minimize SSOs. Most past SSOs in the watershed have been related to FOG issues, but things, such as baby wipes, facial wipes, sanitary pads, and tampons, can create blockages, particularly when large amounts are flushed down the drain. The

larger municipalities in the watershed all have FOG ordinances focused on businesses that use a lot of oils and grease, such as food service and auto related operations. These FOG ordinances include inspections for compliance and enforcement of remediation, if businesses are found out of compliance.

An example is the Harker Heights ordinance dealing with Fats, Oils, and Greases (§53.28) for non-residential uses of the wastewater system and transporters of grease or grit trap waste (http://www.ci.harker-heights.tx.us/docs/22-53_28FatsOilsAndGreases_ContolAndPrevention.pdf).

Information on Killeen's FOG program, including educational brochures, can be found at on the city's website at http://www.killeentexas.gov/index.php?section=126.

Fort Hood also includes a FOG training course offered to Dining Facilities Administration Centers (DFACs) and commercial restaurants to help reduce the amount of grease buildup in sewer lines (http://www.hood.army.mil/dpw/Environmental/MCM_1.aspx).

The cities of Killeen and Harker Heights have agreements to participate in TCEQ's Sanitary Sewer Overflow Initiative (https://www.tceq.texas.gov/compliance/investigation/ssoinitiative).

Appendix D

Urban SWMP Activities

Within the SWMPs associated with the Nolan Creek/South Nolan Creek watershed, a variety of activities are already addressed that should aid in control of bacterial runoff to the creek. A summary of these activities is provided below as an indication of ongoing efforts in the watershed.

Pollution Prevention and Good Housekeeping for Municipal Operations

Because preventing pollutants from entering waterways is less expensive than trying to restore a waterway once polluted, good housekeeping for municipalities focuses on developing and implementing an operations and maintenance program for city-owned facilities and operations. This program includes items such as vehicle maintenance practices, chemical use and storage, and roadway cleaning/sweeping. For pollution prevention, inspection and maintenance of the stormwater drainage system is included under good housekeeping for municipal operations, which ties in directly with IDDE programs and efforts to minimize illegal dumping.

Construction Practices

Runoff from construction sites, if not controlled, can potentially carry large amounts of sediment. As part of their MS4 permits, entities are required to develop a program to reduce sediment from construction sites focusing on areas one acre or greater. This involves the development and passage of ordinances, a program requiring construction site operators to implement erosion control best management practices, requirements to control other waste at the construction site, review of construction site plans with consideration to impacts on water quality, and inspections and enforcement of construction control measures. There also needs to be a process for receiving and considering information submitted by the public regarding construction activities. Construction practices are addressed more fully in SWMPs of each entity in the watershed. The practices outlined in these SWMPs are important as sedimentation not only can cause water quality problems by blocking sunlight and filling creeks and other water bodies, it can carry with it other pollutants, including bacteria from the land surface.

Post-Construction Practices

Practices to increase infiltration and reduce runoff are a focus of post-construction stormwater management in new development and redevelopment areas as part of SWMPs. Some other activities noted in SWMPs or other planning documents for entities in the watershed include the following:

- The Comprehensive Plan for the City of Killeen finalized in 2010 explores expansion and connection of parks and green spaces across the region and recognizes the importance of preserving existing green and open space, particularly in floodplain areas (http://www.killeentexas.gov/index.php?section=178). Building nature into Killeen is weaved throughout the Comprehensive Plan with themes of open space preservation and "green" development including creek corridors and their floodplains. For the City of

Killeen, this includes a maintenance plan that involves restoring riparian areas, where feasible, with native vegetation. Near schools "safe ways" must be included that involve clearing and mowing to "lawn standards" to allow visibility. The City of Killeen Drainage Master Plan developed in 2012 recommends "conventional" BMPs such as sedimentation/filtration ponds, wet ponds and vegetative filter strips and use of low impact development (LID) and construction techniques (http://www.killeentexas.gov/index.php?section=281).

- The Fort Hood SWMP notes its requirement to comply with Section 438 of the Energy Independence and Security Act of 2007, for new construction and redevelopment projects that meet the established criteria. (http://www.hood.army.mil/dpw/Environmental/MCM_5.aspx).

- For Harker Heights, the SWMP includes developing and disseminating information on topics such as landscape design, xeriscaping, reusing yard wastes, and composting as way to increase infiltration and reduce stormwater runoff. Some educational brochures on these topics are available on the Harker Heights stormwater website (http://www.ci.harker-heights.tx.us/index.php/storm-water).

- The Nolanville SWMP encourages and promotes low impact/green designs in partnership with the Central Texas Home Builders Association (target date 2016-2020) and includes identifying and promoting buffer areas around natural waterways (target date 2018).

- Belton within its SWMP plans to identify buffer areas to promote vegetation and install signs that define these management area and also identify future buffer areas as the city continues to develop.

- Bell County (SWMP) promotes use of unlined or pervious drainage ditches instead of impervious concrete gutters or underground storm drain systems. These above ground open, grassy drainage ditch systems allow more stormwater runoff to soak into the ground, reducing runoff and some of the pollutants that might otherwise reach our waterways.

Industrial Practices

For MS4 areas supporting a population of 100,000 or more, industrial practices for pollution control must also be addressed within SWMPs. Within the Nolan Creek/South Nolan Creek, the City of Killeen is the only MS4 entity that meets this population threshold. Industrial activities can vary greatly but focus on material handling and storage, equipment maintenance and cleaning, and other activities that may lead to the transport of industrial pollutants via the storm drainage system (https://www.epa.gov/npdes/stormwater-discharges-industrial-activities). Within the City of Killeen, ordinances for the municipal drainage utility system include industrial wastes and potential runoff. Within Killeen's SWMP, additional activities focus on identifying priorities, adopting a procedures program for industrial stormwater, and developing and implementing an industrial stormwater testing program.

Appendix E

Proposed Bioswale Implementation within Nolanville

Within the City of Nolanville, there are several tributaries that lead to South Nolan Creek. The City of Nolanville proposes designing bioswales on four of these tributaries. The function of the bioswales in these locations is threefold: to reduce levels of bacteria and pollutants leading to South Nolan Creek; to prevent future flooding in the surrounding areas; and to educate the residents on ways to reduce future bacteria deposition into Nolanville's waterbodies. The project would not only implement the four bioswales, but also estimate pollutant loadings and reductions associated with these bioswales and include an educational component on LID and water quality impacts. The four areas recommended for implementation of bioswales are as follows:

Area 1:

The first location (Area 1), located at 10th Street and E. Avenue H, is adjacent to the Community Center. The stream is often stagnant, with algal blooms and eutrophication occurring, causing aquatic ecosystems to suffer and creating an unpleasant aroma. The inclusion of a bioswale at this location, accompanied by street trees and educational signage, would help to filter runoff and slow water movement into South Nolan Creek. This area serves as the central point for the collection of water for the eastern portion of Nolanville. Due to this it often floods the streets and has caused flood damage to surrounding residences. A bioswale designed to infiltrate quicker and hold more water would decrease future flood damage in this area. The educational signage would explain the importance of a healthy waterbody as well as demonstrate the function of bioswales. Due to its proximity to the Community Center and a series of parks and play spaces this area has a high population density which leads the space to serve as a highly utilized asset that educates and engages the users on the importance of preventing future water pollution.

Area 2:

The second location (Area 2), located at West Avenue and 7th Street, is adjacent to Nolanville's City Hall. This site often lays stagnant during dry seasons and severely floods during rain events, causing large amounts of bacteria and sediment to flood into South Nolan Creek. The proposal for a bioswale in this area will decrease the bacteria levels through biofiltration and lower the risk of flooding by expanding the channel and increasing groundwater infiltration. The City Hall Building will demonstrate low impact design for the public serving as an outreach and education component of the project. This location is the central collection point for the western portion of Nolanville. During flood events this not only floods the streets but typically floods nearby residents. A bioswale, fitted to meet the metrics provided by Schiebe Consulting, will lower the flood risk for this area. Additionally, due to its proximity to the city's largest civic building, this location would serve as an educational and cultural asset, with educational signage, dog waste stations, and shady places to sit aside the tributary. The designers will incorporate a demonstration garden on this site, showing a series of small low-impact development strategies that improve non-point source pollution, including a filtered rain cistern and a biofiltration garden.

Area 3:

The third site (Area 3) is a bus stop located on Old Nolanville Road. The concrete bus pad sits atop a steep hill which leads directly to South Nolan Creek. During rain events this area sends

large amounts of sedimentation into the creek, leading to erosion of the hillside and heightened levels of debris in the creek. A bioswale in this area would slow water flow from the paved bus stop to South Nolan Creek, as well as create shade and cooling down the bus pad waiting area.

Area 4:

The final site is on South Main Street (Area 4), situated where Old Nolanville Road and South Nolan Creek intersect. Leading up to this site is a series of culverts with water collected from Main Street. This space currently serves as the terminus for the water collected but does not continue into South Nolan Creek due to grading issues. This has led to algal blooms, unpleasant odors, and occasional flooding of the surrounding areas. The proposal for a bioswale is to prevent current stagnation, thus reducing algal blooms, mosquito breeding, and flooding. This site will require a grading plan to allow for positive drainage into South Nolan Creek after being filtered. A bioswale with educational signage would be a regional benefit given that this area is a start point for bikers and runners throughout Central Texas.

Sustainability is the most important consideration in this project. The goal of low impact design is to reduce the strain on resources, but the measures could lose effectiveness if their benefit is not continuously highlighted. The City of Nolanville is prepared to ensure the enduring success of these measures through the following activities:

- The City will provide field trips from the elementary school annually in coordination with Earth Day events sponsored through Keep Nolanville Beautiful.
- Improvements will be marked with educational information.
- The improvements will also be integrated into State of the City address with tour of the community for City Officials.
- Information on the watershed, benefits and “how to” information will be highlighted on the City Website.
- Cost estimates for maintenance will be provided by the designers to ensure maintenance for up to 10 years is accounted for in the City’s budget.

With regard to readiness, the project has received support from Nolanville’s City Council and has a design team ready to proceed.

Cost for the completed project including installation and maintenance of bioswale, educational component, and load reduction measurements estimated at about $217,000.

Appendix F

Educational Components of SWMPs

While not comprehensive, below are some of the education outreach components noted in SWMPs of entities within the watershed. Educational outreach for the Nolan Creek WAP expands beyond these ongoing efforts implemented within SWMPs.

Killeen

Educational Outreach as part of the City of Killeen's SWMP includes:

- At least 24 cable broadcasts of public service announcements with social media postings,
- Distribution within the KISD of 32,000 school book covers with stormwater related messages per year,
- Educational outreach in schools,
- Distribution of stormwater related brochures (some included on webpage) with targeting of business or locations to address specific issues,
- Utility bill inserts with stormwater related information (2 inserts mailed per year), and
- Storm drain stenciling focusing on older areas of the city known to be more problematic. (Stenciling of inlets involves student and community groups organized through KKB.)

Environmental Services Division webpage contains a link to the Killeen SWMP (http://www.killeentexas.gov/index.php?section=113). Also on the website are links to information regarding stormwater drainage, construction guidance, watershed announcements, some educational brochures, and other related information and links.

Killeen has an organized Storm Water Stakeholder Group that meets regularly that reviewed the SWMP and is involved with updates and review of the City's stormwater management practices.

Killeen SWMP specifically notes support of watershed organizations including outreach efforts dealing with Lake Stillhouse Hollow, the Leon River WPP, the Lampasas River WPP, the Clean Rivers Program, and the Nolan Creek WPP among others.

Harker Heights

As part of its SWMP, Harker Heights has a web presence devoted to stormwater quality to inform the public on issues by displaying educational brochures and other information related to protecting and improving stormwater quality including links to other pertinent sites (http://www.ci.harker-heights.tx.us/index.php/storm-water). The City of Harker Heights has a pet waste brochure developed with distribution focused on pet owners via pet stores, veterinarian clinics, pet adoptions, vaccinations drives and other pet-related events.

Nolanville

The Public Works webpage for Nolanville includes link to SWMP (http://ci.nolanville.tx.us/page/Department_Public_Works). The City of Nolanville in its SWMP

includes development of an Adopt-A-Stream program in partnership with the Killeen Independent School District (target date 2020).

Fort Hood

Department of Public Works –Environmental Division stormwater website contains downloadable brochures, links to educational websites, and other information to educate the Fort Hood community on the importance of keeping our stormwater clean. This stormwater website contains links to information regarding how Fort Hood is addressing each minimum control measure within its SWMP (http://www.hood.army.mil/dpw/Environmental/Municipal%20storm%20water.aspx).

Bell County

The Bell County Storm Water Management webpage contains links to its SWMP and permit along with Public Education materials and IDDE program focusing on the costs of illegal dumping. Educational brochures are also to be distributed at various parks and boat ramps as part of Bell County's stormwater education program (http://www.bellcountytx.com/departments/engineer_2/storm_water_management.php). Bell County also sponsors the Bell County Annual Water Symposium through the Clearwater Underground Water Conservation District (http://www.cuwcd.org/education/annual-water-symposium/).