Watershed Protection Plan for the Leon River Below Proctor Lake and Above Belton Lake

October 2011

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Prepared for the

Stakeholders of the Leon River Watershed

by

Parsons Water & Infrastructure Inc. and the Brazos River Authority

PARSONS

TSSWCB

Brazos River Authority

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This WPP is available on the Brazos River Authority website at:

http://www.brazos.org/LeonRiverWPP.asp

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ACRONYMS AND ABBREVIATIONS

AFO	Animal feeding operation
ARS	Agricultural Research Service
AWEP	Agricultural Water Enhancement Program
BMPs	Best management practices
BRA	Brazos River Authority
BST	Bacterial source tracking
CAFO	Concentrated animal feeding operation
CEAP	Conservation Effects Assessment Project
cfu	Colony forming unit (of bacteria)
CWA	Clean Water Act
DO	Dissolved oxygen
DOPA	Dairy outreach program area
DSS	Decision support system
DSHS	Texas Department of State Health Services
E. coli	*Escherichia coli*
EDAP	Economically Distressed Area Program
GIS	Geographic Information System
HSPF	Hydrologic Simulation Program - FORTRAN
I&I	Inflow and infiltration
LIP	Landowner Incentive Program
LMU	Land management unit
mg/L	Milligram per liter
mL	Milliliter
MUD	municipal utility district
NGO	Non-governmental organization
NLCD	National Land Cover Database
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
Parsons	Parsons Water and Infrastructure Inc.
OSSF	Onsite sewage facility
QAPP	Quality assurance project plan
R/C/I	Residential, commercial, industrial
RUAA	Recreational use attainability analysis
SSO	Sanitary sewer overflow
SWCD	Soil and Water Conservation District
SWQM	Surface water quality monitoring
SWQS	Surface Water Quality Standards
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TLAP	Texas Land Application Permit

TMDL	Total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWS	Texas Wildlife Services
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAF	Waste application field
WHIP	Wildlife Habitat Incentive Program
WQMP	Water quality management plan
WPP	Watershed protection plan
WWTF	Wastewater treatment facility

Acknowledgements

Development of the Leon River Watershed Protection Plan (WPP) was a multi-year effort supported by local stakeholders to reduce levels of bacteria and nutrients in the river and its tributaries. The development of this WPP would not have been successful without the commitment of stakeholders from the Leon River watershed, including municipal officials, landowners, dairy operators, cattle ranchers, farmers, county judges and commissioners, county agricultural extension agents, veterinarians, and other concerned citizens who participated and collaborated in the creation of local solutions to water quality problems.

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- Texas State Soil and Water Conservation Board
- Texas Commission on Environmental Quality
- Texas Parks and Wildlife Department
- Texas Department of Agriculture
- Texas AgriLife Extension Service
- U.S. Environmental Protection Agency
- United States Department of Agriculture – Agricultural Research Service (ARS)
- USDA – Natural Resources Conservation Service (NRCS)

Key individuals supporting this process who were involved in the writing of this report include:

- Jay Bragg, Brazos River Authority
- Mel Vargas, Parsons
- Marcel Dulay, Parsons

Using a federal Clean Water Act §319(h) nonpoint source grant from the U.S. Environmental Protection Agency and the Texas State Soil and Water Conservation Board, as well as hundreds of hours of volunteered time from local participants, BRA and Parsons were able to facilitate a comprehensive stakeholder participation process resulting in this community-based WPP. This WPP was drafted with the intention of providing stakeholders within the watershed as well as regional, state, and federal agencies a flexible management plan to achieve water quality restoration goals.

Executive Summary

The Leon River Watershed Protection Plan (WPP) identifies implementation strategies supported by stakeholders that will reduce bacteria levels in creeks and rivers in the Leon River watershed over time with minimal consequence to the livelihoods of the citizens in the watershed. This WPP is guided by the common objective expressed by the Leon River watershed stakeholders – *"to restore and maintain water quality so that citizens in the watershed may enjoy the water resources with little risk to their health."*

The Leon River watershed, located in the Brazos River Basin, is bound by Proctor Lake upstream and Belton Lake downstream. The Leon River (Segment 1221) is 190 miles long and the watershed is approximately 1,375 square miles covering portions of Comanche, Erath, Hamilton, and Coryell Counties before it reaches Belton Lake (Segment 1220). A small portion of the watershed lies within Mills County. For generations, farming and ranching have been a way of life throughout the watershed. Farmers and ranchers rely on the land and must have access to water resources as part of their business. Residents who own land in Comanche, Hamilton, and Coryell Counties have an enjoyable lifestyle in their rural surroundings where they experience a clean environment, tranquility, open country, farming, and wildlife — a country way of life for their family. The Leon River watershed, located within the North Central Texas climatic division, is classified as subtropical subhumid resulting in persistent hot weather from late May through September. The cool season, beginning about the first of November and extending through March, is typically the driest season of the year as well. Summer drought conditions are common in the area due to strong high-pressure cells.

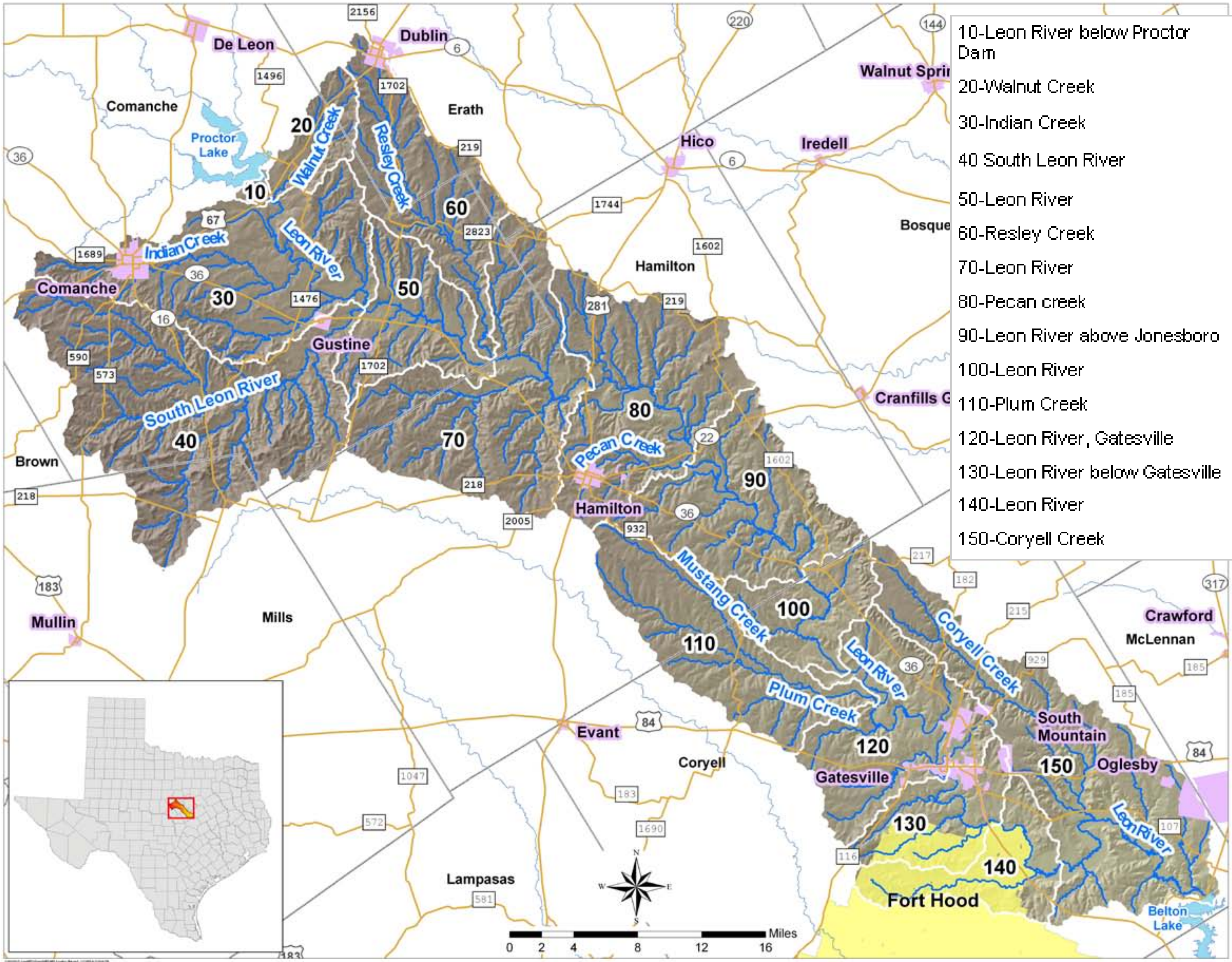
County	County in Watershed	Watershed in County
Comanche	48%	33%
Erath	5%	4%
Mills	4%	2%
Hamilton	45%	28%
Coryell	42%	33%

Comanche, Hamilton, and Coryell Counties account for over 94 percent of the Leon River watershed.

County	Population	Population Density	County Area
Comanche	14,026	15 people per square mile	948 square miles (606,720 acres)
Hamilton	8,092	9.8 people per square mile	837 square miles (535,680 acres)
Coryell	74,978	71.3 people per square mile	1,052 square miles (673,280 acres)

Source U.S. Census Bureau, 2000

Leon River Watershed



Project Background

The Leon River below Proctor Lake was initially placed on the State of Texas Clean Water Act (CWA) §303(d) List of impaired waters in 1996 for having bacteria levels that "sometimes exceed water quality standards" (TCEQ 1996). The U.S. Environmental Protection Agency (USEPA) and the States have established designated uses and water quality criteria for bacteria for the protection of swimmers from gastrointestinal illness in recreational waters (USEPA 2002). Most strains of *Escherichia coli* (*E. coli*) are harmless and live in the intestines of healthy humans and animals (USEPA 2009a). Indicator organisms such as *E. coli* are used to assess surface waters contaminated by fecal pollution (USEPA 2002). The use of indicators provides regulators and water quality managers with a means to ascertain the likelihood that human pathogens may be present in recreational waters (USEPA 2002a).

Placement of the Leon River on the §303(d) List caused the TCEQ to initiate the development of a total maximum daily load (TMDL). In the simplest terms, a TMDL is a daily pollution budget that establishes the amount of a particular pollutant that a waterbody can receive and still meet state water quality standards. TCEQ initiated the TMDL process for the Leon River upstream of Highway 281 in January 2002. Based on additional data collection efforts, data analysis and modeling, and a series of stakeholder meetings, a draft TMDL report prepared by TCEQ (April 2008) proposed that a 21 percent reduction in bacteria loadings in the upper watershed of the Leon River could restore water quality to meet Texas surface water quality standards (SWQS). In August 2008, the TCEQ delayed the final adoption of the Leon River TMDL in response to the potential for proposed revisions to the SWQS for contact recreation. In July 2010, TCEQ adopted the proposed revisions. These changes are discussed at length in chapter 3.3 of the WPP.

Elements of a Watershed Protection Plan

This WPP will advance the long-term health of the watershed by promoting strategies identified by stakeholders that address both elevated levels of *E. coli* and nutrient concerns. The participating stakeholders may accomplish the activities described in this WPP through formal or informal action, guidance, financing, and education. This WPP will incorporate the nine key elements for watershed-based plans as described in the 2004 *Nonpoint Source Program and Grants Guidelines for States and Territories* (USEPA 2003a). The nine elements are:

a. Identification of the causes of impairment and pollutant sources that will need to be controlled to achieve the load reductions described in (b).

b. Estimate of the load reductions expected for the management measures described in (c).

c. Description of management strategies that will need to be implemented to achieve the load reductions described in (b).

d. Estimate of technical and financial assistance needed, associated costs, and the sources and authorities that will be relied upon to implement this plan.

e. Information/education component that will be used to enhance public understanding of this plan.

f. Schedule for implementing management measures described in (c).

g. Description of interim, measurable milestones for determining whether management measures described in (c) are being implemented.

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

i. Monitoring component to evaluate effectiveness of implementation measured against the established criteria described in (h).

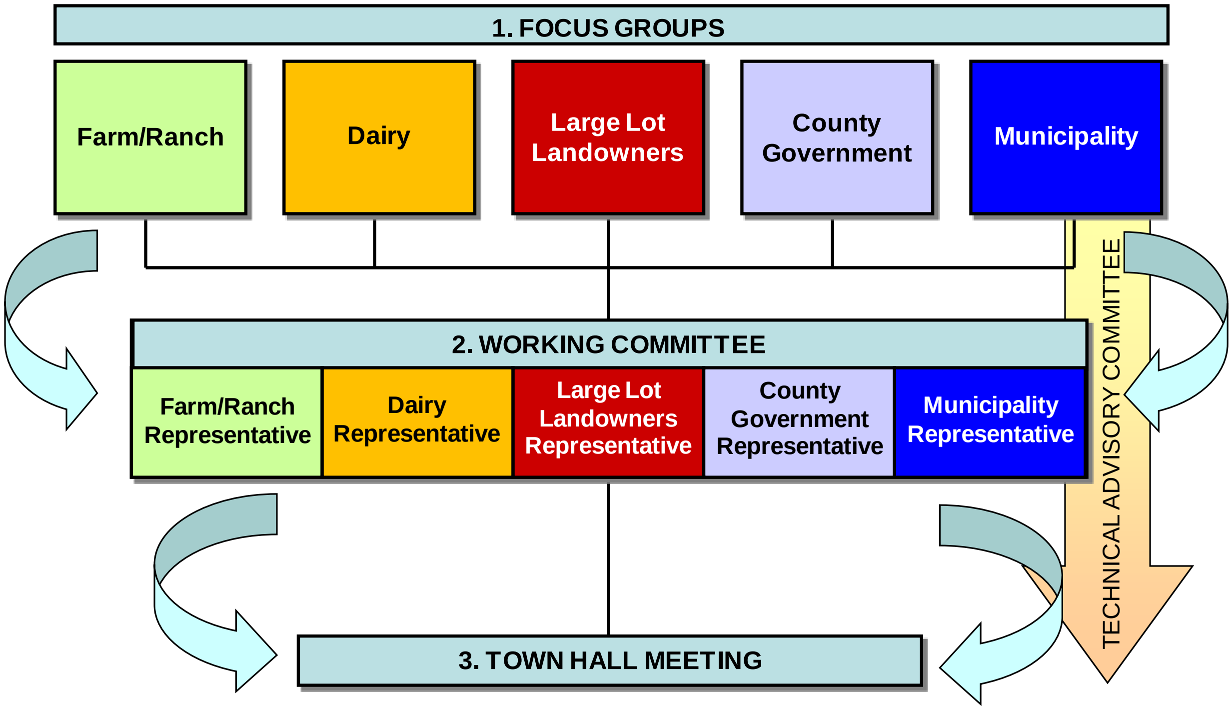
Leon River Stakeholder Group

The principal factor in achieving water quality improvement is to have strategies that are locally developed, supported, and implemented, which can only occur if those affected perceive benefits upon implementation. This WPP is the direct outcome of a public participation process that was used to ensure meaningful contribution by stakeholders in identifying sources of bacteria, suggesting pollution reduction strategies, and discussing the challenges of implementation associated with both bacteria and nutrients. Stakeholders met to discuss which strategies should be implemented relying on technical, economic, and regulatory information as a basis for decision-making.

Throughout the public participation process two objectives were consistently expressed by the stakeholders to: (1) generate management strategies that improve water quality in the Leon River watershed, and (2) select those with minimal adverse effects to the daily lives of the citizens in the watershed. The public participation process for the Leon River WPP was designed in a manner that best responded to the characteristics, concerns, and availability of the concerned citizens and officials of small towns and rural counties. Three levels of public participation were established: 1) focus groups, 2) a working committee, and 3) a town hall meeting. A technical advisory committee was also created to support the WPP process.

The focus groups were designed to listen to stakeholder interests in an interactive setting that allowed free dialogue among the participants and to decrease the tension that can be associated with large meetings. Focus groups were limited in size, which allowed more time for individuals to be heard. Focus groups represented dairy operators, farmers and ranchers, municipalities, county governments, and large lot rural landowners.

The working committee was comprised of at least one representative from each focus group. Meetings were held with the working committee members to explain and evaluate the cumulative effect of the implementation strategies recommended by the focus groups. A sensitivity analysis of different combinations of implementation strategies was also presented to better demonstrate the range of pollutant reduction possible based on incremental levels of strategy implementation. These meetings were effective at showing working committee members how the different combinations of various strategies would change bacteria concentrations in each subwatershed.

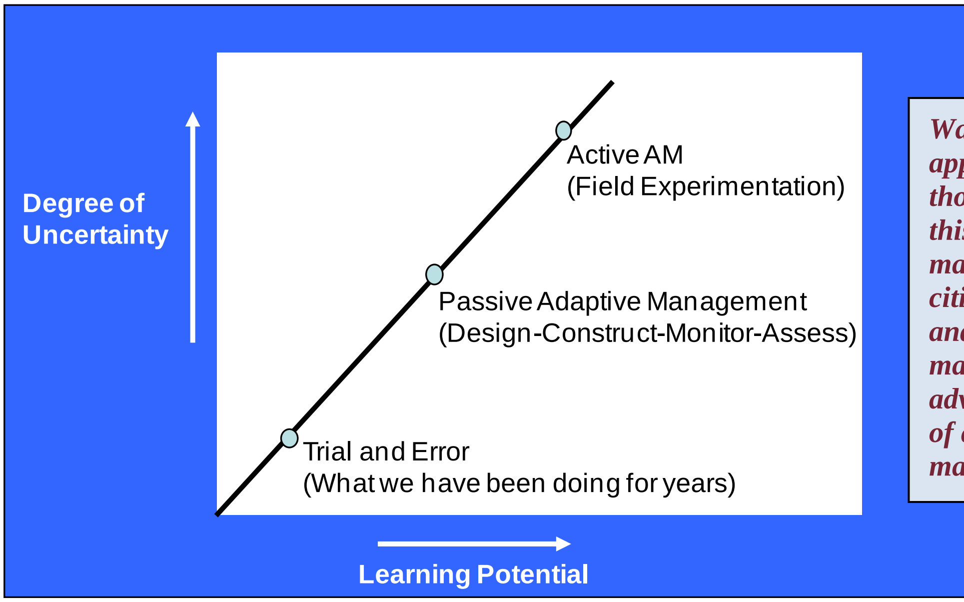


The goal of the town hall meeting was to encourage feedback and participation among all stakeholders. Participation at the town hall meeting was open to the broadest, most diversified audience possible from individuals who live and work in Comanche, Hamilton, Erath, and Coryell Counties. The town hall meeting, held December 2008, provided an initial feedback loop to the larger group of stakeholders to inform them of the strategies suggested by focus group members. It allowed additional stakeholders the chance to comment, voice concerns, and express other interests.

A technical advisory committee was composed of individuals from state, regional, and federal agencies. The project team sought feedback from the technical advisory committee on historical and current water quality monitoring and technical, financial, and regulatory aspects associated with the recommendations of the working committee and focus groups.

Adaptive Management and Sustainability

Stakeholders acknowledge that this WPP is their opportunity to set locally appropriate goals, coordinate actions, and support adaptive management and sustainability principles to address bacteria and nutrient problems in the watershed. The following diagram offers a definition of the concept of adaptive management.



Adaptive management - A natural resource management approach in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices (USEPA 2000).

Watershed-based approaches such as those summarized in this WPP are one of many tools available to citizens, governments, and water resource managers that can advance the principles of adaptive management.

Water Quality in the Leon River Watershed

The rationale for the establishment of this WPP is the acknowledgement by Leon River watershed stakeholders that surface water quality in portions of the Leon River and some of its tributaries can be improved. This rationale is driven by the nexus between SWQS, the characterization of existing water quality conditions and the desired water quality goals supported by the stakeholders.

Existing SWQS TCEQ is responsible for establishing the goals for surface water bodies which are defined in the *Texas Surface Water Quality Standards* (30 TAC §307). SWQS consist of designated uses and numeric and narrative criteria used to determine if these uses are met. TCEQ is also responsible for evaluating the status of water quality throughout the State where sufficient data are available. Water quality in the Leon River watershed has been monitored and assessed since 1974 to satisfy requirements of the CWA. TCEQ prepares a statewide summary of waterbodies that are supporting or not supporting their designated uses and for which there are water quality concerns. The most recent USEPA-approved water quality assessment of the Leon River and its tributaries is derived from the 2008 Texas Water Quality Inventory and 303(d) List. The designated uses assigned to the Leon River are contact recreation, public water supply, and high aquatic life (TCEQ 2000a). Indian Creek and Pecan Creek are assigned an intermediate aquatic life use (TCEQ 2000a). The focus of this WPP is on the contact recreation use and the existing numeric criterion used to assess support of this designated use is 126 colony forming units (cfu) per 100 milliliters (mL). Screening levels are also set by the TCEQ to protect waterbodies from excessive nutrient levels to support the general uses outlined in the SWQS (TCEQ 2000b). The screening levels listed for nutrients and chlorophyll *a*, statistically derived from the most recent ten years of surface water quality monitoring (SWQM) data statewide, include:

TCEQ Screening Levels for Freshwater Streams (85th percentile value)		
Orthophosphorus	**Chlorophyll-*a***	**Nitrate Nitrogen**
0.37 mg/L	14.1 µg/L	1.95 mg/L

<u>Revised Water Quality Standards</u> The Texas statewide water quality management program continues to be modified and improved and 2010 presents an important stage in this evolution. In July 2010, TCEQ adopted revisions to the SWQS in association with its Triennial Standards Revision process. This is of critical importance to the future implementation of the Leon River WPP because statewide changes have been adopted for the designated use and associated numeric criterion for contact recreation. While the numeric and narrative criteria establish the current legal basis for evaluating water quality of the Leon River and its tributaries, it is pragmatic to acknowledge and consider the future implications of changes to the regulatory basis for assessing contact recreation. The following table presents a comparison of the current and revised SWQS associated with recreational use.

Existing Use Category	Existing Geometric Mean *E. coli* Criterion for Freshwater Streams (cfu/100mL)
Contact Recreation	126
Noncontact Recreation	605
Revised Use Categories	**Revised Geometric Mean *E. coli* Criteria for Freshwater (cfu/100mL)**
Primary Contact	126
Secondary Contact 1*	630
Secondary Contact 2*	1030
Noncontact Recreation*	2060

** Revised use categories and geometric mean concentration are pending approval from USEPA*
Source: TCEQ 2010a.

Leon River Water Quality Impairments and Concerns

The water quality problems that served as a catalyst for preparation of this WPP are summarized in the following table. The table summarizes designated use impairments and water quality concerns within the Leon River watershed using water quality data collected by TCEQ, BRA, and the U.S. Geological Survey (USGS) for the 2008 Texas Water Quality Inventory. In preparing the Texas Water Quality Inventory, TCEQ assigns one of five categories to each surface waterbody. The categories indicate the status of water quality in the segment based on assessment results from applying the *2008 Guidance for Assessing and Reporting Surface Water Quality in Texas* (March 19, 2008). Waterbodies that do not support their designated use are placed in category 5.

Water Quality Impairments and Concerns within the Leon River Watershed from 2008 Texas Water Quality Inventory and 303(d) List

Segment or Assessment Units	Subwatershed(s)	Area	Category	First Listed
Impairments - Texas 303(d) List				
1221		**Leon River Below Proctor Lake**		
1221_01	130, 140	*Directly upstream of Lake Belton – Bacteria*	5a	1996
1221_04	90, 100, 120	*From confluence with Plum Creek, upstream to confluence with Pecan Creek – Bacteria*	5a	2008
1221_05	50, 70, 80	*From confluence with Pecan Creek, upstream to confluence with South Leon River – Bacteria*	5a	1996
1221_06	30	*From confluence with South Leon Creek upstream to confluence with Walnut Creek – Bacteria*	5a	1996
1221_07	10	*From the confluence with Walnut Creek upstream to Lake Proctor – Bacteria*	5a	1996
1221A		**Resley Creek (unclassified waterbody)**		
1221A_01	60	*Downstream portion, from confluence with Leon River upstream to confluence with unnamed tributary, approx. 1.0 mile N. of Comanche County Line – Bacteria and Dissolved Oxygen*	5c	2004, 2006
1221A_02	60	*From confluence with unnamed tributary, upstream to end of waterbody, approx. 1.0 mile north west of Dublin – Bacteria*	5c	2004
1221B_01	40	**South Leon River (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
1221C_01	80	**Pecan Creek (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
1221D		**Indian Creek (unclassified waterbody)**		
1221D_01	30	*From confluence with Leon River, upstream to confluence with Armstrong Creek – Bacteria*	5c	2006
1221D_02	30	*From confluence with Armstrong Creek upstream to headwaters of waterbody – Bacteria*	5c	2006
1221F_01	20	**Walnut Creek (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
Concerns - Texas Water Quality Inventory				
1221		**Leon River Below Proctor Lake**		
1221_01	140	*Directly upstream of Lake Belton*	DO Chl-*a*	CS CS
1221_05	50, 70, 80	*From confluence with Pecan Creek, upstream to confluence with South Leon Creek*	DO Chl-*a*	CS CS
1221_06	30	*From confluence with South Leon Creek upstream to confluence with Walnut Creek*	Chl-*a*	CS
1221_07	10	*From the confluence with Walnut Creek upstream to Lake Proctor*	DO Chl-*a*	CS CS
1221A		**Resley Creek (unclassified waterbody)**		
1221A_01	60	*Downstream portion, from confluence with Leon River upstream to confluence with unnamed tributary, approx. 1.0 mile N. of Comanche County Line – Bacteria and Dissolved Oxygen*	Chl-a	CS
1221A_02	60	*From confluence with unnamed tributary, upstream to end of waterbody, approx. 1.0 mile north west of Dublin*	OP NO3	CS CS

Segment or Assessment Units	Subwater-shed(s)	Area	Category	First Listed
1221B	40	**South Leon River (unclassified waterbody)**		
		Entire waterbody	DO	CS
1221D		**Indian Creek (unclassified waterbody)**		
1221D_01	30	*From confluence with Leon River, upstream to confluence with Armstrong Creek*	DO	CN
1221D_02	30	*From confluence with Armstrong Creek upstream to headwaters of waterbody*	OP NO3	CS CS

The Local Perspective – Characterizing Water Quality Problems

Water quality in the region does not support the SWQS for *E. coli*, indicating there are potential health risks with contact recreation. However, stakeholders within the Leon River watershed consider the public health risk of elevated *E. coli* levels to be negligible since over the past 30 years there is no medical evidence substantiating illnesses associated with exposure to surface water. No public access to the majority of the stream miles in the watershed further substantiates that the potential for future human health problems is negligible.

A concern expressed by the Leon River watershed stakeholders is that requiring additional management practices may impose unfair costs or hinder the ability to use their land. Some landowners may be reluctant to change certain practices that might alter historical cultural activities. It is difficult for landowners to justify significant expenditures given the level of uncertainty in the science surrounding bacteria life stages in the environment and the historical basis for the current numeric criterion for contact recreation. This is especially difficult to justify when there is no medical evidence that links illness to contact recreation with waters in the region. Bacterial source tracking (BST) conducted at three SWQM stations on the Leon River in 2004-05 shows that between 41 and 55 percent of bacteria sources originate from wildlife or invasive species (e.g., avian species, wild mammals, and feral hogs), which also makes addressing bacteria pollutants a challenge.

Establishing Water Quality Goals for the Leon River

Given the complexity of this challenge of determining what level of contact recreation use is appropriate for the Leon River, stakeholders made a formal request for TCEQ to conduct a Recreational Use Attainability Analysis (RUAA). As a result of this request, TCEQ funded a RUAA project, which was initiated in July 2009. Concurrently, TCEQ proposed statewide revisions to the designated use and associated numeric criterion for contact recreation. The establishment of a secondary use criteria will have implications for regulators in terms of compliance and for stakeholders in terms of the level of implementation required.

All stakeholders agree that some level of implementation that is cost-effective, reasonable, and does not adversely affect landowners, would benefit the Leon River watershed. All stakeholders believe that a good faith effort from all with a reasonable infusion of funding can result in a delisting of the impaired waterbodies sometime in the future. An adaptive management approach was selected as a path forward because of the uncertainty in water quality standards revisions, availability of science, need for financial support, and other factors.

Goal to Address Contact Recreation Impairment in the Leon River Watershed

The WPP will reduce bacteria levels, where the goal is to achieve an instream concentration of *E. coli* resulting in a long-term geometric mean of 206 cfu/100mL at an appropriate downstream SWQM station recommended for each subwatershed. Maintaining this instream concentration will involve various levels of implementation requiring reductions in bacteria loadings that range from 15 to 26 percent depending on the subwatershed. The ultimate goal of the WPP is to achieve state water quality standards in the Leon River extending beyond the 10 year implementation timeframe of the WPP.

Goal to Address Nutrient Concerns in the Leon River Watershed

Implementation of management strategies to achieve pollutant reduction goals for *E. coli* will have a direct corollary benefit on decreasing nutrient loads and subsequent chlorophyll-*a* and DO impacts.

Sources and Causes of Pollution in the Leon River Watershed

Characterizing the sources and causes of bacteria and nutrient loading in each subwatershed is a critical step in determining appropriate and effective methods and locations of management strategies aimed at restoring water quality in the Leon River watershed. The information used for this WPP was based on published work, available data, including geographic information system shape files and livestock census, observations, and stakeholder input. The draft TMDL report released by TCEQ in 2008 provided an assessment of the sources and causes of high bacteria levels upstream of Hwy 281 (TCEQ 2008b). Watershed reconnaissance surveys were conducted between September 29 and October 2, 2008, in four different geographic areas to further identify pollutant sources and causes as part of the development of this WPP. Stakeholders provided their perspectives on the sources and causes of pollution at various meetings during development of this WPP.

Land Use/Land Cover

Land use and land cover have a direct effect on surface erosion, rainfall runoff, and evapotranspiration at the subwatershed scale, and both influence pollutant loads and concentrations (Natural Resources Conservation Service [NRCS] 2008). Seventy-four percent of the watershed is classified as rangeland which includes pastureland, and 18 percent is classified as forestland.

Pollutant Source Categories

Various pollutant sources identified during the TCEQ TMDL process were confirmed through reconnaissance surveys and focus group meetings. These pollutant sources were organized into the categories presented in the table below to represent different possible pollutant contributions throughout the Leon River watershed. These categories aligned well with the pollutant load model and provided an effective organizing matrix for management strategies aligned with each of the five focus groups. Pollutant sources are placed into two major categories that facilitate grouping of recommended management strategies: direct discharges and polluted storm water wash off. Direct discharges include bacteria and nutrient pollutants that spill, enter, or fall directly into a waterbody with no opportunity for treatment. Under this condition the sources become an immediate pollutant load in the waterbody. Bacteria and nutrients also accumulate on land where, through natural processes, the pollutants can be absorbed or decay over time. The land-based accumulation of bacteria and nutrients is not considered a water pollutant until a rain event transports the pollutants overland to a waterbody which at that point is deemed a wash off source.

Pollutant Source Categories in the Leon River Watershed

Source Category	Cause	Identified By
Direct Discharges of Pollutants to Waterbody		
Wastewater Treatment Facilities (WWTF)[1]	Flow exceedances during rain events resulting in untreated discharges to receiving streams	Municipalities
Wastewater Collection System[1]	Sanitary sewer overflows caused by blockages in collections pipes and collection system failures resulting in untreated wastewater being released into drainage ways and receiving streams; illicit discharges in urban watersheds	Municipalities
Onsite Sewage Facility (OSSF)	Failing household, business, or hunting cabin systems or lack of maintenance resulting in wastewater reaching receiving streams via leaching or overland flow	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies
Direct Deposition	Wildlife roaming in creeks and roosting directly over creeks and streams depositing waste directly into streams	Counties, Municipalities, Landowners, Farmers/Ranchers
	Invasive species roaming in creeks depositing waste directly into streams	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies
	Livestock roaming in creeks depositing waste directly into streams	Landowners, Farmers/Ranchers

Source Category	Cause	Identified By
	Dead animals dumped in creeks release fecal material during decomposition	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies
Polluted Storm Water Wash Off		
Forestland	Wildlife roaming throughout forestland deposit waste on land	Counties, Municipalities, Landowners, Farmers/Ranchers
	Invasive species roaming throughout forestland deposit waste on land	Counties, Municipalities, Landowners, Farmers/Ranchers
Cropland	Application of manure or commercial fertilizers to improve crop yields may result in excessive build up of bacteria or nutrients	Farmers/Ranchers
Rangeland	Build up of bacteria or nutrient loads from deposition of waste from wildlife, invasive species and livestock on rangeland areas	Farmers/Ranchers, Landowners
Waste Application Field (WAF)[1]	Livestock manure applied to land	Dairies, Farmers/Ranchers
Residential/Commercial/ Industrial	Build up of bacteria loads from wildlife, domestic pets, livestock, even humans from residential, commercial, and industrial activities in urban/rural, forestland or rangeland areas transported by rainfall events (storm water) to receiving streams	Municipalities, Counties, Landowners

[1] = Permitted facilities

Nine bacteria pollutant categories were evaluated in each subwatershed to understand the makeup of bacteria sources for better prioritizing implementation strategies. Quantification of pollutant loads was derived from the existing watershed loading model, Hydrologic Simulation Program-Fortran (HSPF), established to support development of the draft TCEQ bacteria TMDL. Additional information used to modify the approach to estimating pollutant loads by subwatershed included potential causes provided by stakeholders, various database sources, and information available in the literature. The loading model used in the TMDL was used as the base case.

To determine the contribution of bacteria loads in each subwatershed, direct discharge rates and fecal waste accumulation factors were reduced to zero and land use factors were maximized to mitigate washoff in each subwatershed. The difference in bacteria concentration between the base geometric mean in the loading model and the zero pollutant case is presumed to be the contribution to the overall bacteria concentration for that source. The following table provides the estimated load contribution from each pollutant source category for each subwatershed. The sum of each subwatershed column provides the total potential load that could be reduced through the implementation of management measures.

Load Contribution of Pollutant Source (10^6 org/day)

Pollutant Source	Subwatershed														
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**
Direct Discharges of Pollutants to Waterbody															
WWTF	-	-	4	-	9	37	-	9	-	-	-	40	22	-	-
Wastewater Collection System	-	-	1,154	-	101	463	-	1,698	-	-	-	5,920	2,299	-	-
OSSF	12	1	305	137	9	73	52	286	25	61	57	107	423	44	109
Direct Deposition	21,672	5,101	45,552	25,131	32,463	12,282	33,089	47,570	14,544	25,742	12,637	80,495	68,250	21,887	21,012
Polluted Storm Water Wash Off															
Forest	13	6	85	56	64	17	123	122	84	76	92	236	150	256	356
Cropland	71	33	619	157	342	65	247	146	109	128	134	186	33	28	464
Rangeland	398	317	4,098	3,958	4,239	901	7,821	4,613	2,697	1,916	3,056	6,198	2,493	2,340	5,873
Waste Application Field	-	193	586	64	606	333	299	196	-	-	-	-	-	-	184
Residential/Commercial/Industrial	4,992	1,072	21,465	3,906	5,513	4,756	9,090	25,658	5,450	4,877	371	39,303	31,245	7,906	13,061
Total Source Loads	**27,157**	**6,723**	**73,868**	**33,410**	**43,348**	**18,925**	**50,720**	**80,299**	**22,909**	**32,800**	**16,346**	**132,485**	**104,914**	**32,461**	**41,059**

Results of the model simulation indicate the major source of bacteria in the watershed is from direct discharges. Direct deposition is the major source with at least 51 percent of the total contribution in all subwatersheds. Direct deposition is primarily from warm-blooded animals, such as wildlife and livestock, roaming near or in creeks where they deposit fecal matter directly in the water. The major finding of the sensitivity analysis conducted indicates that a significant reduction in direct deposition will be needed to reduce bacteria levels that would attain the current *E. coli* standard of 126 cfu/100mL. For example, 100 percent reduction of all other sources combined in subwatershed 60 is only capable of reducing the bacteria concentration to 181 cfu/100mL, which is not sufficient to attain current standard. A reduction level of 100 percent of direct deposition alone is capable of reducing bacteria concentration to attain water quality standards with no other strategies implemented. Stakeholders sought to obtain a better understanding of which management strategies and which sources should be targeted to achieve bacteria reductions that would result in achieving water quality goals. The sensitivity analysis indicates direct deposition is the major bacteria source contribution, but the model cannot distinguish which specific type of direct deposition (domestic or wildlife) is the major contributor in each subwatershed. Although there are three kinds of direct deposition associated with warm-blooded animals - wildlife, feral hogs, and livestock – deciding which of these three contributes the most bacteria loading has major implications. Reducing the level of direct deposition will be a challenge. Despite this challenge, it is necessary to move forward with implementation in the short-term knowing there is uncertainty.

Management Strategies

Stakeholders of the Leon River watershed recognize the need to implement management strategies over time to reduce bacteria loads to attain water quality standards. Focus groups were able to contribute their knowledge of strategies that mitigate bacteria loads which are currently in place or under construction. Management strategies address both point and nonpoint sources that contribute to bacteria loads in creeks and rivers. The success of long-term implementation of this WPP is dependent on the ability to implement the proposed strategies and verify that water quality has improved. The focus of implementation will be placed on subwatersheds 20, 30, 40, and 60, as they have the highest levels of bacteria concentrations. Although many suggestions were made, a group of viable strategies were selected for evaluation based on their ability to be implemented and their cost. Certain management strategies address multiple sources of bacteria. Stakeholders provided inputs on strategy mitigation effectiveness, difficulty, likelihood of success, timelines, and costs. Nutrients are a concern in this watershed and it is expected that sources of nutrients in the watershed are likely to decrease as a result of implementing bacteria reduction strategies. Recommended management strategies are identified in the following table.

Pollutant Source	Management Strategy (Percent of Pollutant Source)	Objective	RG
Direct Discharges of Pollutants to Waterbody			
WWTF	WWTF improvements Operational changes (100%)	Municipalities will enhance their treatment facilities to reduce the potential for releasing raw sewage	95%
Wastewater Collection System	Grease trap ordinance (40%)	Municipalities will develop and enforce an ordinance to reduce the buildup of grease that could block collection systems	80%
	Replace sewers (40%)	Municipalities will repair failing parts of the collection system	95%
	SSO plan (20%)	Municipalities will address issues that cause sanitary sewer overflows	95%
OSSF	Address failing OSSFs (100%)	Municipalities and counties can repair, replace, and remove failed OSSFs within city and rural areas	90%
Direct Deposition[1]	Feral hog management (23%-29%)	Local, county, and state efforts to reduce the number of feral hogs in the area	30%
	Deer population management (1%-3%)	Local, county, and state efforts to reduce the number of deer in the area	5%
	Alternative watering sources (29%-36%)	Ranchers can develop alternative watering sources for livestock away from creeks	35%
	Dead animal disposal facility (37%-42%)	County and city may provide places were dead animals can be disposed	15%
Polluted Storm Water Wash Off			
Forestland[1]	Deer population management (11%)	Landowners can work with the state to control the deer population	8%
	Feral hog management (78%)	Local, county, and state efforts to reduce the number of feral hogs in the area	35%
Cropland	Since only four percent of the watershed is classified as cropland this land use is not considered a significant source of bacteria loading therefore no management strategies are recommended.	Not applicable.	—
Rangeland[2]	Water quality management plans (WQMP) (86%-78%)	Ranchers can implement an appropriate suite of BMPs that will improve ranch operations and also improve water quality	35%

Pollutant Source	Management Strategy (Percent of Pollutant Source)	Objective	RG
	Alternative watering sources (14%-22%)	Ranchers can develop alternative watering sources for livestock away from creeks	35%
Waste Application Field (WAF)	Manure management (100%)	CAFOs can improve operations through DOPA training, new technologies, operation and maintenance, and other practices	25%
Residential, Commercial, and Industrial[1]	Strategies for residential, commercial, and industrial developments: Address failing OSSFs, SSO Plan, and BMPs (16%-20%)	Municipalities and counties can reduce the number of failed OSSFs in the areas and introduce BMPs as needed to reduce the accumulation of sewage and runoff from developed areas	90%

RG = Reduction Goal. A reduction goal is defined as the level of reduction in pollutant loading expected to be achieve once a management strategy is fully implemented. Stakeholders will strive to reach each reduction goal, but there is uncertainty associated with the ultimate level of achievement given environmental, temporal and financial constraints that may exist.
[1] Other sources make up the remainder of the pollutant source (e.g., wildlife)
[2] Rangeland includes all pastureland.

Strategies to address direct discharges are focused on WWTFs, wastewater collection systems, OSSFs, and direct deposition from animals. Management strategies are needed to address a wide array of direct deposition sources throughout the Leon River watershed. The direct deposition sources include deer population management, feral hogs, livestock (cattle, goats, sheep, and horses), and the disposal of dead animals in creeks. Animals with access to riparian corridors contribute the majority of the loading attributed to direct deposition.

Stakeholders agree it is appropriate to address land-based bacteria pollutant sources related to activities in forestland, rangeland, WAFs operated by CAFOs and urban/rural residential, commercial and industrial land uses. Unlike direct deposition, these land-based sources are a result of fecal matter that accumulates on the land and then under storm water runoff events is transported to receiving waters. The origin of the bacteria is from the build-up of waste deposited by wildlife, pets, feral hogs, livestock, manure application, and OSSFs. The estimated load reduction of each management strategy is presented in the following table.

Management Strategy Source Load Reduction

Management Strategy	Subwatershed (10^6 org/day)															Achieved Reduction
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
Direct Discharges of Pollutants to Waterbody																
WWTF improvements	-	-	3	<1	-	45	-	9	-	-	-	37	21	-	-	**116**
WW collection system																
Grease trap ordinance	-	-	364	1	-	193	-	539	-	-	-	1,873	727	-	-	**3,697**
Replace sewers	-	-	432	1	-	229	-	640	-	-	-	2,224	864	-	-	**4,391**
SSO Plan	-	-	216	<1	-	115	-	320	-	-	-	1,112	432	-	-	**2,195**
Address failing OSSFs	17	1	266	124	6	71	45	245	18	52	43	392	372	37	83	**1,772**
Direct deposition																
Feral hog control	2,603	419	3,545	2,034	2,304	927	2,368	3,243	1,064	1,752	782	5,293	4,787	1,663	1,559	**34,344**
Deer population management	376	61	512	294	333	134	342	469	154	253	113	765	692	240	225	**4,961**
Alternative watering sources	2,966	479	4,007	2,298	3,694	1,494	3,767	5,176	1,704	2,813	1,251	8,481	7,684	2,662	2,491	**50,967**
Dead animal disposal	44	7	60	34	44	18	45	62	20	34	15	101	92	32	30	**638**
Polluted Storm Water Wash Off																
Forestland																
Deer population management	<1	<1	1	1	1	<1	1	1	1	1	1	2	1	2	3	**16**
Feral hog management	5	2	22	17	21	6	33	34	26	20	22	61	45	73	94	**481**
Rangeland																
WQMPs	32	18	197	198	192	56	333	232	134	97	124	290	133	127	293	**2,458**
Alternative watering sources	8	6	58	63	61	17	106	68	38	27	37	78	32	24	69	**692**
WAF manure management	-	31	82	10	87	62	46	28	-	-	-	-	-	-	26	**371**
Strategies for R/C/I developments	798	124	4,366	882	728	1,465	1,207	6,013	722	642	46	9,338	7,551	1,051	1,779	**36,712**
Source load reduction achieved	**6,850**	**1,147**	**14,130**	**5,957**	**7,471**	**4,833**	**8,293**	**17,079**	**3,882**	**5,689**	**2,434**	**30,048**	**23,434**	**5,912**	**6,653**	**143,811**

R/C/I = Residential, commercial, industrial land use

Load reductions were estimated for each management strategy by simulating with the HSPF model the effect of only having that strategy in place with no other loads reduced.

Estimate of Pollutant Load Reductions

The fundamental question during development of this WPP was how much pollutant reduction is necessary in each subwatershed to meet SWQS. Through the sensitivity analysis performed, it was possible to allow stakeholders to make informed decisions, and give some insight as to how implementation of all the strategies would affect water quality in relation to the numeric criteria for *E. coli*. The following table presents a final summary of the expected pollutant load reduction results based on the level of implementation of strategies and how compliance is met.

SW	Base Source Load[1]	Collective Reduction	Reduced Daily Load[2]		MDL at 206 cfu/100mL			*E. coli* Geomean	
					Limit	Capacity	Excess	Existing[3]	Reduced
	10^6org/d	10^6org/d	10^6org/d	%	10^6org/d			cfu/100mL	
10	27,157	6,850	20,307	25%	65,663	45,356	-	85	64
20	6,723	1,147	5,576	17%	4,677	-	900	301	248
30	85,775	18,873	66,902	22%	135,722	68,821	-	130	102
40	33,410	5,957	27,453	18%	32,411	4,958	-	229	188
50	105,642	21,279	84,363	20%	196,758	112,395	-	111	88
60	18,925	4,833	14,091	26%	15,081	990	-	253	191
70	140,855	27,523	113,332	20%	274,987	161,655	-	106	85
80	148,434	31,496	116,938	21%	328,597	211,658	-	93	73
90	103,410	20,964	82,447	20%	350,791	268,344	-	61	48
100	108,282	21,388	86,895	20%	361,806	274,912	-	62	49
110	16,346	2,434	13,912	15%	34,598	20,686	-	97	83
120	209,022	42,650	166,371	20%	461,432	295,061	-	93	74
130	257,450	53,907	203,544	21%	484,055	280,511	-	110	87
140	239,463	49,165	190,299	21%	496,694	306,395	-	99	79
150	199,266	39,152	160,114	20%	545,528	385,414	-	75	60
Totals	717,315	143,811							

1 = Derived from HSPF base case model run for 2001 to 2004

2 = The resulting source load input once strategies are implemented

3 = Geometric mean *E. coli* concentration for the base case model run for 2001 to 2004

MDL = Maximum daily load

sw = subwatershed

not compliant at *E. coli* water quality goal of 206 org/100mL

not compliant at current *E. coli* water quality standard of 126 org/100mL

The base source load originating from all 15 subwatersheds from all pollutant sources is 717,315 x 10^6 orgs/day. An average of 39 percent of this source load originates from wild birds and other wild mammals which are considered uncontrollable sources. The cumulative reduction achieved is the amount of load removed from the subwatershed from strategies suggested by the stakeholders; once fully implemented, this totals 143,811 x 10^6 orgs/day. This is a total source load reduction of approximately 20 percent, ranging between 16 and 26 percent. The reduced daily load is base source load less the reduction achieved from implementation, which is what enters waterbodies and accumulates downstream. The cumulative effect was addressed using the HSPF model because it takes into account all the natural processes that make a simple mass balance inappropriate for determining compliance.

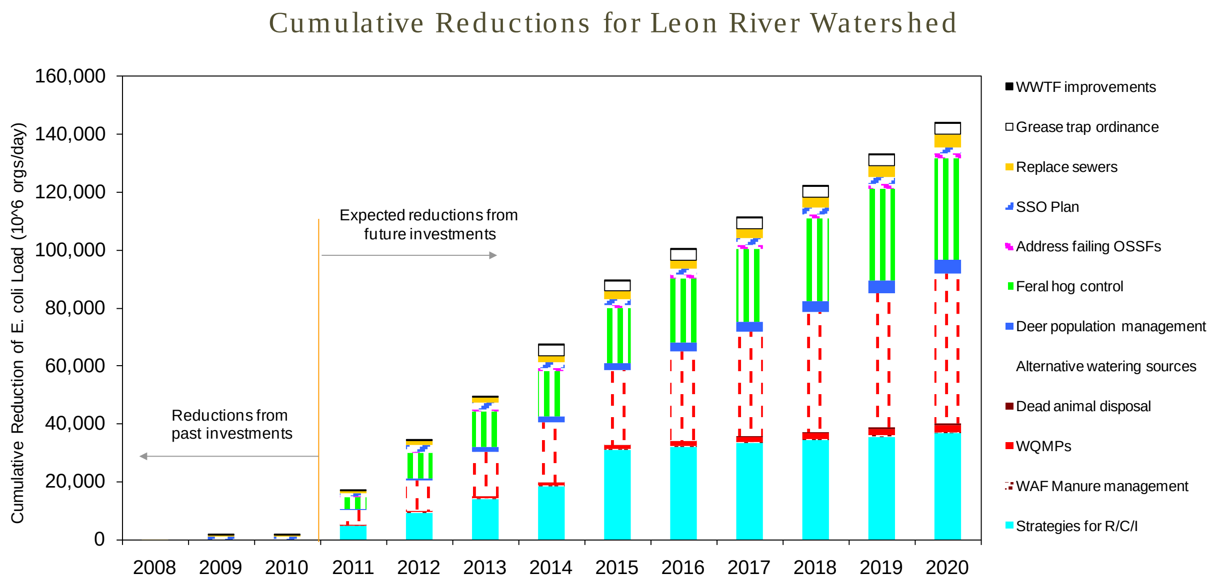
The base daily load is the load based on the measured *E. coli* concentration and the flow in a given subwatershed. The available capacity of subwatershed 150 represents the effect of all the strategies in place in the entire Leon River watershed. Compliance can be determined by comparing the reduced daily load to the maximum daily load limit under a given standard. The maximum daily load is calculated assuming the base flow has the water quality goal as an average concentration. The daily load based on the simulation for the period between 2001 and 2004 indicates that four subwatersheds (20, 30, 40, and 60) were not compliant based on current *E. coli* standards. As a result of the strategies, the daily load was reduced between 15 and 25 percent for the subwatersheds and subwatershed 40 and 60 became compliant under the water quality goal and subwatershed 30 became compliant under the existing criterion. Although subwatershed 20 had reduced daily load of 17 percent, it did not become compliant under the higher water quality goal. Under the water quality goal, subwatershed 20 had an excess daily load of 900 x 10^6 orgs/day with subwatersheds 30, 40, and 60 having significant additional capacity.

Implementation Schedule

A 10-year timeline, beginning in 2011, was proposed for the implementation of management strategies but some could take longer or less than the estimated timeframes. Stakeholders categorized management strategies into the following groups which are differentiated by start dates:

- Management strategies currently being implemented, planned, or constructed,
- Management strategies that should be initiated between 2011 and 2015 (1-5 years), and
- Management strategies that should be initiated between 2016 and 2020 (6-10 years).

Stakeholders grouped management strategies into these categories based on their interpretation of when each strategy might be practically implemented given all external factors. Some management strategies will require time for planning, legal or permit approvals, acquisition of funding, and potentially hiring staff.



This schematic implementation schedule shows how reduction increases over time as strategies are implemented and the relative amount each strategy contributes to reduction over time. Starting in 2011 a rise in reductions occurs that ultimately achieves a removal of source load totaling 143,811 x 106 orgs/day.

Institutional Framework for Implementation

Through development of this WPP stakeholders of the Leon River watershed recognized the need to formulate an organizational entity that could provide equitable representation of watershed stakeholders and guide future decision-making regarding implementation of management strategies. The success of long-term implementation of the recommendations in this WPP will depend on the establishment of an institutional framework that can secure support and commitments necessary to implement management strategies, conduct outreach and education, and evaluate progress toward attaining water quality goals. This organizational entity called the Leon River Watershed Steering Committee (WSC) evolved from members selected from focus groups during development of this WPP.

The WSC will guide implementation of the management strategies and actions outlined in this WPP. The WSC will also serve as the liaison to the TCEQ, TSSWCB, BRA as well as all local, regional, state, and federal agencies for communication on water quality issues and progress. The WSC will call upon the five focus groups and other stakeholders to assist them with deliberation of activities or issues on implementation strategies where appropriate. The roles of the WSC include:

- Ongoing clarification and updating of water quality goals;
- Communicating the progress of the WPP to interested parties and agencies within and outside the Leon River watershed;
- Advancing principles of adaptive management to better target and prioritize implementation projects throughout the Leon River watershed;

- Updating the WPP over time to advance water quality improvements; and
- Promoting the addition of stakeholders in the watershed to each of the five focus groups and advancing the role and effectiveness of the WSC.

In fulfilling these various roles, the WSC will provide the long-term guidance and local leadership necessary to advance implementation of management strategies and local support for improving and protecting water quality.

The business of implementing the WPP over the next 10 years and beyond will require a consistent level of commitment to promote BMP implementation, conduct outreach and education, acquire funding support, and track, evaluate and communicate water quality improvements. To provide the level of effort necessary to accomplish these important and time-demanding activities, the WSC has identified the need for a full-time watershed coordinator position. This individual will attend to the day-to-day business of providing communication, coordination and technical assistance support to the WSC and Leon River watershed stakeholders involved in implementing the WPP. The watershed coordinator will participate in all WSC meetings and assist the WSC in organizing and conducting its business meetings each year. The watershed coordinator will advise the WSC on technical, financial, scheduling, outreach, and educational aspects associated with existing or future management strategies in the WPP. In addition, the watershed coordinator will participate in any and all activities held in the Leon River watershed to promote water quality improvements and implementation, and serve as a liaison to all local, regional, state, and federal agencies participating in water quality management activities in the watershed. Establishing a full-time watershed coordinator position is considered a critical building block of the infrastructure needed by the WSC to accelerate implementation of management strategies identified in the WPP.

Relationships between the WSC, watershed coordinator, watershed stakeholders, and other key agencies will provide the coordination and technical support to advance implementation.

Integrated Outreach and Education Strategy

Improving watershed stewardship among citizens, businesses, and local governments depends on the knowledge they have about water quality problems and their willingness to promote stewardship. To advance these principles, a public outreach and education strategy customized to the environmental and social characteristics of the Leon River watershed will need to be funded. Implementing various outreach and education components in a coordinated manner will have a positive benefit on the stewardship ethic of Leon River watershed stakeholders, which will lead to reductions in bacteria and nutrients and improvements in water quality over time.

The key driver that influences the design of an effective, integrated outreach and education strategy for the Leon River watershed is the promotion of implementation strategies to reduce bacteria and nutrient levels. Guided by this WPP, the watershed coordinator, in conjunction with Texas AgriLife Extension Service, can carry out the outreach and education strategy to meet the following objectives:

- Increase public awareness of water quality problems in the Leon River watershed.
- Increase public awareness of water quality goals in the Leon River watershed.
- Develop a campaign to promote the intrinsic value the Leon River and its tributaries provide to the citizens within and outside the Leon River watershed.
- Identify and build linkages with other outreach and education opportunities and programs structured for the region.
- Customize outreach and education efforts for each of the five focus groups and assist the focus groups in expanding the distribution of information.

There is a wide array of existing programs, tools, and materials already available that can be used or customized to accelerate outreach and education efforts aimed at improving water quality in the Leon River watershed. The focus groups identified at least one outreach and education strategy that can be implemented to advance each management measure.

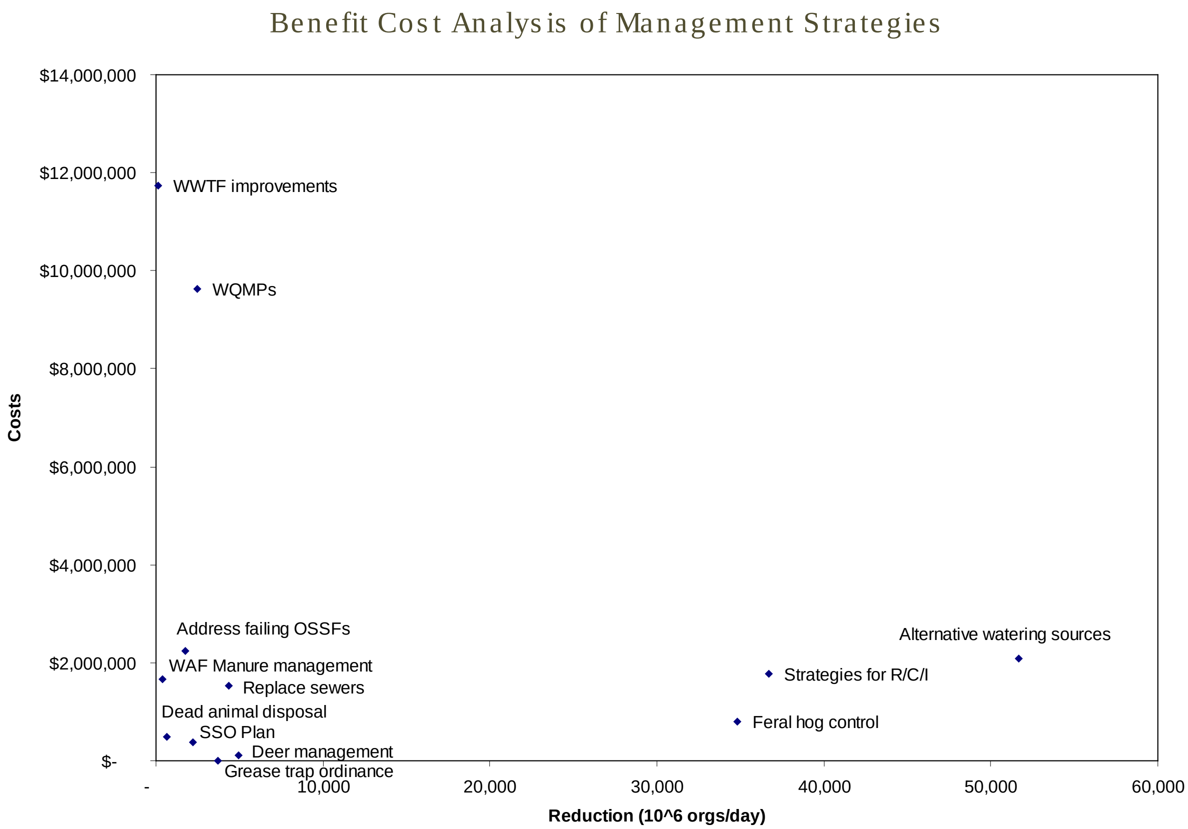
Technical and Financial Assistance Resource Needs

Limited technical and financial support are available to varying degrees from federal, state, regional, and local government agencies, universities, non-governmental organizations (NGO), council of governments, and business and trade associations. The keys to acquiring technical and financial assistance that will advance the actions outlined in this WPP are knowledge of where to go to get assistance, when the assistance is available, and investing the time and energy necessary to obtain and utilize the assistance. Stakeholders and the WSC will require various types of technical assistance to effectively pursue the goal of restoring water quality in the Leon River watershed. Each management or outreach and education strategy will dictate the type, degree and provider of the technical and financial assistance needed. Discussions with the focus groups, working committee representatives, and the Technical Advisory Committee provided general information that was used to estimate financial needs. Successful acquisition of funding sources that can sustain implementation is fundamental if the goals of the WPP are to be achieved. There are various federal and state programs available to provide some of the funding for the management strategies identified in the Leon River WPP.

The following table summarizes the estimated financial needs for implementing management strategies, education and outreach and future water quality monitoring to evaluate progress of improving water quality.

Summary of Financial Assistance Needed to Support Implementation

Management Strategy	Completed Investments			Future Capital Costs (Dollars)										Capital Cost
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
WWTF improvements	-	1,738,000	5,050,000	167,600	4,167,600	167,600	168,114	268,114	514	514	514	514	514	**$ 11,729,600**
Grease trap ordinance	-	-		0	0		10,000		0	0	0			**$ 10,000**
Replace sewers	85,667	85,667	85,667	136,400	136,400	136,400	136,400	136,400	120,000	120,000	120,000	120,000	120,000	**$ 1,539,000**
SSO Plan	-	150,000	-	-	225,000	-	-	-	-	-	-	-	-	**$ 375,000**
Address failing OSSFs	-	-	-	275,000	275,000	275,000	275,000	275,000	174,500	174,500	174,500	174,500	174,500	**$ 2,247,500**
Feral hog control	-	-	-	95,000	105,000	85,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	**$ 796,000**
Deer population management	-	-	-	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**$ 100,000**
Alternative watering sources	-	-	-	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	**$ 2,080,000**
Dead animal disposal	-	-	-	12,800	12,800	12,800	12,800	12,800	84,000	84,000	84,000	84,000	84,000	**$ 484,000**
WQMPs	-	-	-	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	**$ 9,630,000**
WAF Manure management	-	-	-	320,000	335,000	320,000	370,000	320,000	-	-	-	-	-	**$ 1,665,000**
Strategies for R/C/I	-	-	-	223,000	223,000	223,000	223,000	598,000	55,000	55,000	55,000	55,000	55,000	**$ 1,765,000**
Subtotal	**$ 85,667**	**$1,973,667**	**5,135,667**	**$2,410,800**	**$6,660,800**	**$2,400,800**	**$2,449,314**	**$2,864,314**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$ 32,421,100**
Outreach and Education[1]				$289,000	$258,000	$294,000	$258,000	$284,000	$168,000	$184,000	$168,000	$184,000	$168,000	$2,255,000
Water Quality Monitoring[2]				60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	600,000
Total Costs				**2,759,800**	**$6,978,800**	**$2,754,800**	**2,767,314**	**$3,208,314**	**$1,916,014**	**$1,932,014**	**$1,916,014**	**$1,932,014**	**$1,916,014**	**$ 35,276,100**



Measuring Progress

Measuring progress is one of the fundamental components of adaptive management that will be used to guide decision-making throughout implementation. Stakeholders and water resource managers alike recognize that many aspects of bacteria and nutrient sources in the environment are not entirely understood. Scientific understanding of bacteria deposition rates, terrestrial and aquatic survival, source differentiation, overland and downstream transport, and cumulative inter-relationships between pollutants is limited. Despite the uncertainty created by the complexities of environmental systems and their impact on human and environmental health, implementation of the Leon River WPP can move forward by adhering to adaptive management principles. As management strategies are implemented, tracking progress through a multi-tiered evaluation framework will provide information necessary to make adjustments to the WPP. With this approach, bacteria load reduction and progress toward achieving water quality goals can be tracked to evaluate progress. The multi-tiered evaluation framework provides the foundation for the Leon River WPP to meet the following three key elements of a WPP as recommended by USEPA guidance:

a. Interim, measurable milestones for determining whether management strategies are being implemented;

b. Indicators based on a set of criteria to be used to determine whether load reductions are being achieved; and

c. Monitoring component to evaluate effectiveness of implementation measured against the established criteria.

Tracking the Water Quality Goal for the Leon River Watershed

The primary goal of the Leon River WPP is to maintain an instream concentration of *E. coli* based on the long-term geometric mean of 206 cfu/100mL by lowering bacteria loads through voluntary management strategies and existing regulatory controls. Preliminary reduction goals have been estimated for each subwatershed, which range from 15 to 26 percent. Reaching these goals through implementation of management strategies and the recommended outreach and education activities will also result in a corollary reduction of instream nutrient concentrations.

The WSC has established a list of measurable milestones that can serve as programmatic and social indicators. Accomplishing these short-term milestones can also demonstrate the completion of organizational tasks and select management strategies that are critical to solidifying the functional responsibilities of the WSC and watershed coordinator.

Through the implementation of management strategies, instream *E. coli* concentrations are expected to decrease over time. By using interim targets defined by estimated *E. coli* concentrations, ongoing feedback can be provided to stakeholders allowing them to adjust implementation of management strategies both spatially and temporally. The following table provides a summary of recommended interim environmental indicators at key SWQM stations that stakeholders, the WSC and TCEQ can use as an index for tracking and reporting progress of changes in water quality over time. All the values represent *E. coli* concentrations as geometric means for each subwatershed.

As demonstrations are made measuring instream *E. coli* concentrations from year to year, additional data collected will be used to demonstrate that nutrient and chlorophyll *a* levels are also diminishing over time. The WSC can couple these data analysis results with the documentation of the number of stream miles supporting their designated uses. After all management strategies are implemented, only subwatershed 20 will be slightly above the WPP goal of 206 cfu/100mL. While specific interim targets have not been established for nutrients, sampling analysis results for nitrate nitrogen and orthophosphorus from ambient water quality monitoring will also be tracked and reported. The watershed coordinator will pay special attention to developing reporting tools that can effectively convey water quality changes to stakeholders.

	Proposed Evaluation Location	Relative Decrease in Concentration		*E. coli* Geometric Mean		
SW	SWQM Station	2008-2015	2015-2020	2008	2015	2020
10	11934	12	9	85	73	64
20	17379	35	17	301	266	248
30	11818	23	6	130	108	102
40	11817	26	15	229	203	188
50	18781	16	6	111	95	88
60	11808	43	19	253	210	191
70	11932	14	6	106	91	85
80	17547	14	5	93	79	73
90	11930	9	3	61	52	48
100	11929	9	4	62	53	49
110	18405	7	7	97	90	83
120	17501	14	5	93	79	74
130	11926	18	5	109	92	87
140	11925	16	5	99	83	79
150	11804	11	3	75	64	60

Note: Geometric mean at fecal coliform to *E. coli* ratio of 0.76

not compliant at *E. coli* water quality goal of 206 org /100mL

not compliant at current *E. coli* water quality standard of 126 org/100mL

Long-term Monitoring Strategy

The existing ambient water quality monitoring network will serve as the foundation of the long-term monitoring strategy. However, as currently implemented, the existing monitoring network cannot achieve all the objectives recommended to measure actual environmental progress. An expanded monitoring strategy is recommended for implementation through the Clean Rivers Program to verify that bacteria and nutrient reductions are occurring at the subwatershed scale and that the water quality goal set in this WPP is being achieved on schedule. The recommendation to increase the number of SWQM stations for instream sampling by the BRA from 14 to 16 and collecting samples on a monthly rather than a quarterly basis, will cost an additional $60,000 per year, to ultimately demonstrate success at restoring the contact recreation use. Other key components of the long-term monitoring strategy that provide important data to measure progress of the environmental indicators includes effluent monitoring of *E. coli* for all WWTFs and special studies.

Water quality monitoring stations at the downstream site on each subwatershed can be used for evaluating short-term and long-term water quality conditions at the subwatershed scale to measure progress and provide critical data to guide decision-making through adaptive management. These SWQM stations are listed in the following table.

BRA Monitoring Stations Selected for Measuring Progress in each Subwatershed

Subwatershed	Waterbody	2010 Assessment Unit ID	SWQM Station ID	SWQM Station Description	County	Monitoring Frequency Proposed in WPP[1]
10	Leon River	1221_07	11934	Leon River at US 67/ US 377 downstream Lake Proctor	Comanche	Monthly
20	Walnut Creek	1221F_01	17379	Walnut Creek at FM 1476 south of Procter	Comanche	Monthly
30	Indian Creek	1221D_02	11818	Indian Creek at Comanche County Road 304, 3.51 kilometers upstream of the confluence with the Leon River	Comanche	Monthly
30	Indian Creek	1221D_01	17542	Indian Creek at SH 36 east of Comanche	Comanche	Monthly
40	South Leon River	1221B_01	11817	South Leon River at SH 36 east of Gustine	Comanche	Monthly
50	Leon River	1221_05	18781	Leon River at Hamilton County Road 109	Hamilton	Monthly
60	Resley Creek	1221A_01	11808	Resley Creek at Comanche County Road 394, 740 meters upstream of the confluence with the Leon River	Comanche	Monthly
70	Leon River	1221_05	11932	Leon River at US 281 north of Hamilton	Hamilton	Monthly
80	Pecan Creek	1221C_01	17547	Pecan Creek at SH 22 east of Hamilton	Hamilton	Monthly
90	Leon River	1221_04	11930	Leon River at Hamilton County Road 431 southwest of Jonesboro	Hamilton	Monthly
100	Leon River	1221_04	11929	Leon River at Coryell County Road 183 northeast of Levita	Coryell	Monthly
110	Plum Creek	Not Assessed	18405	Plum Creek at Coryell County Road 106 near Levita	Coryell	Monthly
120	Leon River	1221_03	17501	Leon River at Faunt Leroy Park immediately east of S 7th St, 452 meters south of College St upstream of US 84 in Gatesville	Coryell	Monthly
130	Leon River	1221_03	11926	Leon River at SH 36 southeast of Gatesville	Coryell	Monthly
140	Leon River	1221_03	11925	Leon River at FM 1829 southeast of North Fort Hood	Coryell	Monthly
150	Coryell Creek	Not assessed	11804	Coryell Creek at Coryell County Road 107	Coryell	Monthly

[1] Dependent on available funding

Chapter 1: Introduction

The purpose of this Leon River WPP is to identify implementation strategies supported by stakeholders that can reduce bacteria levels in creeks and rivers in the Leon River watershed over time with minimal consequence to the livelihoods of the citizens in the watershed. This WPP is guided by the common objective expressed by the Leon River watershed stakeholders – *"to restore and maintain water quality so that citizens in the watershed may enjoy the water resources with little risk to their health."* This WPP is also guided by the fundamental premise that management of surface water resources is most effective when approached on a watershed basis. **Acceptable watershed protection and restoration activities can be implemented over time dependent on changes to water quality standards, the degree of water quality improvement achieved, and available implementation funds.**

This WPP summarizes recommendations proposed by stakeholders who diligently defined strategies to remove, reduce, or mitigate bacteria while considering how these strategies would affect the different types of businesses, residents, and municipalities within the watershed. Stakeholders were also conscious that implementation strategies that result in bacteria reductions would have the added benefit of reducing nutrient levels in certain areas of the Leon River watershed. These strategies considered many factors such as pollution reduction effectiveness, associated costs, implications to landowners, operations, ability to implement, and common sense. This process successfully engaged stakeholders and water resource management agencies to agree to move forward with a plan that can be amended if needed in the future as bacteria and nutrient reductions are achieved. This WPP presents the best available data and information regarding the water quality conditions of the Leon River and its tributaries. Recommendations for reducing point and nonpoint sources of bacteria pollution, associated costs, outreach needs, schedule, measurable goals, and monitoring for each activity are discussed.

1.1 Watershed Characteristics

The Leon River watershed, located in the Brazos River Basin, is bound by Proctor Lake upstream and Belton Lake downstream. Figure 1.1 displays the geographic extent of the watershed and the general physiographic character of the Leon River watershed. The Leon River (Segment 1221) is approximately 190 miles long and the watershed is approximately 1,375 square miles covering portions of Comanche, Erath, Hamilton, and Coryell Counties before it reaches Belton Lake (Segment 1220). A small portion of the watershed lies within Mills County. The Leon River watershed lies within the Western Cross Timbers and Limestone Cut Plain level IV ecoregions (USEPA 2008a).

The key characteristics of the Western Cross Timbers ecoregion are soil with mostly fine sandy loam, clay subsoil that retains water, deciduous trees dominated by post oak, blackjack oak, cedar, and hickory with an understory of greenbriar, little bluestem, and purpletop grasses (USEPA 2008a). The area has a long history of coal, oil, and natural gas production from the Pennsylvanian sandstone/limestone/shale beds (USEPA 2008a). Deeper soil in the eastern part of this ecoregion supports a dairy industry, pastureland, and cultivation of forage sorghum, silage, corn, and peanuts (USEPA 2008a).

The Limestone Cut Plain ecoregion is underlain by Lower Cretaceous limestone, including the Glen Rose Formation and Walnut Clay. The Glen Rose Formation has alternating layers of limestone, chert, and marl that erode irregularly and easily when exposed to increased precipitation and runoff (USEPA 2008a). The Limestone Cut Plain has flatter topography, lower drainage density, and a more open woodland character (USEPA 2008a). The vegetation of the Limestone Cut Plain is similar to that of the Balcones Canyonlands, but less diverse: post oak, white shin oak, cedar elm, Texas ash, plateau live oak, and burr oak are prevalent (USEPA 2008a).

The upper watershed located in Comanche County consists of scenic rolling land with elevations from 650 to 1,700 feet (TSHA 2010a). The elevation in Hamilton County ranges between 900 and 1,600 feet above sea level (TSHA 2010b). The lower watershed in Coryell County has elevations ranging from 600 to 1,493 feet above sea level (TSHA 2010c). Table 1.1 provides the various percentages of how much of each county falls within the watershed and how much of the total watershed area is in each county. The Leon River receives flow releases from Proctor Lake (Segment 1222), and several tributaries. The longest tributary flowing to the Leon River is the South Leon River (Segment 1221B) located in southern Comanche County. Table 1.2 provides a summary of physical characteristics of the Leon River and its main tributaries. Figure 1.2 provides a select group of photographs depicting the Leon River and two of its tributaries, Pecan Creek and South Leon River.

Table 1.1 Percentage of Watershed Area vs. County Area

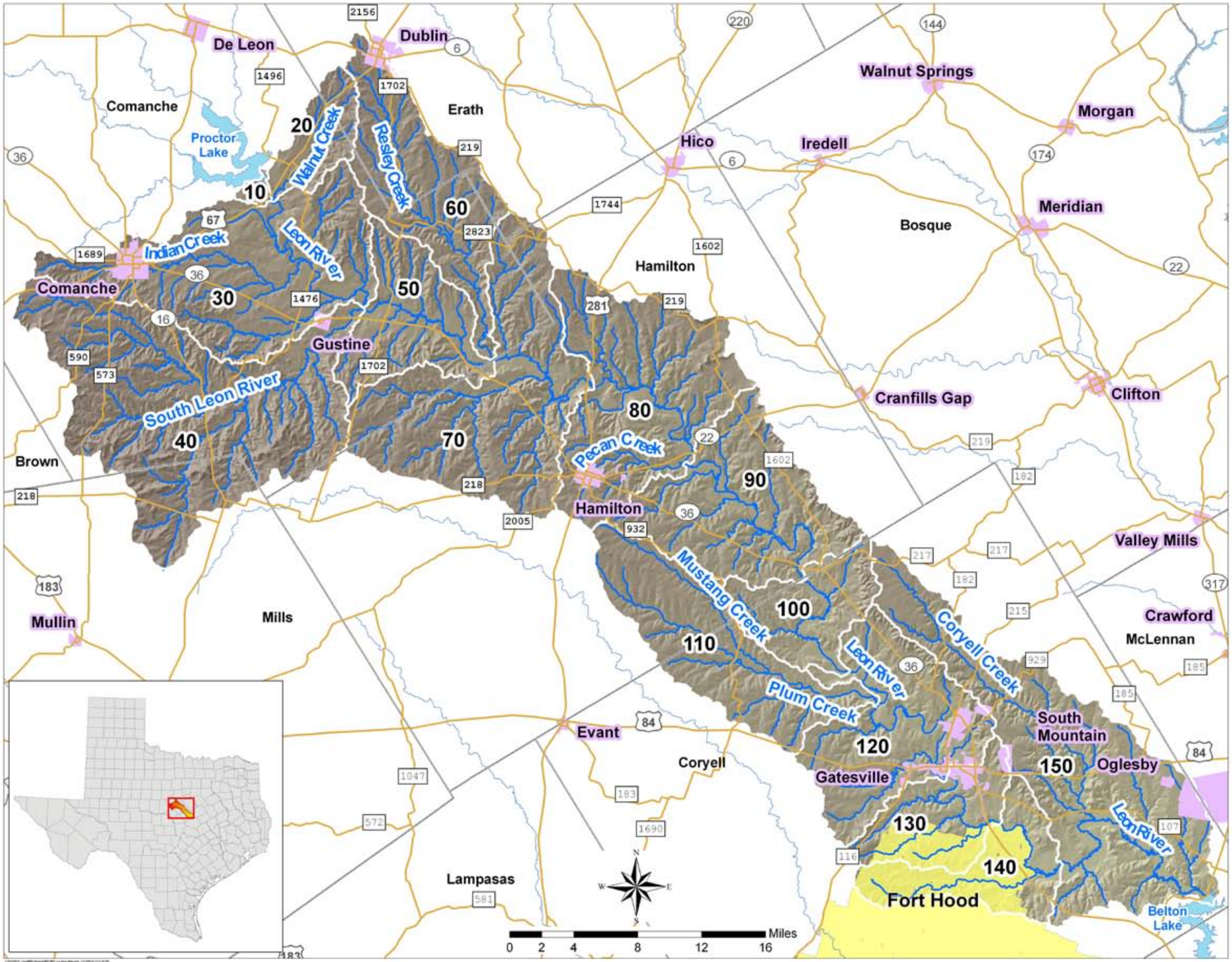
County	County in Watershed	Watershed in County
Comanche	48%	33%
Mills	4%	2%
Coryell	42%	33%
Erath	5%	4%
Hamilton	45%	28%

Table 1.2 Stream Characteristics of the Leon River and its Tributaries

Stream (subwatershed)	Length	Elevation Change[1]	Type
Leon River (various)	190 miles	574	Perennial
Walnut Creek (20)	15 miles	361	Intermittent
Indian Creek (30)	30 miles	574	Perennial
South Leon River (40)	39 miles	594	Perennial
Resley Creek (60)	34 miles	492	Intermittent
Pecan Creek (80)	16 miles	377	Perennial
Plum Creek (110)	26 miles	509	Intermittent w/ Perennial Pools
Coryell Creek (150)	29 miles	548	Perennial

[1] Approximate change in elevation (feet) from headwater to confluence.

Figure 1.1 Leon River Watershed



PARSONS

Figure 1.2 Photographs of the Leon River, Pecan Creek, and South Leon River

1.1.1 Climate

The Leon River watershed, located within the North Central Texas climatic division, is classified as subtropical subhumid. Hot weather is persistent from late May through September, accompanied by prevailing southeasterly winds. The cool season, beginning about the first of November and extending through March, is typically the driest season of the year as well. Winters are typically short and mild, with most of the precipitation falling as drizzle or light rain. As with the rest of the interior of the State, maximum precipitation periods in the area are typically late spring (May) and early autumn (September). Precipitation is caused by late season cold air migrations, warm season thunderstorms, and spring low-pressure troughs. In September, cold air converges with moisture-laden southerly winds, and late season convective thunderstorms drive the precipitation. Summer drought conditions are common in the area due to strong high-pressure cells that result in lengthy dry spells. Table 1.3 summarizes average climate characteristics of each county.

Table 1.3 Average Climate Conditions

County	Average Growing Season (days)	Average Temperature (Fahrenheit)	Average Annual Rainfall (inches)
Comanche	238	32° minimum; 95° maximum	18.5
Hamilton	239	34° minimum; 96° maximum	29.6
Coryell	244	33° minimum; 97° maximum	32

Source: Texas State Historical Agency 2010a, b, c

1.1.2 Demographics and Economy

Only Comanche, Hamilton, and Coryell Counties are discussed in this subsection as these three counties account for over 98 percent of the Leon River watershed.

Comanche County was named for the Indians that had roamed this land for decades before F.M. Collier built the first log house in 1855 (Comanche County Genealogical Society 2010). Comanche County covers 948 square miles (606,720 acres), has an estimated population of 14,026, and a population density of 15 people per square mile (U.S Census Bureau 2000). The 2008 population was estimated at 13,483 (Texas Association of Counties 2010). Between 1990 and 2000 the population experienced a 4.8 percent increase (Texas Association of Counties 2010). Approximately 52 percent of the population lives in urban areas. The largest urban area is the City of Comanche with a population of 4,482, which serves as the county seat (Texas Association of Counties 2010). Other small towns within the watershed include Proctor, Hasse, Lamkin, Gustine, and Newburg. The county's economy includes agribusiness, limited oil production, and seasonal hunting (TSHA 2010a). Agribusiness is an important component of the economy. There are approximately 1,450 farms with an average size of 399 acres, accounting for 95 percent of the county's area (USDA NASS 2007). Cattle are the primary type of livestock raised in the county. There are also significant dairy operations. Harvested cropland accounts for 15 percent of the total farmland (USDA NASS 2007). Peanuts and other edible nuts account for a significant portion of the harvested crops.

The County of Hamilton was named in honor of General James Hamilton, a governor of South Carolina, who put up $216,000 in gold to finance the Texas struggle for independence from Mexico (NRCS 1991). Hamilton County covers 837 square miles (535,680 acres), has an estimated population of 8,092, and a population density of 9.8 people per square mile (U.S. Census Bureau 2000). Between 1990 and 2000 the population saw a 6.4 percent increase (Texas Association of Counties 2010b). Approximately 54 percent of the population lives in urban areas. The largest urban area is the City of Hamilton with a population of 2,977, which serves as the county seat (Texas Association of Counties 2010). Other small communities include Evant, Hico, Olin, and Carlton. The county's economy includes agribusiness, manufacturing, hunting, and limited oil production (TSHA 2010b). Oil production continues to decline as demonstrated by the extraction of only 2,067 barrels in 1990 compared to 5,000 barrels in 1982 (TSHA 2010b). Agribusiness is an important component of the economy. There are approximately 1,045 farms with an average size of 451 acres, accounting for 88 percent of the county's area (USDA NASS 2007). Livestock raised in the county includes beef and dairy cattle, sheep, and goats. Harvested cropland accounts for just 11 percent of the total farmland (USDA NASS 2007).

Coryell County was named in honor of James Coryell, a hero of the Texas Revolution (SCS 1983). Coryell County covers 1,052 square miles (673,280 acres), and in 2000 had an estimated population of 74,978 and a population density of 71.3 people per square mile U.S. Census Bureau 2000). The 2008 population was estimated at 72,654 (Texas Association of Counties 2010). Between 1990 and 2000 the population experienced a 16.8 percent increase (Texas Association of Counties 2010). Approximately 62 percent of the population lives in urban areas. The largest urban area is the City of Copperas Cove, located outside the watershed in the southern portion of the county, with a population of 29,787. The City of Gatesville, located within the watershed, is the second largest city of the county with a population of 15,591 (Texas Association of Counties 2010). Other small towns within the watershed include Jonesboro, Arnett, Fort Gates, South Mountain, Flat, Leon Junction, and Oglesby. The economy includes professional services, manufacturing, trade, public administration, and agribusiness (TSHA 2010c). The U.S. Army Fort Hood military base also plays an important role in the county economy. Agribusiness is still a significant component of the county's economy. There are approximately 1,339 farms with an average size of 365 acres, accounting for 73 percent of the county's area (USDA NASS 2007). Livestock raised in the county includes cattle, horses, and goats. Harvested cropland accounts for just 13 percent of the county's total farmland (USDA NASS 2007).

1.1.3 History

The following historical summaries for each county were obtained from the Texas State Historical Association. Comanche County was dominated from the eighteenth to the mid-nineteenth centuries by the Comanche Indians. White settlement in the area began with a colony, and in 1856 the Texas legislature formed Comanche County from Coryell and Bosque Counties. In 1859 the centrally located town of Comanche became county seat. Cattle ranching was the most important economic activity and by 1880 Comanche County had farms and ranches that encompassed 190,482 acres. As the economy of the area rapidly developed in the 1870s, its population increased almost eightfold. Agriculture was further encouraged in 1881 when the Texas Central Railroad began service and started carrying cattle and cotton to market. Cotton had come to be the single most important crop by 1890, when almost 35,000 acres of land were devoted to the fiber. Oil drillers moved into northern Comanche in the wake of oil discoveries in Eastland County in 1918. Oil drillers brought in wells at Sipe Springs, Sidney, Comyn, and Proctor. The mechanization of agriculture combined with other factors (such as the droughts of the 1950s) began to depopulate the area from the 1940s to 1960s. Federal funding became available for a reservoir on the Leon River in 1960 to protect farmland in the Leon River floodplain and store water in Proctor Lake. Oil wells in the county are still producing. In the 1980s, agricultural production in the county was fairly well balanced between farming and ranching (TSHA 2010c).

Prior to the first permanent white settlers in Hamilton County, which arrived in 1854, Waco and Tawakoni Indians lived and moved throughout Central Texas. Comanches also traveled through the Hamilton County area. Settlers asked that a new county be formed to accommodate their needs. Later that year the Texas legislature approved the request and marked off Hamilton County from land previously assigned to Comanche, Bosque, and Lampasas Counties. Geography helped determine the pattern of settlement, as pioneers built along the wooded streams that crossed the rolling prairie, leaving the intervening divides to remain open range. Though Indians continued to raid the area periodically until 1875, the threat had been considerably reduced by 1870, and settlers began moving into the county in greater numbers. By 1870, the area remained primarily devoted to ranching. Further growth was encouraged in 1880, when the Texas Central Railroad extended its tracks across the northeastern corner of the county. Between 1880 and 1900 cotton farming, grain production, and sheep and cattle ranching expanded. During the 1880s and 1890s many settlers bought farm tracts from speculators who subdivided former rangeland; others purchased public school lands (TSHA 2010b).

Central Texas, including Coryell County, has supported human habitation for at least 12,000 years. Prior to European settlers moving into central Texas, the area was inhabited by Tonkawa, Lipan Apache, Kiowa, and Comanche Indians. In 1854 the legislature established Coryell County. The county economy began to recover from the post-Civil War recession in the late 1860s. The overall population more than doubled between 1870 and 1880. Between 1880 and 1900 the population nearly doubled again by the turn of the century. Most of the incoming residents were from other parts of Texas or from other southern states; however, new immigrants arrived from Germany and from Mexico. The permanent establishment of Fort Hood in 1950 changed the ethnic makeup of the county. For the first third of the twentieth century, roughly half of the county's improved acreage was devoted to cotton, but the Great Depression persuaded farmers to devote more of their resources to feed crops and livestock. Sheep, goat, and cattle ranching gradually increased in importance. The U.S. involvement in World War II brought an end to the Depression; on a local level, new war industries paved the way for a dramatic increase in the population of Coryell County. Among the military facilities built in and near the county in the 1940s were Camp Hood, the Bluebonnet Ordnance plant, and a camp for German prisoners of war. In the 1970s and 1980s, the county seat, Gatesville, was chosen as the site for several new units of the Texas Department of Corrections, making it one of the county's largest employers. By the early 1980s, 88 percent of the land in Coryell County (exclusive of Fort Hood) was devoted to farms and ranches (TSHA 2010c).

1.2 Project Background

The Leon River (Segment 1221) was initially placed on the State of Texas Clean Water Act (CWA) §303(d) List of impaired waters in 1996 for having bacteria levels that “sometimes exceed water quality standards” (TCEQ 1996). The U.S. Environmental Protection Agency (USEPA) and the Texas Commission on Environmental Quality (TCEQ) have established designated uses and water quality criteria for bacteria for the protection of swimmers from gastrointestinal illness in recreational waters (USEPA 2002). Most strains of *Escherichia coli* (*E. coli*) are harmless and live in the intestines of healthy humans and animals (USEPA 2009a). Indicator organisms such as *E. coli* are used to assess surface waters contaminated by fecal pollution (USEPA 2002). The use of indicators provides regulators and water quality managers with a means to ascertain the likelihood that human pathogens may be present in recreational waters (USEPA 2002).

Placement of the Leon River on the §303(d) List caused the TCEQ to initiate the development of a total maximum daily load (TMDL). In the simplest terms, a TMDL is a daily pollution budget that establishes the amount of a particular pollutant that a waterbody can receive and still meet state water quality standards. TCEQ initiated the TMDL process for the Leon River upstream of Highway 281 in January 2002. Based on additional data collection efforts, data analysis and modeling, and a series of stakeholder meetings, a draft TMDL report prepared by TCEQ (April 2008) proposed that a 21 percent reduction in bacteria loadings in the upper watershed of the Leon River could restore water quality to meet Texas surface water quality standards (SWQS). In August 2008, the TCEQ delayed the final adoption of the Leon River TMDL in response to the potential for proposed revisions to the SWQS for contact recreation. In July 2010, TCEQ adopted statewide revisions to the SWQS which includes changes to the designated use and associated numeric criterion for contact recreation. These changes are discussed at length in chapter 3.3 of the WPP.

Between January 2005 and April 2008, as the Leon River Bacteria TMDL Advisory Group established by TCEQ learned more about the TMDL process, stakeholders throughout the watershed from Proctor Lake downstream to Belton Lake began to advocate a more locally driven process than that which was occurring through the TMDL process. **Local stakeholders expressed interest in taking an active role in defining specific voluntary strategies to reduce bacteria loadings throughout the watershed and saw the WPP process as a more effective vehicle for pursuing this objective.** During development of the WPP, stakeholders were encouraged to holistically address the sources and causes of impairments and threats to surface water resources within a watershed.

At the specific and urgent call by watershed stakeholders, the Brazos River Authority (BRA) sought and obtained a CWA §319(h) nonpoint source grant from the Texas State Soil and Water Conservation Board (TSSWCB) and the USEPA to support development of this WPP. Parsons was hired to support BRA with the development of the WPP providing technical analysis, stakeholder coordination, and other expertise. The project team of BRA and Parsons received input from stakeholders of the Leon River watershed throughout this watershed planning process. Stakeholders contributing to development of this WPP recognized that while the TMDL and the WPP for the Leon River watershed have the same ultimate objective - *"to restore and maintain water quality,"* the two processes pursue this objective in different manners. The TMDL process is a federally driven and state-led regulatory process that seeks to establish the instream loading limits for bacteria separate and apart from details or discussion of what implementation strategies are necessary to reach these limits. Conversely, this WPP process was stakeholder-driven and identified and evaluated implementation strategies aimed at reducing bacteria while considering cost and practicality. Further, a successfully developed and implemented WPP may obviate the need to complete draft bacteria TMDLs for the Leon River.

1.3 Elements of a Watershed Protection Plan

This WPP will advance the long-term health of the watershed by promoting strategies identified by stakeholders that address both elevated levels of *E. coli* and nutrient concerns. The participating organizations may accomplish the activities described in this WPP through formal or informal action, guidance, financing, and education. This WPP incorporates the nine key elements for watershed-based plans as described in the 2004 *Nonpoint Source Program and Grants Guidelines for States and Territories* (USEPA 2003a). The nine elements are:

a. Identification of the causes of impairment and pollutant sources that will need to be controlled to achieve the load reductions described in (b).

b. Estimate of the load reductions expected for the management measures described in (c).

c. Description of management strategies that will need to be implemented to achieve the load reductions described in (b).

d. Estimate of technical and financial assistance needed, associated costs, and the sources and authorities that will be relied upon to implement this plan.

e. Information/education component that will be used to enhance public understanding of this plan.

f. Schedule for implementing management measures described in (c).

g. Description of interim, measurable milestones for determining whether management measures described in (c) are being implemented.

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

i. Monitoring component to evaluate effectiveness of implementation measured against the established criteria described in (h).

This WPP is a coordinated framework for local control of implementing prioritized and integrated water quality protection and restoration strategies driven by environmental objectives that account for social and economic realities.

Chapter 2: Leon River Stakeholder Group

This chapter provides a summary of the process and outcomes utilized throughout development of the WPP to identify and gain local support for implementation of management strategies to reduce bacteria and nutrient levels in the Leon River watershed.

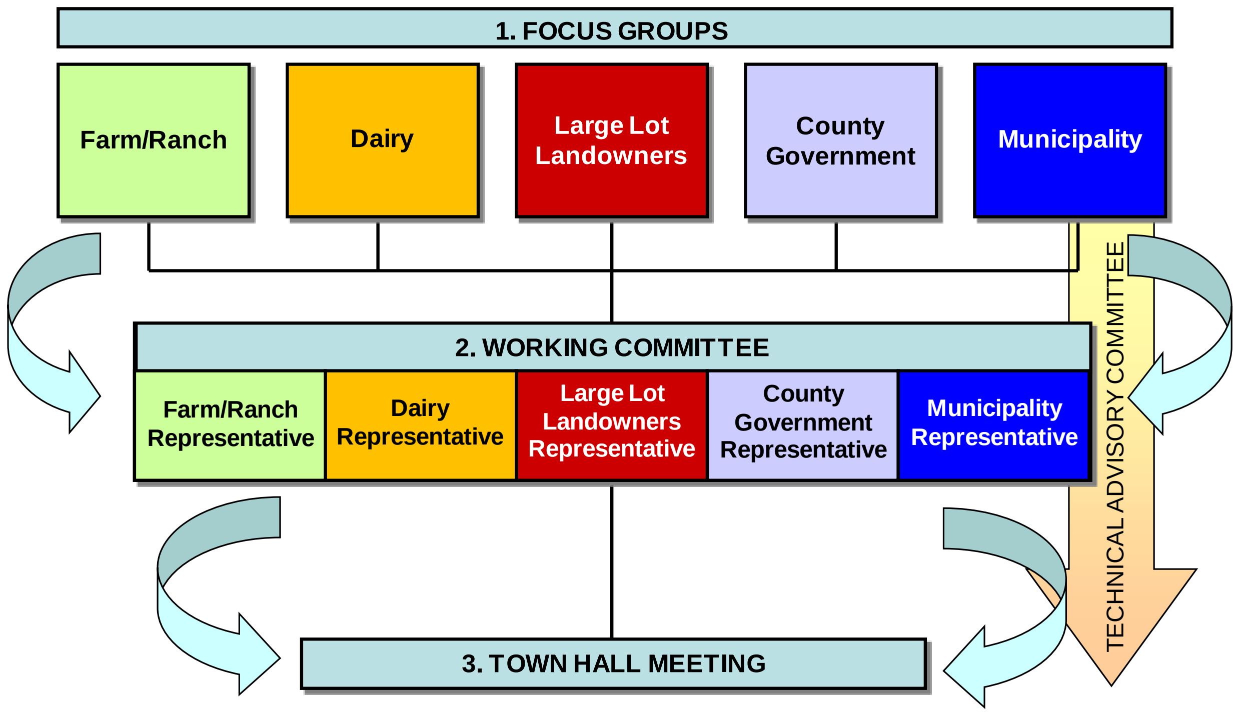
2.1 Participation Objectives & Organizational Structure

The principal factor in achieving water quality improvement is to have strategies that are locally developed, supported, and implemented, which can only occur if those affected perceive benefits upon implementation. Otherwise, it may require regulation to force people to implement actions that are seen as detrimental to their interests. This WPP is the direct outcome of a public participation process managed by the project team that was used to ensure meaningful contribution by stakeholders in identifying sources of bacteria, suggesting pollution reduction strategies, and discussing the challenges of implementation associated with both bacteria and nutrients. Key goals were to make the process accessible, allow meaningfully contribution to decision-making, and apply the best available science to make informed decisions. The project team met with stakeholders to discuss which strategies should be implemented using technical, economic, and regulatory information as a basis for decision-making. **Throughout the public participation process two objectives were consistently expressed by the stakeholders to: (1) generate management strategies that improve water quality in the Leon River watershed, and (2) select those with minimal adverse effects to the daily lives of the citizens in the watershed.** The public participation process for the Leon River WPP was designed in a manner that best responded to the characteristics, concerns, and availability of the concerned citizens and officials of small towns and rural counties.

The first step of the public participation process was attendance by the project team at stakeholder meetings associated with the TCEQ bacteria TMDL development process in October and December 2007. Parsons and BRA attended these two TCEQ-sponsored stakeholder meetings to identify and condense the general water quality concerns and issues expressed by the TCEQ Leon River Bacteria TMDL Advisory Group and establish a public participation process to advance preparation of the Leon River WPP. A list of the TCEQ Leon River Bacteria TMDL Advisory Group is provided in Appendix A. The project team also relied on the comments formally submitted by stakeholders in March 2008 as part of the public comment period for the TCEQ draft bacteria TMDL, which has not been adopted by the TCEQ.

To transition stakeholders' participation from the TMDL process to the WPP, three levels of public participation, depicted in Figure 2.1, were established: 1) focus groups, 2) a working committee, and 3) a town hall meeting. A technical advisory committee was also created to support the WPP process.

Figure 2.1 Organizational Structure of Public Participation Groups Supporting Preparation of the Leon River WPP



2.1.1 Focus Groups

The first organizational level was the focus groups. The principal goals of the focus groups were to listen to stakeholder interests in an interactive setting that allowed free dialogue among the participants and to decrease the tension typically felt in large town hall style meetings. Focus groups were limited in size, which allowed more time for individuals to be heard. In addition, the groups were organized to only include individual representatives of a particular constituency group responsible for or affected by implementation strategies in the watershed. Focus groups represented concentrated animal feeding operations (CAFO), specifically dairies, farmers and ranchers, municipalities, county governments, and large lot rural landowners. Membership for each focus group was initially developed from available stakeholder lists, attendant lists from past meetings, as well as contacts provided by Texas AgriLife Extension Service, TSSWCB, BRA, and TCEQ. Rosters of each focus group are provided in Appendix A.

Separate meetings with each focus group were held to discuss concerns, perspectives, and ideas on how to improve water quality in the Leon River watershed. Focus group meetings were held in December 2007, April 2008, and June 2009. A synopsis of the concerns and perspective of each focus group that established working philosophies throughout the preparation of the WPP are provided in Appendix B. Stakeholders openly commented and survey results confirmed that the small size of focus groups did allow greater attention to detail and more time to explain how implementation affected the specific constituency group. The outcome of each focus group was a list of implementation strategies reflective of each group's interests that included insight on the effectiveness, difficulty, certainty, timing, and costs associated with each strategy. Much of the information acquired from the focus group meetings was used as input into a decision support system (DSS) developed based on the existing watershed-loading model used for the draft TMDL. The DSS was developed as a graphical user interface to more effectively display how the various implementation strategies would change bacteria concentrations in each subwatershed based on insights and assumptions provided by each focus group. This tool allowed focus group members to make informed decisions about the degree to which they wished to voluntarily implement the strategies they felt were best-suited to reduce bacteria in the watershed. A more in-depth explanation of the existing watershed-loading model and the sensitivity analysis prepared using the DSS is provided in Chapter 4.

2.1.2 Working Committee

The second organizational level used to advance public participation was called the working committee. The working committee is comprised of at least one representative from each focus group. As a first step, separate meetings were held with each working committee member to explain and discuss the outputs provided by the DSS, which reflected the cumulative effect of implementing all the implementation strategies recommended by the focus groups. A sensitivity analysis of different combinations of implementation strategies was also presented to better demonstrate the range of pollutant reduction possible based on incremental levels of strategy implementation. These pre-meetings to deliberate outputs of the DSS were very effective at showing working committee members how the different combinations of various strategies would change bacteria concentrations in each subwatershed.

With an understanding of the technical basis for how the model would represent pollutant reductions as watershed-based instream concentrations of bacteria, and a general acceptance of the level of uncertainty associated with the DSS outputs, the next step was to meet with the full working committee. The working committee meeting, held July 2009, was designed to advance interaction between the different focus groups and facilitate the communication necessary to obtain support for the integration of implementation strategies and promote consensus within the WPP. During the meeting, working committee members were able to further deliberate the degree to which a strategy or suite of strategies might be implemented and better evaluate the effect management strategies may have in a subwatershed. The outcome of the working committee was a final consensus on the degree to which each program would be implemented in each subwatershed. A roster of the representatives who served on the working committee is provided in Appendix A. Figure 2.2 shows examples of different meetings held with a focus group and the working committee.

Figure 2.2 Local Stakeholders Participating in the Preparation of the WPP

Focus Group Meeting

Working Committee Meeting

2.1.3 Town Hall Meeting

The third level of the public participation process was structured as a town hall meeting. The goal of the town hall meeting was to encourage feedback and participation among all stakeholders. Participation at the town hall meeting was open to the broadest, most diversified audience possible from individuals who live and work in Comanche, Hamilton, Erath, and Coryell Counties. The town hall meeting, held December 2008, provided an initial feedback loop to the larger group of stakeholders to inform them of the strategies suggested by focus group members. It allowed additional stakeholders the chance to comment, voice concerns, and express other interests.

2.1.4 Technical Advisory Committee

A technical advisory committee was composed of individuals from state, regional, and federal agencies. The project team sought feedback from the technical advisory committee on historical and current water quality monitoring and technical, financial, and regulatory aspects associated with the recommendations of the working committee and focus groups. Two technical advisory committee meetings were held, one in January 2008 and one in August 2009. A list of agencies that participated on the technical advisory committee is provided in Appendix A.

2.1.5 Synopsis of Public Participation Process

Through these three levels of interaction, stakeholders participated in a formal, transparent mechanism for decision-making. Between December 2007 and August 2009, over twenty individual meetings were held among these three organizational levels, and dozens of other conference calls were also held to facilitate participation and obtain feedback. The smaller focus groups allowed interests to be heard, allowed free speech, and more attention to details in discussions. The working committee contributed critical input that supported decision-making. The town hall meeting encouraged participation by the greatest number of stakeholders possible.

A comprehensive organization chart of the different stakeholder groups that assisted with the development of the WPP is provided in Appendix A. This organization chart was ever changing throughout development of the WPP as the project team adhered to its goal of providing an open, public participation process. Through the public participation process the following objectives were achieved:

- Stakeholder understanding of differences between the TMDL and the WPP development process.
- Management strategies to reduce bacteria and nutrient loads were identified and prioritized.
- Stakeholders were provided more explicit information regarding pollutant sources (point and nonpoint) and pollutant load reduction at the subwatershed scale.
- Stakeholders obtained information that allowed them to better evaluate options and costs for implementation strategies.
- The project team was able to effectively capture the rationale and limitations of improving water quality from the stakeholders' point of view.

2.2 Stakeholder Rationale to Improve Leon River Water Quality

Landowners such as dairy farmers, ranchers, and homeowners, as well as city leaders and county officials throughout the Leon River watershed consider the region as pleasant, environmentally safe, and a good place for a variety of businesses. The livelihoods of some landowners are based on dairy operations, cattle ranching, farming, hunting, and recreation, which contribute to the regional economy. If creeks within the Leon River watershed are polluted, it could decrease land value and prohibit enjoyment and use of the land. Perception of poor water quality could also reduce the attractiveness of the region to hunters, campers, and other recreational users. Landowners who manage livestock or wild game or who farm the land recognize that such activities may contribute bacteria or nutrient loads; therefore, most landowners already implement various measures to mitigate potential impacts to the environment. Most have long been committed to conservation measures, not only as a good business practice but because landowners do not wish to pollute their own land. The stakeholders also acknowledge that there is a level of uncertainty about which sources of bacteria are the most significant and therefore want to be prudent about selecting voluntary solutions and practical about complying with existing regulations that are designed to protect water resources. Additional information summarizing stakeholder perspectives, concerns, and recommendations acquired from discussions and interviews with focus group members is provided in Appendix B.

2.3 Desired Outcomes

Associated with these general expectations, stakeholders also support the need for establishment of appropriate SWQS for all surface waters in the Leon River watershed. **The stakeholders question the presumption that all waterbodies in the Leon River watershed have an existing or attainable use of contact recreation.** As a result, the priority outcome that the stakeholders support as part of implementing the WPP is completion of a recreational use attainability analysis (RUAA) for the Leon River watershed. A RUAA is a waterbody-specific study conducted to determine if current contact recreation uses assigned to the Leon River and its tributaries are appropriate. The outcome of a RUAA is a report that TCEQ uses to make decisions on whether existing SWQS should be changed. There is strong support for changes to the existing water quality standards (designated uses and water quality criteria) in the Leon River watershed. The stakeholders support the regulatory process the TCEQ has undertaken to re-evaluate contact recreation uses and bacteria criteria statewide through their Standards Revision Process and the financial and technical support the TCEQ is providing to conduct the RUAA. For further explanation of this topic see subsections 3.6 and 3.7.

In addition, the Working Committee has requested that TCEQ consider dividing the Leon River (segment 1221) into two different stream segments based on hydrology and applicable recreational uses. This request is supported by a Texas Parks and Wildlife Department (TPWD) document entitled, "*An Analysis of Texas Waterways: A Report on Physical Characteristics of Rivers, Streams and Bayous in Texas*" (TPWD 1974). The document reports that the reach of the Leon River below Lake Proctor and above Gatesville "becomes suitable for recreational activities only during periods when water is being released from the dam and after heavy rains". The report goes on to say, "A good point to begin recreational use of this section [of the Leon River] is the US 84 crossing near the western city limits of Gatesville." It should be noted that while the publication is over 30 years old and more of a historic reference, the Working Committee asserts that the report appropriately characterizes current conditions of the Leon River. The report can be found on TPWD's webpage at http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1047/index.phtml.

There is one common goal among all parties involved in the WPP: all should do their part to improve water quality in the Leon River watershed. Key issues that influence this goal include:

- To best understand the severity and extent of *E. coli* and nutrient levels, what is the true water quality condition of the Leon River and each of its tributaries?
- *E. coli* water quality criterion and the screening levels for identifying nutrient concerns directly influence the magnitude of the effort needed to improve water quality. When will these be revised?
- What level of financial support from outside agencies can be provided to implement actions?
- What can feasibly be accomplished with voluntary and enforceable actions, which determine the expense of implementing actions?
- To respect private property rights, any strategies identified to improve water quality should be adopted through voluntary programs.

Figure 2.3 depicts the importance of finding a balance between stakeholder needs and stakeholder concerns. Despite these complex issues, stakeholders are hopeful that through discussion, meaningful contribution, fair decision-making, effective use of science, and creative solutions, this WPP can be the foundation for achieving water quality goals in the Leon River watershed.

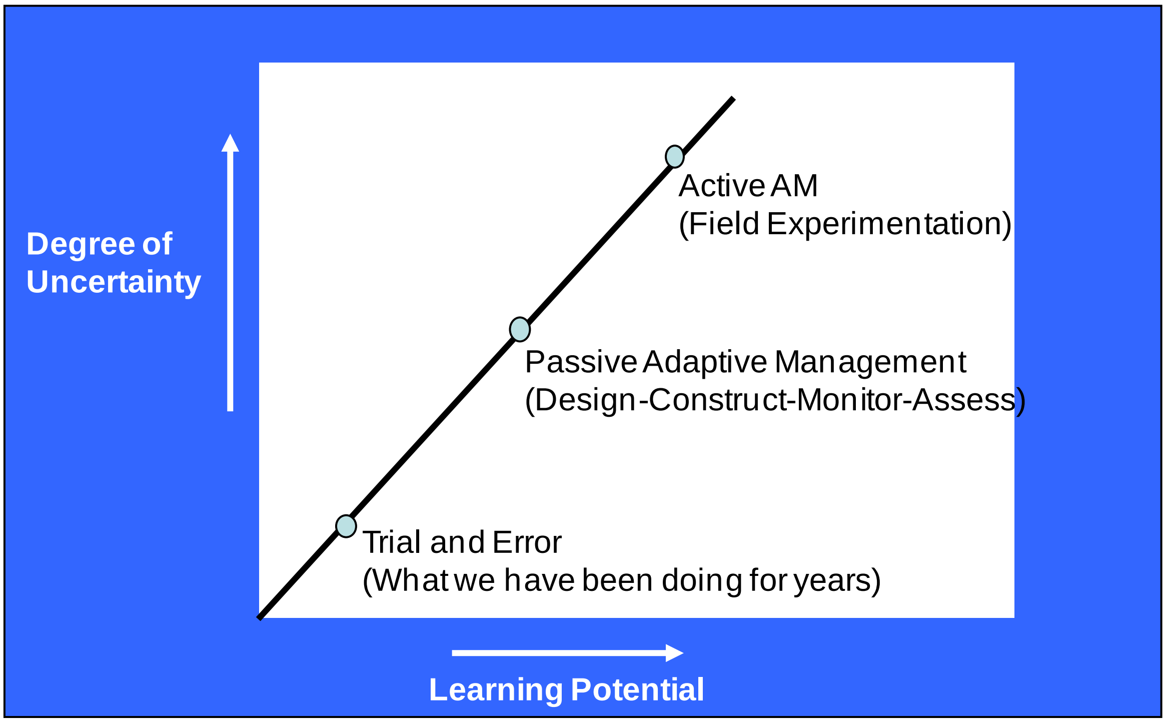
Figure 2.3 Balancing the Complexities of Water Quality Restoration through Adaptive Management

Stakeholder concerns must be addressed by committing resources to address stakeholder needs.

2.4 Adaptive Management and Sustainability

Despite these complex issues, stakeholders acknowledge that this WPP is their opportunity to set locally appropriate goals, coordinate actions, and support an adaptive management and sustainability approach to address bacteria and nutrient problems in the watershed. Figure 2.4 is a diagram that offers a definition of the concept of adaptive management.

Figure 2.4 Adaptive Management Principles



Adaptive management - A natural resource management approach in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices (USEPA 2000).

Applying the discipline of adaptive management is beneficial when there are high levels of uncertainty and/or disagreement about how well environmental systems and response are understood and what the desired endpoint or goal should be. In the Leon River watershed, there is a high level of uncertainty associated with the environmental systems and their responses and there are options for what the desired water quality goal should be. Adaptive management helps stakeholders and water resource managers maintain flexibility in their decisions, knowing that uncertainties exist (Williams, Szaro, and Shapiro 2009). This approach provides a framework for taking actions in the face of critical uncertainties, and a formal process for reducing those uncertainties so that management performance can be improved over time (Williams, Szaro, and Shapiro 2009). Based on these conditions in the Leon River watershed, and using Figure 2.4 to help identify the best outcome based on adaptive management principles, the water resource management approach should aim for the upper one-third of the line graph by attempting a more active adaptive management approach. **For the Leon River watershed stakeholders, the success of this WPP will in large part be based on the commitment to and effectiveness of an adaptive management approach.**

Through an adaptive management approach, the integration of economic, environmental, and social data can advance sustainability. Figure 2.5 displays the importance of the integration of three factors – economic, environmental, and social. These three components are often referred to as the triple-bottom line in sustainability.

Figure 2.5 Advancing Sustainability

Source: Parsons Water & Infrastructure Inc. 2010 and W.M. Adams 2006.

By integrating these three factors into water resource management decisions, the concept of sustainability, which includes life-cycle cost analysis (the economic sector of the triple bottom line) and life-cycle assessments (the environmental and social sector of the triple bottom line), assists decision makers. Watershed-based approaches such as those summarized in this WPP are one of many tools available to citizens, governments, and water resource managers that can advance the principles of sustainability.

Landowners, county and municipal officials, and businesses recognize that by expanding their commitment to continued stewardship to the extent that resources allow will enhance water quality, a resource vital to maintaining their quality of life.

Chapter 3: Water Quality Conditions in the Leon River Watershed

3.1 Introduction

There are vast amounts of data available to provide an in-depth summary of the water quality conditions in the Leon River watershed; however, there are insufficient health data to adequately quantify the risk of human illness resulting from elevated levels of bacteria. At the end of 2008 there were over 6,100 water quality measurement values collected from the Leon River watershed reported by various agencies for numerous parameters dating back as far as 1968. Although there are substantial amounts of data from which to determine the water quality conditions of the watershed, there are still uncertainties regarding bacteria and nutrient sources and the fate and transport of these pollutants. This is due in large part to the dynamic and constantly changing environmental conditions of the watershed. There are many factors that affect the survival and detectability of microbial pathogens in surface water, including age, pH, temperature, sunlight, sediment characteristics, and predation (Gunnison 1999). The factors affecting survival almost never occur in isolation; their interaction can enhance or degrade the ability of microorganisms to survive depending on location and characteristics of the body of water (Gunnison 1999). While the abundance of nutrients can play a major role in survival of bacteria (Brettar and Hofle 1992), and resuspension of bacteria from sediments in some waterbodies can occur, microorganisms constantly age as they move through a watershed. However, in general the sum total of all these factors over time is a decrease in the overall concentration of microbial pathogens in an aquatic system (Gunnison 1999).

This chapter describes existing surface water quality standards, water quality impairments, and concerns. The local perspective on water quality is also described. The chapter closes with a discussion of water quality goals for the Leon River WPP and what would happen if there is no action.

3.2 Current Surface Water Quality Standards – Numeric and Narrative

Water quality in the Leon River watershed has been monitored and assessed since 1974 by the State of Texas to satisfy requirements of the CWA. TCEQ is responsible for evaluating the status of water quality throughout the State where sufficient data are available. Using a well-defined protocol for the analysis of ambient water quality data, TCEQ prepares a summary of waterbodies that are supporting or not supporting their designated uses and for which there are water quality concerns. It is the best means available to identify potential risks to human health and aquatic life based on statistical analysis of long-term ambient water quality data. The most recent USEPA-approved water quality assessment of the Leon River and its tributaries is derived from the 2008 Texas Water Quality Inventory and §303(d) List. The designated uses assigned to the Leon River found in the *Texas Surface Water Quality Standards* (30 TAC §307), are contact recreation, public water supply, and high aquatic life (TCEQ 2000b). Indian Creek and Pecan Creek are assigned an intermediate aquatic life use (TCEQ 2000b). The SWQS also specify the numeric and narrative criteria used to determine if these uses are supported.

The numeric criteria for assessing contact recreation use for the Leon River and its tributaries include a long-term geometric mean criterion of 126 colony-forming units of bacteria per 100 milliliters of water (cfu/100mL), and a single sample criterion of 394 cfu/100mL for *E. coli* bacteria. Recreation use is not supported if the geometric mean concentration of *E. coli* in the samples collected over the assessment period (two to seven years) exceeds the criterion or if the criterion for individual samples is exceeded greater than 25 percent of the time (TCEQ 2008b).

The high aquatic life use is assessed using both dissolved oxygen (DO) and nutrients. The numeric criterion for DO for Leon River is 5.0 milligram per liter (mg/L) (TCEQ 2000b). The numeric criterion for DO for Indian Creek and Pecan Creek is 4.0 mg/L (TCEQ 2000b). Numeric screening levels are also set by the TCEQ to protect waterbodies from excessive nutrient levels to support the general uses outlined in the SWQS (TCEQ 2000b). The screening levels listed for nutrients and chlorophyll *a* in Table 3.1 were statistically derived from the most recent ten years of surface water quality monitoring (SWQM) data statewide. Using the 85th percentile value suggests that waterbodies that exceed the screening values in Table 3.1 are on average experiencing pollutant concentrations higher than 85 percent of the streams in Texas. It is important to note that this screening level assessment for nutrients only indicate a relative level of concern and not a definitive impairment of the designated use (TCEQ 2009a). A concern for water quality is identified if the screening level is exceeded greater than 20 percent of the time based on the number of exceedances for a given sample size (TCEQ 2008c).

Table 3.1 TCEQ Screening Levels to Identify Water Quality Concerns Associated with Nutrient Enrichment

TCEQ Screening Levels for Freshwater Streams (85th percentile value)		
Ortho-phosphorus	**Chlorophyll *a***	**Nitrate Nitrogen**
0.37 mg/L	14.1 µg/L	1.95 mg/L

3.3 Revised Water Quality Standards

The Texas statewide water quality management program continues to be modified and improved and 2010 presented an important stage in this evolution. In July 2010 TCEQ adopted revisions to the SWQS. This is of critical importance to the future implementation of the Leon River WPP because statewide changes were made to the designated use and associated numeric criterion for contact recreation. While the numeric and narrative criteria summarized in subsection 3.2 above establish the current legal basis for evaluating water quality of the Leon River and its tributaries, it is pragmatic to acknowledge and consider the future implications of changes to the regulatory basis for assessing contact recreation. Table 3.2 presents a comparison of the current SWQS associated with recreational use and the revised SWQS which must still be approved by EPA. The revised SWQS will not affect the nutrient screening levels for streams summarized above in subsection 3.2.

Table 3.2 TCEQ Current and Revised Surface Water Quality Standards Associated with Contact Recreation

Existing Use Category	**Existing Geometric Mean *E. coli* Criterion for Freshwater Streams (cfu/100mL)**
Contact Recreation	126
Noncontact Recreation	605
Revised Use Categories	**Revised Geometric Mean *E. coli.* Criteria for Freshwater (cfu/100mL)**
Primary Contact*	126
Secondary Contact 1*	630
Secondary Contact 2*	1030
Noncontact Recreation*	2060

**** Revised use categories and geometric mean concentration are pending approval from USEPA***
Source: TCEQ 2010a.

Attention must be given to understanding the implications and results of assessing the Leon River and its tributaries using a geometric mean of 206 cfu/100 mL (10 year goal of the WPP) or 126 cfu/100 mL (ultimate goal of the WPP) Consequently, it is prudent to present all remaining sections of this WPP in relation to both. Therefore, to assist the reader of this WPP in evaluating the implications of understanding future actions in relation to these two different potential water quality criteria, data assessment and modeling outputs, where practical, will be presented using the color coded key in Table 3.3 to demonstrate whether actions lead to water quality conditions that support the water quality goal or SWQS for *E. coli*. Additional discussion of the implications of the existing and revised water quality criteria for *E. coli* and its importance to the Leon River watershed stakeholders can be found in subsection 3.7.

Table 3.3 Key for Comparing Water Quality Assessment and Implementation Results based on Existing and Revised *E. coli* Criterion

Maps and Tables	Geometric Mean Ranges	Contact Recreation Condition
	E. coli Geometric Mean = 0 - 125 cfu/100mL	Supports Primary Contact Recreation based on current SWQS
	E. coli Geometric Mean = > 126 but ≤ 206 cfu/100mL	Does not support Primary Contact Recreation based on current SWQS; but achieves the water quality goal set forth in the WPP
	E. coli Geometric Mean = > 206 cfu/100mL	Does not support Primary Contact Recreation based on SWQS or meet the water quality goal set forth in the WPP

3.4 Water Quality Impairments and Concerns

The water quality problems that served as a catalyst for preparation of this WPP are summarized in Table 3.4. Table 3.4 summarizes designated use impairments and water quality concerns within the Leon River watershed using water quality data collected by TCEQ, BRA, and the U.S. Geological Survey (USGS) for the 2008 Texas Water Quality Inventory and 303(d) List. In preparing the 2008 Texas Water Quality Inventory, TCEQ assigns one of five categories to each surface waterbody. The categories indicate the status of water quality in the segment based on assessment results from applying the *2008 Guidance for Assessing and Reporting Surface Water Quality in Texas* (March 19, 2008). Waterbodies that do not support their designated use are placed in category 5, which is further subdivided into subcategories 5a, 5b, and 5c, which represents different TCEQ methods for assigning priority for developing TMDLs as required under federal regulations 40 CFR 130.7(b)(4) and 130.10(b)(2). Subcategory 5a is the group with the highest priority for TMDL development, followed by 5c for medium priority, and 5b for lowest priority (TCEQ 2008c). The remainder of Chapter 3 provides additional supporting information and local knowledge that describes the water quality problems and characteristics of the Leon River watershed. Figure 3.1 displays the geographic extent of the watershed and the general physiographic character of the Leon River watershed.

Figure 3.1 Leon River Watershed

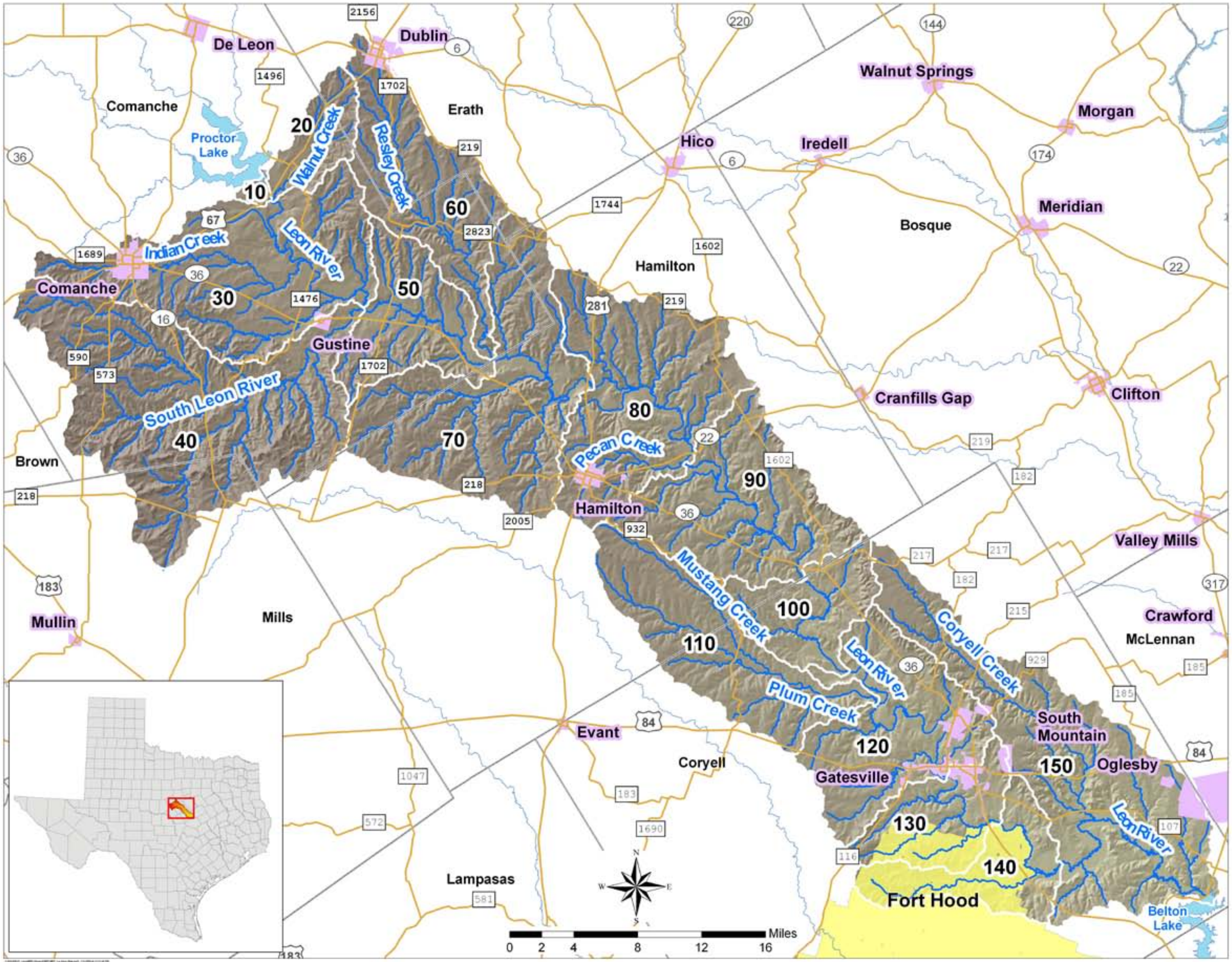


Table 3.4 Water Quality Impairments and Concerns within the Leon River Watershed from 2008 Texas Water Quality Inventory and 303(d) List

Segment or Assessment Units	Subwater-shed(s)	Area	Category	First Listed
		Impairments - Texas 303(d) List		
1221		**Leon River Below Proctor Lake**		
1221_01	130, 140	*Directly upstream of Lake Belton – Bacteria*	5a	1996
1221_04	90, 100, 120	*From confluence with Plum Creek, upstream to confluence with Pecan Creek – Bacteria*	5a	2008
1221_05	50, 70, 80	*From confluence with Pecan Creek, upstream to confluence with South Leon River – Bacteria*	5a	1996
1221_06	30	*From confluence with South Leon Creek upstream to confluence with Walnut Creek – Bacteria*	5a	1996
1221_07	10	*From the confluence with Walnut Creek upstream to Lake Proctor – Bacteria*	5a	1996
1221A		**Resley Creek (unclassified waterbody)**		
1221A_01	60	*Downstream portion, from confluence with Leon River upstream to confluence with unnamed tributary, approx. 1.0 mile N. of Comanche County Line – Bacteria and Dissolved Oxygen*	5c	2004, 2006
1221A_02	60	*From confluence with unnamed tributary, upstream to end of waterbody, approx. 1.0 mile north west of Dublin – Bacteria*	5c	2004
1221B_01	40	**South Leon River (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
1221C_01	80	**Pecan Creek (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
1221D		**Indian Creek (unclassified waterbody)**		
1221D_01	30	*From confluence with Leon River, upstream to confluence with Armstrong Creek – Bacteria*	5c	2006
1221D_02	30	*From confluence with Armstrong Creek upstream to headwaters of waterbody – Bacteria*	5c	2006
1221F_01	20	**Walnut Creek (unclassified waterbody)** *Entire waterbody – Bacteria*	5c	2006
		Concerns - Texas Water Quality Inventory		
1221		**Leon River Below Proctor Lake**		
1221_01	140	*Directly upstream of Lake Belton*	DO Chl-*a*	CS CS
1221_05	50, 70, 80	*From confluence with Pecan Creek, upstream to confluence with South Leon Creek*	DO Chl-*a*	CS CS
1221_06	30	*From confluence with South Leon Creek upstream to confluence with Walnut Creek*	Chl-*a*	CS
1221_07	10	*From the confluence with Walnut Creek upstream to Lake Proctor*	DO Chl-*a*	CS CS
1221A		**Resley Creek (unclassified waterbody)**		
1221A_01	60	*Downstream portion, from confluence with Leon River upstream to confluence with unnamed tributary, approx. 1.0 mile N. of Comanche County Line – Bacteria and Dissolved Oxygen*	Chl-a	CS
1221A_02	60	*From confluence with unnamed tributary, upstream to end of waterbody, approx. 1.0 mile north west of Dublin*	OP NO3	CS CS
1221B	40	**South Leon River (unclassified waterbody)**		

Segment or Assessment Units	Subwater-shed(s)	Area	Category	First Listed
		Entire waterbody	DO	CS
1221D		**Indian Creek (unclassified waterbody)**		
1221D_01	30	*From confluence with Leon River, upstream to confluence with Armstrong Creek*	DO	CN
1221D_02	30	*From confluence with Armstrong Creek upstream to headwaters of waterbody*	OP NO3	CS CS

Source: TCEQ 2008a Texas Water Quality Inventory and 303(d) List.
http://www.tceq.texas.gov/waterquality/assessment/08twqi/twqi08.html

5a = A TMDL is underway or scheduled

5c = Additional data and information will be collected before a TMDL is scheduled

Nutrients: Chl-a = chlorophyll *a*; OP = orthophosphorus; NO3 = nitrate

CN - Concern for near-nonattainment of the Water Quality Standards

CS - Concern for water quality based on screening levels

The TCEQ 2008 water quality assessment was based on data collected in the most recent seven years prior to the assessment (December 1, 1999 through November 30, 2006) for parameters with adequate datasets, and up to ten years if needed to attain a minimum sample number for assessment (TCEQ 2008a). While there is additional data prior to 2001 that can be used to summarize conditions in the watershed, most data in this report represent conditions after 2000. The quality of water described in this report represents a snapshot of conditions during the time period considered in the 2008 assessment (TCEQ 2008a). TCEQ is currently conducting the statewide 2010 water quality assessment and released a draft 2010 Integrated Report, which is a combination of the Texas Water Quality Inventory and §303(d) List, for public comment in February 2010. TCEQ approved submitting the final 2010 Integrated Report to USEPA in August 2010 . With the exception of segment 1221C_01 (Pecan Creek), the list of impaired waterbody/pollutant combinations provided in Table 3.4 are still recommended for listing in category 5 of the draft 2010 §303(d) List (TCEQ 2010).

3.5 Bacteria

As previously stated, placement of the Leon River and certain tributaries on the §303(d) List caused the TCEQ to develop a draft bacteria TMDL, a legal requirement of the CWA. The water quality impairments of the contact recreation use caused by elevated levels of *E. coli* are based on data collected from a select group of SWQM stations in the Leon River watershed. Water quality data collected by different entities are available at 30 different SWQM stations throughout the watershed. Table 3.5 provides a list of these SWQM stations where water quality data were collected at some time over the past 10 years. However, data analysis results presented in this report only represent the assessment of water quality data collected by BRA and TCEQ from 23 of those SWQM stations since this data set is available from the TCEQ surface water quality database and correlates best with the data set TCEQ used for preparation of the draft 2010 Integrated Report (TCEQ 2010).

Using the data analysis results from these 23 SWQM stations, Figures 3.1 and 3.2 were prepared to provide a summary of the statistical analysis of *E. coli* samples that represent ambient water quality conditions between 2001 and 2008. As a reminder, data analysis results in Figures 3.1 and 3.2 as well as other tables in this chapter are presented using the color code in Table 3.3 to demonstrate whether water quality conditions support the existing or revised water quality criterion for *E. coli*. The 15 subwatersheds used throughout this WPP and displayed in Figure 3.2 are derived from the watershed-loading model developed for the draft bacteria TMDL used to support evaluation of management strategies discussed in Chapter 5. Figures 3.1 and 3.2 present a general summary of the spatial extent and temporal trends of the contact recreation use impairment in the Leon River watershed.

Table 3.5 Water Quality Monitoring Stations in the Leon River Watershed

Subwatershed	Water Body	SWQM Station	USGS Gage Station	SWQM Station Description	County	Monitoring Agency
10	Leon River	11934	08099500	Leon River immediately downstream of US 67/ US 377, downstream Lake Proctor	Comanche	BRA
20	Walnut Creek	17379		Walnut Creek at FM 1476, south of Proctor	Comanche	BRA
30	Indian Creek	11818		Indian Creek at Comanche, County Road 304, 3.51 kilometers upstream of the confluence with the Leon River	Comanche	BRA
30	Indian Creek	17542		Indian Creek at SH 36, east of Comanche	Comanche	BRA
30	Leon River	17591		Leon River immediately upstream of Comanche, County Road 340, north of Gustine	Comanche	BRA
40	South Leon River	11817		South Leon River, 20 meters downstream of SH 36, east of Gustine	Comanche	BRA
50	Leon River	15769		Leon River at FM 1702, 4 miles east of Gustine	Comanche	BRA
50	Leon River	18781		Leon River at Hamilton, County Road 109	Hamilton	BRA
60	Resley Creek	11808		Resley Creek at Comanche, County Road 394, 740 meters upstream of the confluence with the Leon River	Comanche	BRA
60	Resley Creek	17376		Resley Creek at FM 1702, south of Dublin	Erath	BRA
60	Resley Creek	17377		Resley Creek at FM 2823, west of Carlton	Comanche	BRA

Subwatershed	Water Body	SWQM Station	USGS Gage Station	SWQM Station Description	County	Monitoring Agency
60	Resley Creek	17477		Resley Creek, 299 meters upstream Comanche, County Road 392 west of Comanche County, Road 396 northeast of Lamkin	Comanche	BRA
60	Resley Creek	309[1]		Resley Creek at County Road 309	Erath	ARS
60	Resley Creek	394[1]		Resley Creek at County Road 394	Comanche	ARS
60	Resley Creek	2823[1]		Resley Creek at County Road 2823	Comanche	ARS
70	Leon River	11932	08100000	Leon River immediately downstream of US 281, north of Hamilton	Hamilton	BRA
80	Pecan Creek	17547		Pecan Creek at SH 22, east of Hamilton	Hamilton	BRA
80	Leon River	64[1]		Leon River upstream of SH 22	Hamilton	Texas AgriLife Research
90	Leon River	11930		Leon River at Hamilton, County Road 431, 1.6 km downstream of SH 36 southwest of Jonesboro	Hamilton	BRA
100	Leon River	11929		Leon River, 18 meters upstream of Coryell County Road 183 northeast of Levita	Coryell	BRA
110	Plum Creek	18405		Plum Creek 10 meters downstream of Coryell County Road 106 near Levita	Coryell	BRA
110	Mustang Creek	3340[1]		Mustang Creek at County Road 3340	Hamilton	ARS
110	Mustang Creek	101[1]		Mustang Creek at County Road 101	Coryell	ARS
120	Leon River	11928	08100500	Leon River Bridge on US 84 in Gatesville	Coryell	BRA

Subwatershed	Water Body	SWQM Station	USGS Gage Station	SWQM Station Description	County	Monitoring Agency
120	Leon River	17501		Leon River at Faunt Leroy Park immediately east of S. 7th St., 452 meters South of College St., 2.78 km downstream of US 84 in Gatesville	Coryell	BRA
120	Leon River	17545		Leon River at Moccasin Bend Road, northwest of Gatesville	Coryell	BRA
120	Leon River	63[1]		Leon River Bridge upstream of US 84	Coryell	Texas AgriLife Research
130	Leon River	11926		Leon River at SH 36 southeast of Gatesville	Coryell	BRA
130	Leon River	11927		Leon River immediately downstream of Straws Mill Road, 2.5 kilometers upstream of SH 36	Coryell	BRA
140	Leon River	11925		Leon River immediately downstream of FM 1829, southeast of North Fort Hood	Coryell	BRA

[1] Station identification numbers were assigned by the respective monitoring entity and are not TCEQ SWQM station identification numbers.

Figure 3.2 Assessment of Contact Recreation Use Based on Geometric Mean of *E. coli* Data

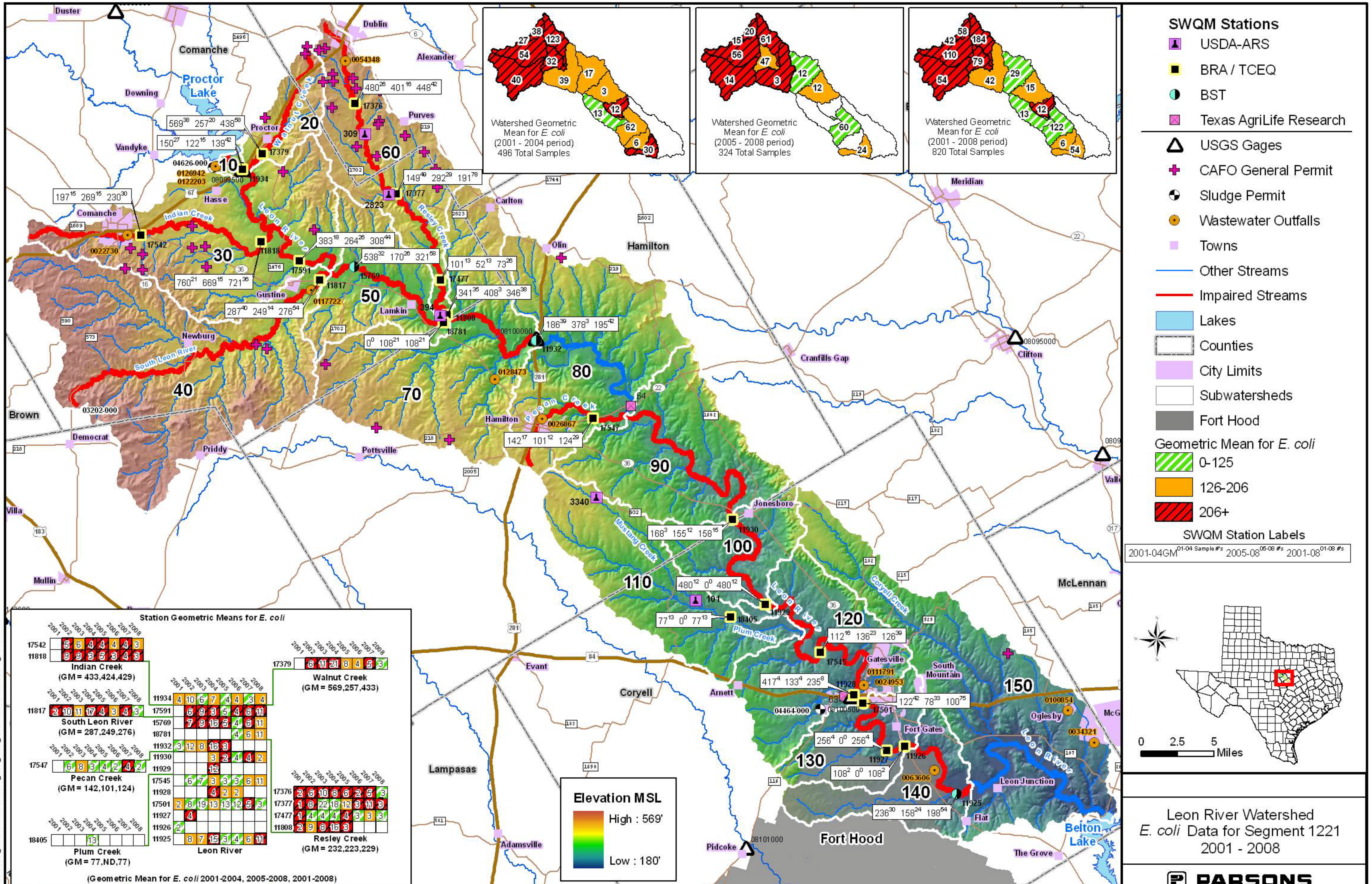
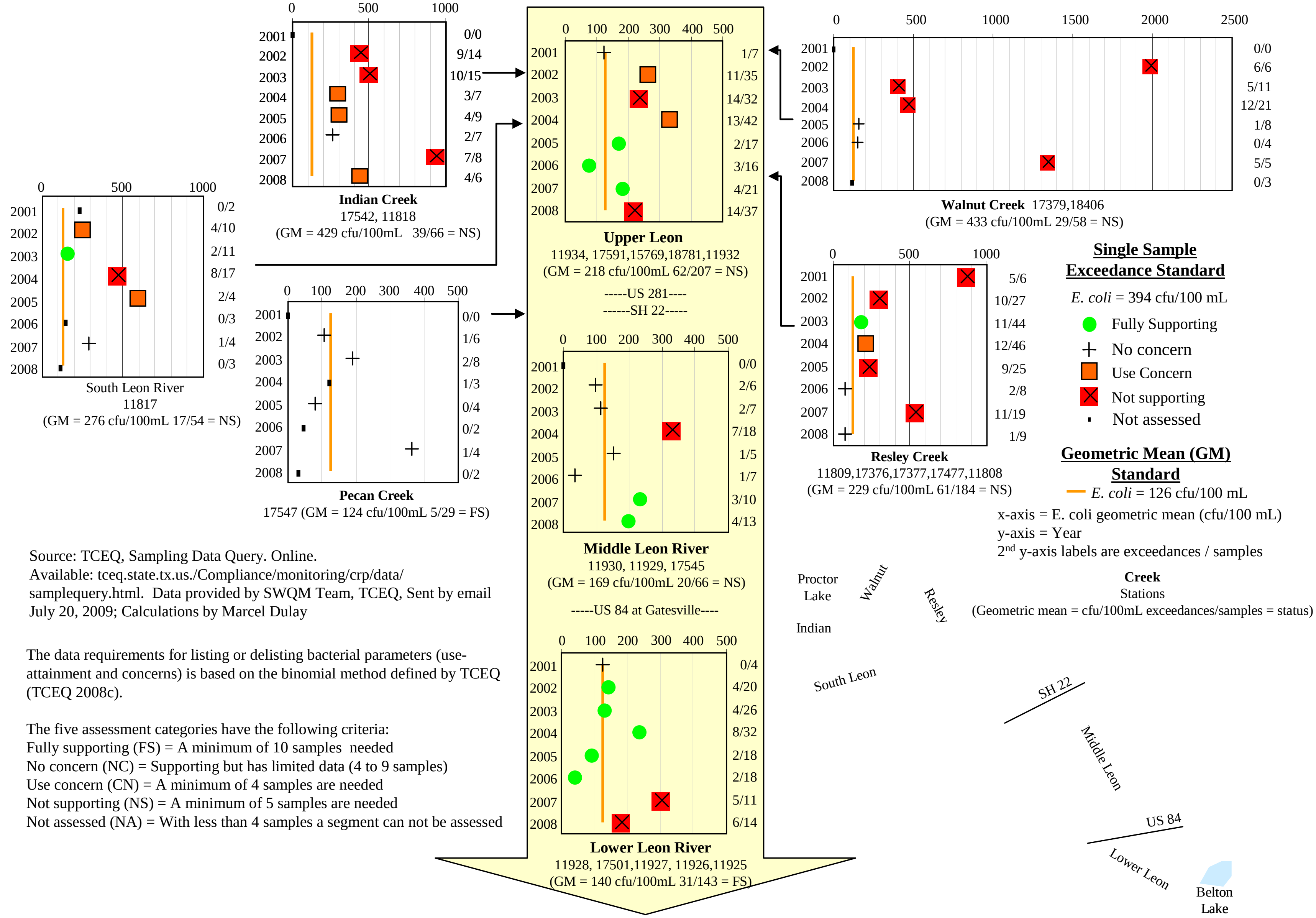


Figure 3.3 Annual Summary of *E. coli* Data by Creek - 2001-2008



Source: TCEQ, Sampling Data Query. Online. Available: tceq.state.tx.us./Compliance/monitoring/crp/data/samplequery.html. Data provided by SWQM Team, TCEQ, Sent by email July 20, 2009; Calculations by Marcel Dulay

The data requirements for listing or delisting bacterial parameters (use-attainment and concerns) is based on the binomial method defined by TCEQ (TCEQ 2008c).

The five assessment categories have the following criteria:
Fully supporting (FS) = A minimum of 10 samples needed
No concern (NC) = Supporting but has limited data (4 to 9 samples)
Use concern (CN) = A minimum of 4 samples are needed
Not supporting (NS) = A minimum of 5 samples are needed
Not assessed (NA) = With less than 4 samples a segment can not be assessed

Data in Figure 3.2 are summarized to represent three different time frames 2001- 2004, 2005-2008, and 2001-2008. The data are subsequently presented for these three time periods in Table 3.6 to provide additional detail on spatial and temporal changes in *E. coli* concentrations. The rationale for providing data analysis results for three different time frames was driven by pre-determined conditions, including existing data limitations, model development, natural phenomena, and TCEQ data analysis methods. These pre-determined conditions are:

1. The existing watershed loading model established to support development of the draft bacteria TMDL - Hydrologic Simulation Program FORTRAN (HSPF) - was based on fecal coliform and calibrated for the period 2000-2004. Therefore, this time frame established a base condition from which to convert model outputs of fecal coliform concentrations to *E. coli* concentrations. A more detailed explanation of the conversion from fecal coliform model outputs to *E. coli* results is provided in subsection 4.7.2.
2. It was decided that 2000 should be removed from the period of analysis because this was an abnormally wet year and the model calibration was not sufficient to account for such large variations in flow. Such weather conditions are also not typical of climate conditions in the area.
3. The change by TCEQ to use *E. coli* starting in 2001 as a bacteria indicator decreased fecal coliform data availability, which ultimately terminated in 2004. However, because *E. coli* samples overlapped for the period between 2001 and 2004, it was possible to draw relationships between the two parameters (see discussion in subsection 4.7.2). This was another reason 2000 was removed from the period of analysis.
4. Discussions were held on whether to recalibrate the model between 2001 and 2008 with *E. coli* data. This was deemed cost prohibitive as many watershed-specific coefficients and other related inputs were still under development and not available for this WPP. To respond to the fact that an entirely new *E. coli* model could not be created to support this project, the fecal coliform simulation results were converted to *E. coli* and compared against sample data of existing *E. coli* data (2001-2004). Comparisons were reasonable and the converted model outputs (2001-2004) were used as a surrogate to understand the general magnitude of *E. coli* concentrations expressed as geometric means over time for the watershed.
5. The rationale for presenting water quality data analysis results from 2001-2008 is derived from the fact that it demonstrates a seven-year assessment period typically used by TCEQ for water quality assessments. TCEQ used the data period of December 1, 2001 through November 30, 2008 for preparing the draft 2010 §303(d) List (TCEQ 2010). The geometric mean concentrations calculated from the 2001-2008 period are most relevant for comparison with the model outputs to better depict the magnitude of pollutant concentrations that may be achievable from implementing management strategies in the future. The data analysis results in Figure 3.2, 3.3, and Table 3.6 for 2005-2008 is provided for informational purposes only to display short-term trends.

Table 3.6 Summary of *E. coli* Data for All Subwatersheds – 2001-2008

Watershed and Waterbody	SWQM Stations	2001-04 GM	2001-04 No. of Samples	2005-08 GM	2005-08 No. of Samples	2001-08 GM	2001-08 No. of Samples
10 - Leon River below Proctor Lake Dam	11934	**150**	27	**122**	15	**139**	42
20 - Walnut Creek	17379	**569**	38	**257**	20	**433**	58
30 - Indian Creek	17542, 11818	**433**	36	**424**	30	**429**	66
30 – Leon River	17591	**383**	18	**264**	26	**308**	44
40 - South Leon River	11817	**287**	40	**249**	14	**276**	54
50 - Leon River	15769, 18781	**538**	32	**139**	47	**241**	79
60 - Resley Creek	17376, 17377, 17477, 11808	**232**	123	**223**	61	**229**	184
70 - Leon River	11932	**186**	39	**378**	3	**195**	42
80 - Pecan Creek	17547	**142**	17	**101**	12	**124**	29
90 - Leon River above Jonesboro	11930	**168**	3	**155**	12	**158**	15
100 - Leon River	11929	**480**	12	—	ND	**480**	12
110 - Plum Creek	18405	**77**	13	—	ND	**77**	13
120 - Leon River, Gatesville	17545, 17501, 11928	**129**	62	**100**	60	**114**	122
130 - Leon River below Gatesville	11927, 11926	**192**	6	—	ND	**192**	6
140 - Leon River	11925	**236**	30	**158**	24	**198**	54
150 - Coryell Creek	Not assessed	—	ND	—	ND	—	ND

GM = Geometric Mean
ND = No data

Table 3.6 provides additional detail on the trends and severity of exceedances of the geometric mean for aggregated *E. coli* data in each subwatershed. For all subwatersheds, except subwatershed 70, which only had three samples in four years, *E. coli* concentrations appear to have declined from the period 2001-2004 to 2005-2008. As displayed in Figure 3.2 the upper portion of the Leon River watershed (subwatersheds 20, 30, 40, 50, 60, and 70) has the highest exceedances of the *E. coli* geometric mean of 126 cfu/100mL. Subwatersheds 100 and 130 show high levels of *E. coli* between 2001 and 2004, but the small data sets of only 12 and 6 samples, respectively, and the lack of recent data collected do not provide an adequate characterization of water quality conditions for contact recreation. Subwatershed 150 has not been assessed since there are no data available for this portion of the Leon River mainstem nor Coryell Creek. The various colors differentiating geometric mean values in Table 3.6 correspond to the color-coded legend in Table 3.3.

Additional bacteria data available from select SWQM stations in the Leon River watershed were collected by U.S. Department of Agriculture (USDA) - Agricultural Research Service (ARS) (USDA-ARS 2009) and Texas AgriLife Research and are provided in Table 3.7 for informational purposes only. The location of these agency's monitoring stations can also be found on Figure 3.2. These data were not combined with the data used to calculate geometric means in Figures 3.1 and 3.2 or Table 3.6 above because these data were not collected under a TCEQ-approved Quality Assurance Project Plan (QAPP) and are not part of the TCEQ water quality data set used for the 2008 Texas Water Quality Inventory and 303(d) List. The Texas AgriLife Research SWQM station 64 at Hwy 22 provides data for a SWQM station that TCEQ or BRA have not traditionally assessed. The data at this SWQM station indicates that the Leon River between Hwy 281 and Hwy 22 (subwatershed 80) does not exceed the numeric criterion for *E. coli* (Texas AgriLife Research 2009). The ARS stations on Mustang Creek in subwatershed 110 represent "background" conditions of *E. coli* concentrations since this subwatershed is representative of least impacted conditions. The geometric mean of *E. coli* samples from these two sites range from 57 to 180 cfu/100mL (USDA-ARS 2009). The *E. coli* concentrations from Mustang Creek suggest that bacteria loading at a subwatershed scale can be above the SWQS criterion of 126 cfu/100mL even in the absence of anthropogenic activities. The data analysis results computing the geometric mean using the ARS samples collected in Resley Creek indicate elevated levels of *E. coli* similar to those demonstrated by the data results shown in Table 3.6.

Table 3.7 Additional SWQM Stations with *E. coli* Data in the Leon River Watershed

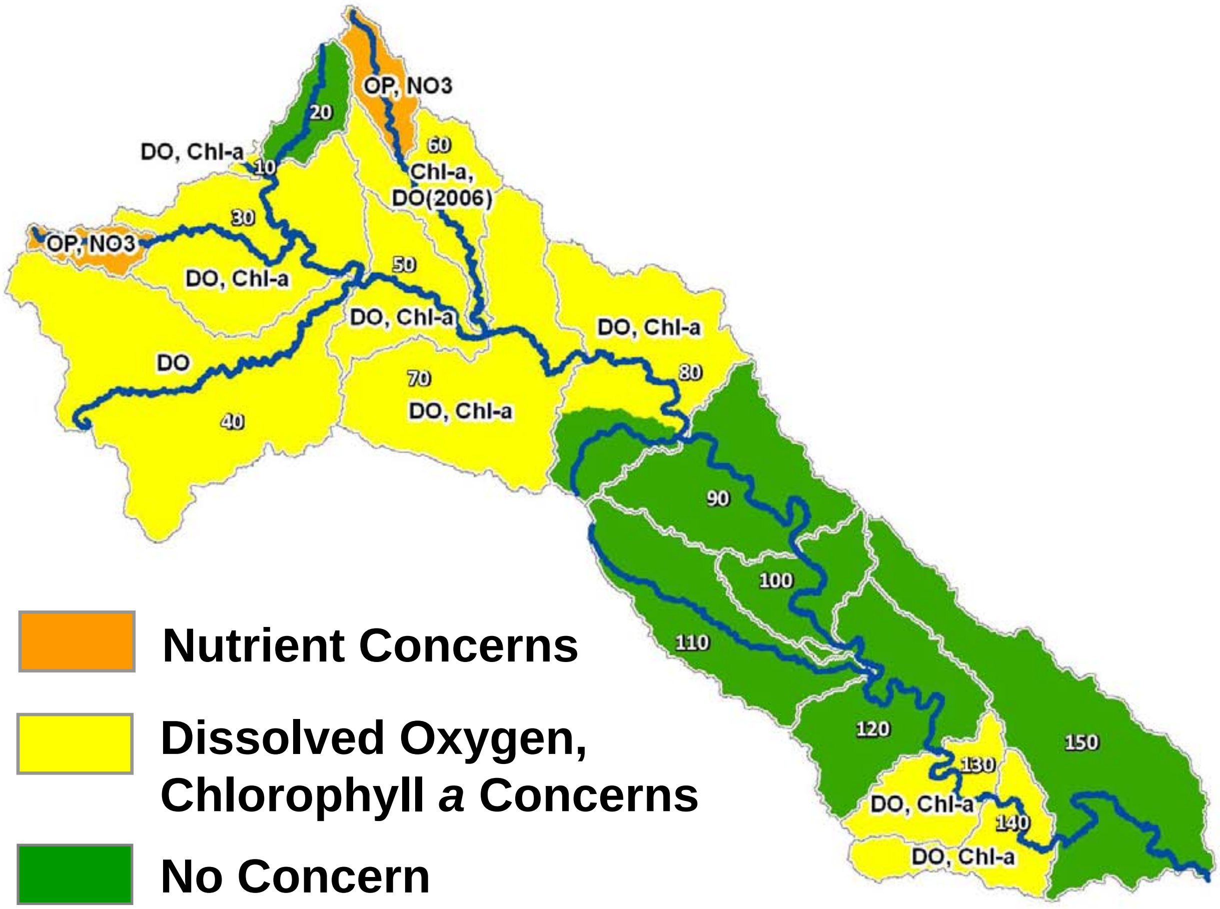
SWQM Station ID[1]	Entity	Station Location	Period of Record	Number of *E. coli* Samples/ Geometric Mean
Leon River Mainstem - Subwatershed 80 and Subwatershed 120				
63	Texas AgriLife Research	Leon River at Leon St. in Gatesville, TX	January 2005 – January 2008	49 samples 15 cfu/100mL
64	Texas AgriLife Research	Leon River at Hwy 22	January 2005 – January 2008	53 samples 23 cfu/100mL
Resley Creek – Subwatershed 60				
309	ARS	Resley Creek at County Road 1702	March 2006 - August 2008	19 samples 457 cfu/100mL
394	ARS	Resley Creek at County Road 394	March 2006 - August 2008	24 samples 209 cfu/100mL
2823	ARS	Resley Creek at County Road 2823	March 2006 - August 2008	35 samples 207 cfu/100mL
Mustang Creek – Subwatershed 110				
101	ARS	Mustang Creek at Road 101	February 2005 - August 2008	69 samples 57 cfu/100mL
3340	ARS	Mustang Creek at FM 3340 south of County Road 932	February 2005 - August 2008	54 samples 180 cfu/100mL

[1] Station identification numbers were assigned by the respective monitoring entity and are not TCEQ SWQM station identification numbers.

3.6 Nutrients, Chlorophyll *a*, and Dissolved Oxygen

Table 3.4 above and Figure 3.4 below present a general summary of the spatial extent of the water quality concerns for nutrients, chlorophyll *a*, and DO in the Leon River watershed based on ambient water quality data collected from 2001 through 2008. Figure 3.4 displays the spatial extent of the concerns as identified in the 2008 Texas Water Quality Inventory (TCEQ 2008a).

Figure 3.4 Water Quality Concerns Identified in Leon River Watershed



Source: 2008 Texas Water Quality Inventory, TCEQ.

Figure 3.5 provides a summary of the temporal trends of the water quality concern for nitrate-nitrogen for selected subwatersheds. Figure 3.5 indicates that Indian Creek (subwatershed 30) and Resley Creek (subwatershed 60) have the highest annual average concentrations of nitrate-nitrogen (mean = 11.50 mg/L and 1.32 mg/L, respectively). The elevated nitrate-nitrogen concentrations in Indian Creek are most likely contributing to the high levels of chlorophyll *a*. Although nitrate-nitrogen mean concentrations still exceed the screening level of 1.95 mg/L, Indian Creek did experience a reduction from its peak average concentration in 2005 of 18.7 mg/L to 10.9 mg/L in 2008 (2007 average concentration was 9.1 mg/L).

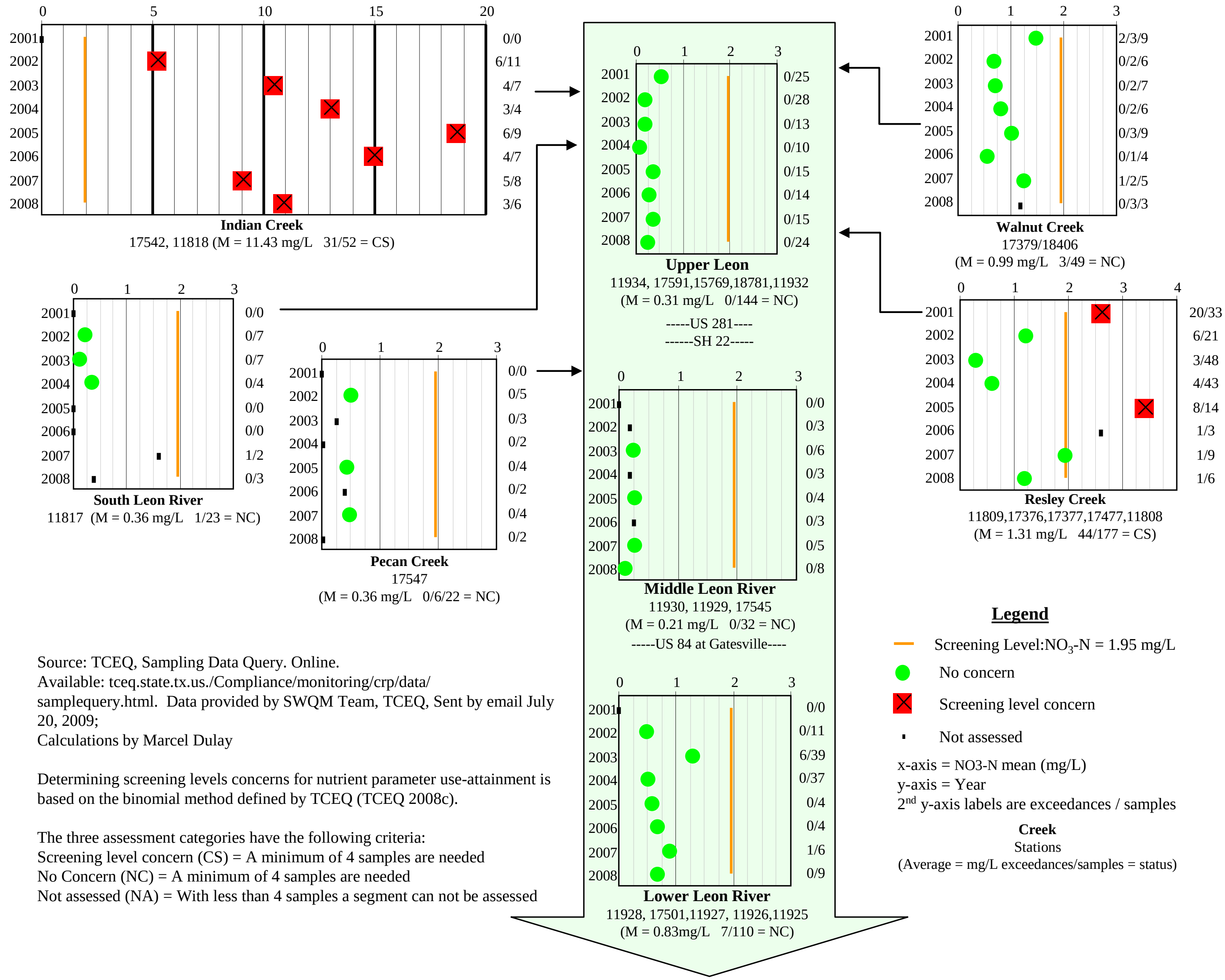
Figure 3.6 provides a summary of the temporal trends of the water quality concern for orthophosphorus for select subwatersheds. Figure 3.6 indicates that Indian Creek (subwatershed 30) and the lower Leon River (subwatersheds 130 and 140) have the highest concentrations of orthophosphorus (mean = 0.39 mg/L and 0.25 mg/L, respectively). The available data indicate that, for those subwatersheds with water quality concerns throughout the entire period of record, there is no trend indicating a shift toward higher mean concentrations of nutrients, with most even showing decreasing concentrations. It should be noted that the concern for nitrate-nitrogen and orthophosphorus in the orange subwatershed shown in Resley

Creek in Figure 3.4 is based on analysis by TCEQ using data from the two upstream-most SWQM stations. However, in Figure 3.6, the water quality status for Resley Creek suggests no concern because the data set presented in this figure was much larger since it combined samples from five different Resley Creek SWQM stations.

High levels of chlorophyll *a* and low DO are biochemical responses to excessive nutrient loading in river systems. Tables 3.8 and 3.9 provide summaries of the data analysis associated with the water quality concerns for chlorophyll *a* and DO, respectively, displayed in Figure 3.4. A concern for water quality for nutrients and chlorophyll *a* is identified if the screening level listed in Table 3.1 above, is exceeded greater than 20 percent of the time using the binomial method, based on the number of exceedances for a given sample size (TCEQ 2008c).

With no specific numeric criteria at this time for nutrient parameters or chlorophyll *a*, the severity of impacts nutrient levels may have on aquatic life in the Leon River and its tributaries can only be characterized in a qualitative manner. DO levels in the Leon River will continue to be measured and compared to the criterion of 5.0 mg/L and 4.0 mg/L (Indian Creek and Pecan Creek) to indicate instream responses to elevated nutrient loadings. While elevated chlorophyll *a* levels are a direct response to elevated nutrient loadings, no specific water quality goal will be established for nutrient parameters or chlorophyll *a* at this time. However, over the next five years as nutrient data from the Leon River watershed are collected, the data can be used to provide valuable scientific information that could be used by TCEQ to develop and adopt numeric water quality criteria for nutrients in streams in the future.

Figure 3.5 Annual Summary of Nitrate-Nitrogen Data by Creek - 2001-2008

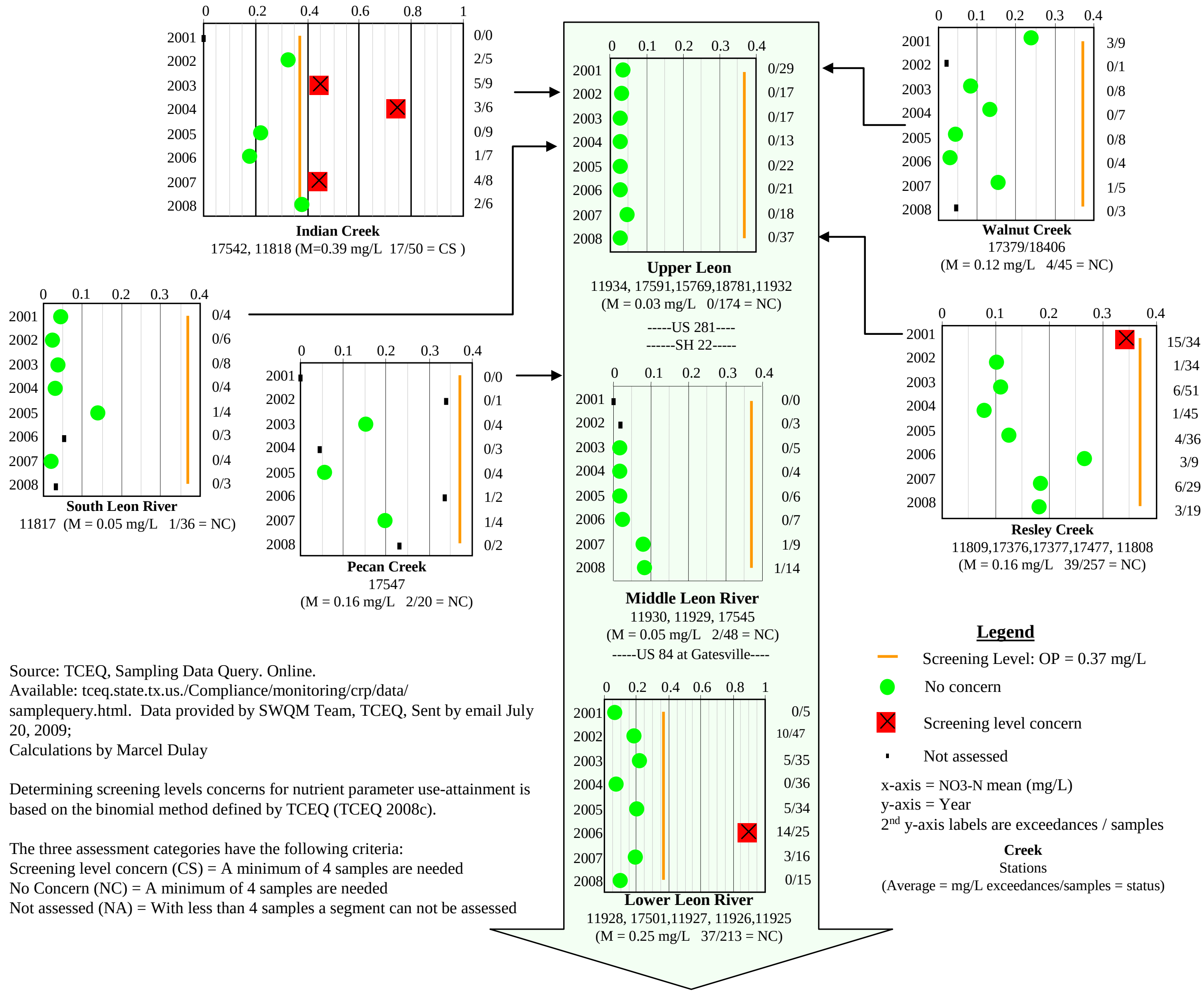


Source: TCEQ, Sampling Data Query. Online.
Available: tceq.state.tx.us./Compliance/monitoring/crp/data/samplequery.html. Data provided by SWQM Team, TCEQ, Sent by email July 20, 2009;
Calculations by Marcel Dulay

Determining screening levels concerns for nutrient parameter use-attainment is based on the binomial method defined by TCEQ (TCEQ 2008c).

The three assessment categories have the following criteria:
Screening level concern (CS) = A minimum of 4 samples are needed
No Concern (NC) = A minimum of 4 samples are needed
Not assessed (NA) = With less than 4 samples a segment can not be assessed

Figure 3.6 Annual Summary of Orthophosphorus Data by Creek - 2001-2008



Source: TCEQ, Sampling Data Query. Online.
Available: tceq.state.tx.us./Compliance/monitoring/crp/data/samplequery.html. Data provided by SWQM Team, TCEQ, Sent by email July 20, 2009;
Calculations by Marcel Dulay

Determining screening levels concerns for nutrient parameter use-attainment is based on the binomial method defined by TCEQ (TCEQ 2008c).

The three assessment categories have the following criteria:
Screening level concern (CS) = A minimum of 4 samples are needed
No Concern (NC) = A minimum of 4 samples are needed
Not assessed (NA) = With less than 4 samples a segment can not be assessed

Table 3.8 Summary of Water Quality Concerns for Chlorophyll *a* – 2001-2008

Waterbody	SWQM Stations	Average Concentration (µg/L)	Maximum Concentration (µg/L)	Samples	Number of Exceedances	Number of Exceedances Allowed[1]	Status
Walnut Creek	17379	14.8	111	36	8	9	No Concern
Indian Creek	17542, 11818	15.3	154	49	12	12	No Concern
South Leon River	11817	12.7	182	29	3	8	No Concern
Resley Creek	17376, 17377, 17477, 11808	17.7	191.52	228	72	51	Screening Level Concern
Pecan Creek	17547	5	18.2	20	3	5	No Concern
Plum Creek	18405, 11806	5	5	1	0	1	Insufficient Data
Upper Leon River	11934, 17591	23.7	91.8	123	90	28	Screening Level Concern
Middle Leon River	15769, 18781, 11932	16.7	80.2	37	18	9	Screening Level Concern
Lower Leon River	11925, 11926, 11927	10.95	67.2	206	51	46	Screening Level Concern

Note: TCEQ Chlorophyll *a* Screening Level = 14.1 µg/L
[1] Number of exceedances allowed to determine water quality concerns based on narrative criteria is derived from binomial method as defined by TCEQ which reduces the likelihood that waterbodies are inappropriately determined to exceed screening levels based on random chance (TCEQ 2008c)

Table 3.9 Summary of Water Quality Concerns for Dissolved Oxygen – 2001-2008

Waterbody	SWQM Stations	Samples	Average Concentration (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)	Number of Exceedances	Exceedances Allowed	Status
Walnut Creek	17379	65	6.5	1.3	18.6	23	7	Screening Level Concern
Indian Creek	17542, 11818	67	7.2	0.9	15.7	8	7	Screening Level Concern
South Leon River	11817	54	7.2	1.5	13.2	11	6	Screening Level Concern
Resley Creek	17376, 17377, 17477, 11808	309	7.8	0.4	16.4	61	29	Not supporting
Pecan Creek	17547	30	8.1	4.1	13.4	2	4	No Concern
Plum Creek	18405, 11806	13	7.2	4.9	9.7	1	2	No Concern
Upper Leon River	11934, 17591	237	7.5	1.3	12.2	23	22	Screening Level Concern
Middle Leon River	15769, 18781, 11932	70	7.4	3.7	12.4	5	7	No Concern
Lower Leon River	11925, 11926, 11927	246	8.5	2.3	14.8	12	23	No Concern

Note: Numeric criterion for DO average concentration is 4.0 mg/L for Indian and Pecan Creek; DO criterion is 5.0 mg/L for all other classified and unclassified segments in the Leon River watershed. The 24-hour minimum DO criterion for all segments in the Leon River is 3.0 mg/L.

3.7 The Local Perspective – Characterizing Water Quality Problems

The Texas Department of State Health Services (DSHS) compiles and maintains disease and injury registries; public health surveys, field investigations, health assessments, and epidemiology studies. Some of this information can be used for assessing community health trends, public health planning, and understanding health concerns across various demographics.

There are no recent epidemiology studies in Texas available to demonstrate direct relationships between instream concentrations of *E. coli* (indicator species for fecal contamination) and corresponding incidents of human illnesses. However, stakeholders requested a qualitative investigation to see if there were any data available that could indicate if recent reported human illnesses were prevalent in the area. Therefore, data summarizing the number of human illness caused by various bacteria, viruses or protozoa from the ingestion of contaminated food or water were obtained from the DSHS Center for Health Statistics in February 2010. DSHS provided data compiled from Comanche, Hamilton, and Coryell counties, collected between 2001 and 2008. Data reporting illnesses associated with pathogens usually transmitted by food or water were analyzed including Campylobacteriosis, Cryptosporidiosis, *E. coli*, Hepatitis A, and Shigellosis. The DSHS stipulates that while the reported illnesses can be associated with waterborne pathogens, it is not possible to discern if the pathogen causing the reported illness was from the ingestion of contaminated food or water, or was transmitted from person to person. All reported cases were laboratory confirmed and some form of probable syndrome was verified (e.g., number of diarrheal episodes within a 24-hr period).

There are many factors (social, environmental, physiological, epidemiological) involved in identifying and reporting illnesses related to water borne pathogens, making it difficult at this time to draw any firm conclusion about water quality conditions and human illness cases associated with contact recreation. However a comparison of reported illnesses and instream *E. coli* concentrations was conducted to identify if any qualitative relationships could be discerned. The reported illness data were matched to the geometric mean of *E. coli* for ambient water quality by year and county. Table 3.10 presents the results of the number of cases in each county along with the geometric mean. Figure 3.7 presents a plot of the number of cases versus geometric mean by county over time.

Table 3.10 County Summary of Reported Illnesses Related to Waterborne Pathogens

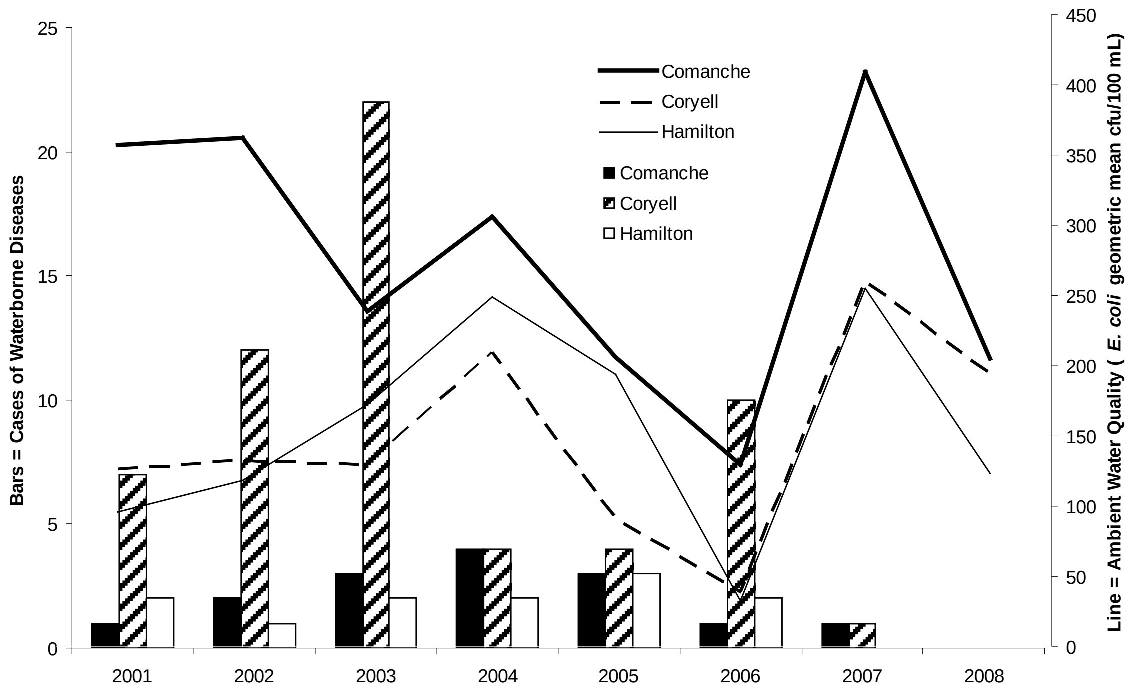
County	Year	*E. coli* Geometric Mean (cfu/100 mL)	Number of *E. coli* Samples[1]	Reported Illness Cases
Comanche	2001	357	10	1
Comanche	2002	363	74	2
Comanche	2003	239	95	3
Comanche	2004	306	109	4
Comanche	2005	207	54	3
Comanche	2006	130	32	1
Comanche	2007	409	46	1
Comanche	2008	205	44	0
Coryell	2001	127	4	7
Coryell	2002	133	26	12
Coryell	2003	129	33	22
Coryell	2004	209	60	4
Coryell	2005	91	21	4
Coryell	2006	39	21	10
Coryell	2007	260	17	1
Coryell	2008	193	25	0
Hamilton	2001	95	3	2
Hamilton	2002	119	18	1
Hamilton	2003	173	16	2
Hamilton	2004	249	22	2
Hamilton	2005	194	9	3
Hamilton	2006	33	10	2
Hamilton	2007	255	14	0
Hamilton	2008	123	15	0

[1] Number of samples is aggregate of samples collected from monitoring stations in Leon River watershed within respective county.

Source: Texas Department of State Health Services, Emerging & Acute Infectious Disease (EAID) Branch, provided by Venessa Cantu via email, March 4, 2010.

Geometric mean calculations by Parsons.

Figure 3.7 County Summary of Reported Illnesses Related to Waterborne Pathogens



Data Source: Texas Department of State Health Services, Emerging & Acute Infectious Disease (EAID) Branch, provided by Venessa Cantu via email, March 4, 2010.

The evaluation of this data is only provided to give some general insight about the extent of reported illnesses from waterborne pathogens in the Leon River. It is not intended to be a definitive study about the relationship between reported illnesses and instream *E. coli* concentrations. A detailed epidemiology study would be necessary to determine if such a relationship exists. Coryell County has the highest number of cases, which is expected because the population of the county is higher than the other three counties. Water quality data peaks for the same period do not coincide and it appears there is little relationship between water quality and cases for Coryell County. Comanche County does appear to have a small spike of cases in 2004 and here again there appears to be no relationship to water quality. In addition, there was an observed spike in 2007 of instream bacteria concentrations that did not result in an increased number of reported illnesses. Although the data samples are too few to attempt a statistical analysis for trends, the data visually suggests that there is no relationship between increased bacteria concentrations in surface water and increased incidents of waterborne diseases in the Leon River watershed.

A concern expressed by the Leon River watershed stakeholders is that requiring additional management practices may impose unfair costs or hinder the ability to use their land. Landowners who have livestock businesses are currently facing higher costs of production with prices staying relatively the same, which makes them sensitive to any additional financial burdens. Certain landowners may be on fixed incomes and would find it difficult to pay for implementing additional expensive measures. Others such as absentee owners are not likely to implement land management changes without first understanding the issues or becoming engaged in finding solutions to water quality problems. Some landowners may be reluctant to change certain practices that might alter historical cultural activities. It is difficult for landowners to justify significant expenditures given the level of uncertainty in the science surrounding bacteria life stages in the environment and the historical basis for the current numeric criterion for contact recreation. This is especially difficult to justify when there is no medical evidence that links illness to contact recreation with waters in the region. Bacterial source tracking (BST) conducted at three SWQM stations on the Leon River in 2004-05 shows that between 41 and 54 percent of bacteria sources originate from wildlife or invasive species (e.g., avian species, mammals, and feral hogs), which also makes addressing bacteria pollutants a challenge. Further, the draft TMDL says wildlife sources are not as significant a risk to human health as human sources of bacteria (TCEQ 2008b).

The SWQS stipulate that all surface waters, unless specifically designated, should be safe for contact recreation. Stakeholders believe that conditions in the Leon River and most of its tributaries do not allow for contact recreation given the low annual average flow conditions and limited accessibility. Although landowners agree that having good water quality is beneficial to the region, to do more than what is already being done should not be forced on them. A better strategy is to provide funds and incentives for landowners to enhance what they are doing and to verify compliance and enforce existing rules.

The resulting challenge is to determine what level of contact recreation use is appropriate for the Leon River versus what degree of implementation is necessary to reduce bacteria levels. There are several issues associated with this challenge that must be addressed through an adaptive management approach, including but not limited to:

- What are the appropriate designated uses that should be applied to the Leon River and its tributaries? The RUAA that has been completed will provide an important step toward addressing this issue.
- How will future data collection efforts be best used to advance adaptive management principles of decision making and performance evaluation? Data collection efforts must evolve over the life of the WPP to provide better feedback loops to decisions makers and stakeholders on where and how to adjust management strategies.
- Is it reasonably possible to achieve the water quality goals established in the WPP? Stakeholders have expressed a willingness to voluntarily implement this WPP, and believe through locally led solutions that the water quality goals they have established can be achieved.

This WPP establishes a framework to systematically address these issues. This WPP promotes forward movement with actions to improve water quality despite uncertainties.

3.8 Establishing Water Quality Goals for the Leon River

Given the complexity of this challenge of determining what level of contact recreation use is appropriate for the Leon River, stakeholders made a formal request for TCEQ to conduct a RUAA. As a result of this request, TCEQ funded a RUAA project, which was conducted in summer 2009. Concurrently, TCEQ proposed statewide revisions to the designated use and associated numeric criterion for contact recreation. In the revised SWQS, the numeric criterion for primary contact recreation remains the same; however, the revision establishes a numeric criteria for two secondary contact recreation uses. The numeric criteria for these use subcategories are provided above in Table 3.2.

Only through completion of the RUAA project can this question be adequately addressed to meet the regulatory strictures associated with changing designated uses; however, implementation of this criterion must also receive USEPA approval. Therefore, the revised criterion could be applied to the Leon River and its tributaries through future biennial assessments. Attainment of water quality standards is a regulatory exercise that establishes a threshold for acceptable protection of the public based on the human health risk exposure. The establishment of secondary contact use criteria will have implications for regulators in terms of compliance and for stakeholders in terms of the level of implementation required.

During the SWQS revision process, TCEQ staff proposed increasing the numeric criterion for primary contact recreation for *E. coli* from 126 cfu/100mL (risk factor of 8 illness per 1,000 individuals) to 206 cfu/100mL (risk factor of 10 illnesses per 1,000 individuals), which is the upper limit of acceptable risk levels recommended by EPA for primary contact recreation. The TCEQ ultimately decided to retain the criterion of 126. Leon River stakeholders are confident that the upper limit of risk levels recommended by EPA provides an adequate level of protection to the Leon River.

With these conditions in mind, the Leon River watershed stakeholders established the following goals as the basis for guiding the recommendations and outcomes of this WPP over the next 10 years.

Goal to Address Contact Recreation Impairment in the Leon River Watershed

The WPP will reduce bacteria levels, where the goal is to achieve an instream concentration of *E. coli* resulting in a long-term geometric mean of 206 cfu/100mL at an appropriate downstream SWQM station recommended for each subwatershed. Maintaining this instream concentration will involve various levels of implementation requiring reductions in bacteria loadings that range from 15 to 26 percent depending on the subwatershed. The ultimate goal of the WPP is to achieve state water quality standards in the Leon River extending beyond the 10 year implementation timeframe of the WPP.

Goal to Address Nutrient Concerns in the Leon River Watershed

Implementation of management strategies to achieve pollutant reduction goals for *E. coli* will have a direct corollary benefit on decreasing nutrient loads and subsequent chlorophyll-*a* and DO impacts.

3.9 Consequence of No Action

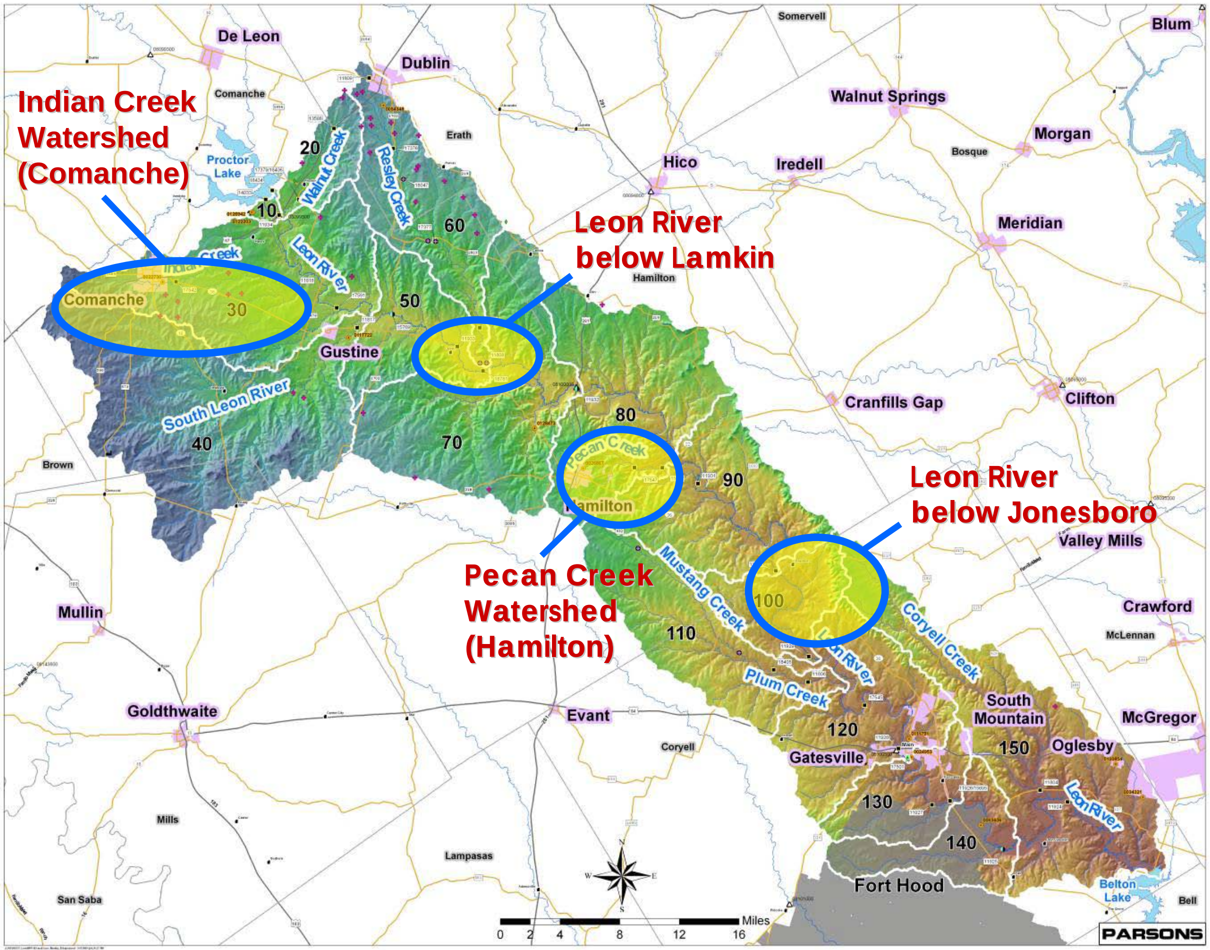
It was difficult for stakeholders to reach consensus on the degree to which environmental improvement can be attained through this WPP given the level of uncertainty caused by environmental conditions and limited financial resources. However, all stakeholders agree that some level of implementation that is cost-effective, reasonable, and does not adversely affect landowners, is necessary in the Leon River watershed. All stakeholders believe that a good faith effort from all with a reasonable infusion of funding will result in a delisting of the impaired waterbodies sometime in the future. The project team provided stakeholders an opportunity to establish a locally driven program that offers options that consider the practical application of management measures to improve the environment with consideration of how they affect land use patterns, costs, and ability to evaluate their effectiveness over time. An adaptive management approach was selected as a path forward because of the uncertainty in water quality standards revisions, availability of science, need for financial support, and other factors. The selected activities in this WPP were those that could improve water quality, respects citizen rights, not harm someone's livelihood, and be cost-effective by leveraging financial and technical resources where possible.

Despite recent actions to avoid discharges of bacteria and nutrients to local creeks, stakeholders understand there are federal and state regulations that must be met because some creeks and parts of the Leon River are not attaining SWQS. They recognize that taking no reasonable action to decrease bacteria or nutrient levels is not acceptable and further recognize that they ultimately have the responsibility of making the appropriate changes to land stewardship and business practices, social habits, and local government administration to avoid future state and federal regulatory requirements.

Chapter 4: Sources and Causes of Pollution in the Leon River Watershed

Characterizing the sources and causes of bacteria and nutrient loading in each subwatershed is a critical step in determining appropriate and effective methods and locations of management strategies aimed at restoring water quality in the Leon River watershed. The information used for this WPP was based on published work and available data, including geographic information system (GIS) shape files livestock census, observations, and stakeholder input. The draft TMDL report released by TCEQ in 2008 provided an assessment of the sources and causes of high bacteria levels upstream of Hwy 281 (TCEQ 2008b). Watershed reconnaissance surveys were conducted between September 29 and October 2, 2008, in four different geographic areas to further identify pollutant sources and causes as part of the development of this WPP. Figure 4.1 displays the four geographic areas where the reconnaissance surveys were performed. Stakeholders provided their perspectives on the sources and causes of pollution at various meetings during development of this WPP. This chapter summarizes the sources and causes of bacteria and nutrient loads to the Leon River and key tributaries.

Figure 4.1 Geographic Focus of Reconnaissance Survey



4.1 Land Use/Land Cover Characteristics

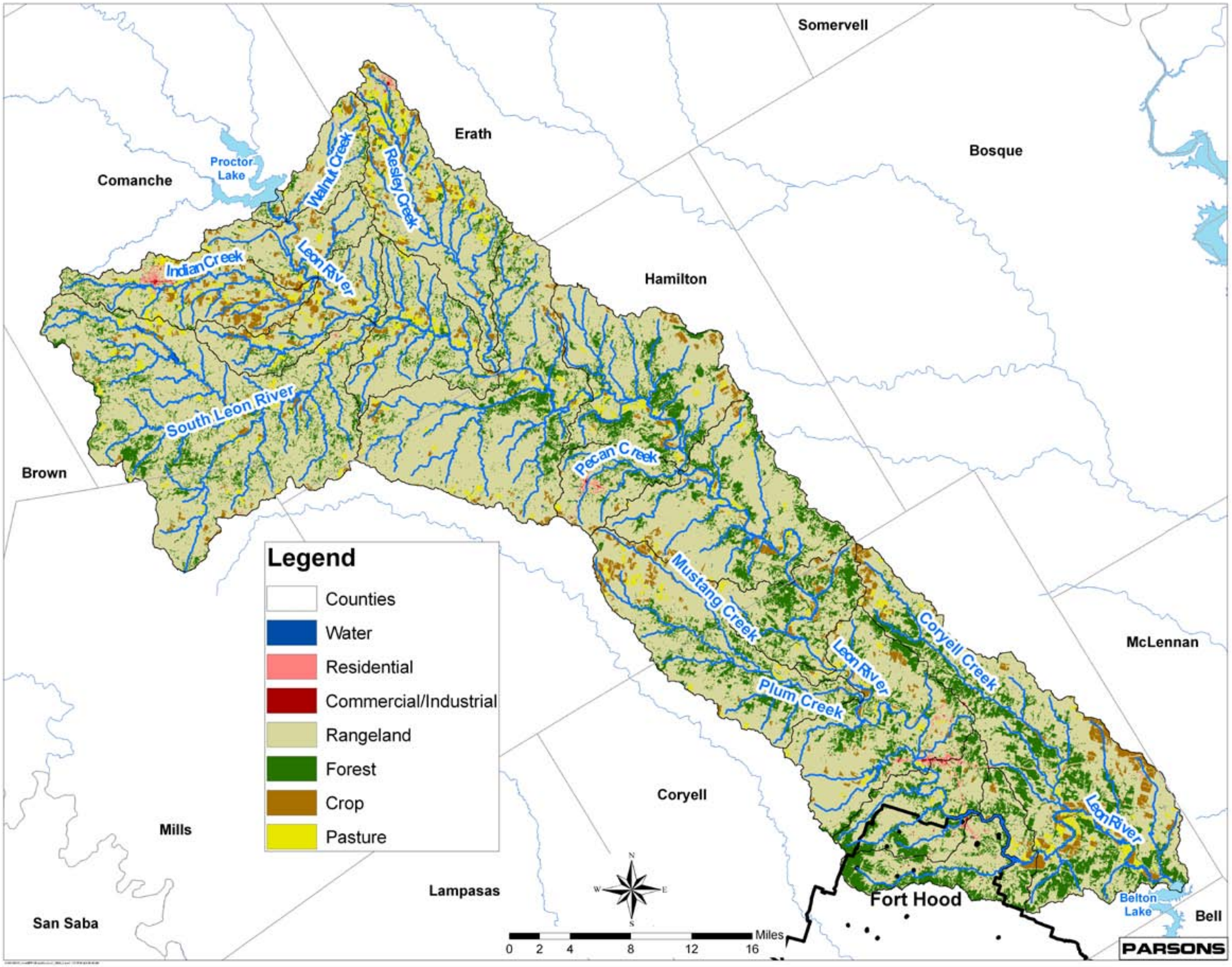
Using land use/land cover data is an effective method for understanding the causes and sources of bacteria and nutrient pollutants in the Leon River watershed. Land use and land cover have a direct effect on surface erosion, rainfall runoff, and evapotranspiration at the subwatershed scale, and both influence pollutant loads and concentrations (NRCS 2008). The acreages and percentages of the different land use/land cover categories presented in Table 4.1 were derived from the 2001 National Land Cover Database (NLCD) (USGS 2001). The NLCD data were re-classified into six categories that generally correspond to pollutant source categories discussed later in Chapter 4. For informational purposes, the land use/land cover data derived from the 1992 NLCD data set that was used and summarized in the TCEQ draft bacteria TMDL report is provided in Appendix C. While the acreages of each land use category differ between the two tables, the relative proportions of the different categories are consistent. Figure 4.2 displays the distribution of land use/land cover data from Table 4.1 in each subwatershed.

Table 4.1 Land Use/Land Cover Classifications in the Leon River Watershed

Subwatershed	Residential	Commercial/ Industrial	Rangeland	Forestland	Cropland	Pasture	Total Area
	Land Use Categories						
Acres of Land							
10	1	0	1,261	360	97	0	1,720
20	52	0	13,124	1,651	820	555	16,202
30	807	107	65,599	8,155	7,649	4,358	86,674
40	153	5	101,855	19,658	2,524	3,196	127,392
50	18	0	28,838	5,200	1,034	1,667	36,757
60	318	41	39,676	5,748	3,407	4,393	53,583
70	66	1	73,467	12,254	1,591	1,402	88,782
80	478	67	57,495	15,601	2,464	1,463	77,567
90	49	0	48,786	11,401	1,899	971	63,105
100	42	1	18,899	8,725	1,161	433	29,261
110	4	0	44,201	10,325	2,666	1,253	58,449
120	712	119	43,369	11,661	1,634	1,048	58,542
130	666	101	19,354	8,774	101	340	29,335
140	225	16	18,993	10,940	655	368	31,197
150	276	13	65,580	29,404	8,535	3,141	106,948
Total Acres	**3,867**	**471**	**640,497**	**159,857**	**36,236**	**24,588**	**865,515**
Land Use Percentage in Watershed							**% Total Area**
10	0.08	0.00	73.35	20.92	5.63	0.03	0.20%
20	0.32	0.00	81.00	10.19	5.06	3.42	1.87%
30	0.93	0.12	75.68	9.41	8.82	5.03	10.01%
40	0.12	0.00	79.95	15.43	1.98	2.51	14.72%
50	0.05	0.00	78.46	14.15	2.81	4.54	4.25%
60	0.59	0.08	74.05	10.73	6.36	8.20	6.19%
70	0.07	0.00	82.75	13.80	1.79	1.58	10.26%
80	0.62	0.09	74.12	20.11	3.18	1.89	8.96%
90	0.08	0.00	77.31	18.07	3.01	1.54	7.29%
100	0.14	0.00	64.59	29.82	3.97	1.48	3.38%
110	0.01	0.00	75.62	17.67	4.56	2.14	6.75%
120	1.22	0.20	74.08	19.92	2.79	1.79	6.76%
130	2.27	0.34	65.97	29.91	0.34	1.16	3.39%
140	0.72	0.05	60.88	35.07	2.10	1.18	3.60%
150	0.26	0.01	61.32	27.49	7.98	2.94	12.36%
% of Watershed	**0.45%**	**0.05%**	**74.00%**	**18.47%**	**4.19%**	**2.84%**	**100.00%**

Data Source: USGS 2001 National Land Cover Database, http://www.mrlc.gov/

Figure 4.2 Land Use Classification Map of the Leon River Watershed



4.2 Pollutant Source Categories

Various pollutant sources identified during the TCEQ TMDL process were confirmed through reconnaissance surveys and focus group meetings. These pollutant sources were organized into the categories presented in Table 4.2 to represent different possible pollutant contributions throughout the Leon River watershed. These categories aligned well with the pollutant load model and provided an effective organizing matrix for management strategies aligned with each of the five focus groups. Pollutant sources are placed into two major categories that facilitate grouping of recommended management strategies as discussed in Chapter 5: direct discharges and polluted storm water wash off. Direct discharges include bacteria and nutrient pollutants that spill, enter, or fall directly into a waterbody with no opportunity for treatment. Under this condition the sources become an immediate pollutant load in the waterbody. Bacteria and nutrients also accumulate on land where, through natural processes, the pollutants can be absorbed or decay over time. The land-based accumulation of bacteria and nutrients is not considered a water pollutant until a rain event transports the pollutants overland to a waterbody which at that point is deemed a wash off source. Table 4.2 provides the organizational sequence for the remainder of Chapter 4.

Table 4.2 Pollutant Source Categories in the Leon River Watershed

Source Category	Cause	Identified By
Direct Discharges of Pollutants to Waterbody		
Wastewater Treatment Facilities (WWTF)[1]	Flow exceedances during rain events resulting in untreated discharges to receiving streams	Municipalities
Wastewater Collection System[1]	Sanitary sewer overflows caused by blockages in collections pipes and collection system failures resulting in untreated wastewater being released into drainage ways and receiving streams; illicit discharges in urban watersheds	Municipalities
Onsite Sewage Facility (OSSF)	Failing household, business, or hunting cabin systems or lack of maintenance resulting in wastewater reaching receiving streams via leaching or overland flow	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies
Direct Deposition	Wildlife roaming in creeks and roosting directly over creeks and streams depositing waste directly into streams	Counties, Municipalities, Landowners, Farmers/Ranchers
	Invasive species roaming in creeks depositing waste directly into streams	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies

Source Category	Cause	Identified By
	Livestock roaming in creeks depositing waste directly into streams	Landowners, Farmers/Ranchers
	Dead animals dumped in creeks release fecal material during decomposition	Counties, Municipalities, Landowners, Farmers/Ranchers, Dairies
Polluted Storm Water Wash Off		
Forestland	Wildlife roaming throughout forestland deposit waste on land	Counties, Municipalities, Landowners, Farmers/Ranchers
	Invasive species roaming throughout forestland deposit waste on land	Counties, Municipalities, Landowners, Farmers/Ranchers
Cropland	Application of manure or commercial fertilizers to improve crop yields may result in excessive build up of bacteria or nutrients	Farmers/Ranchers
Rangeland	Build up of bacteria or nutrient loads from deposition of waste from wildlife, invasive species and livestock on rangeland areas	Farmers/Ranchers, Landowners
Waste Application Field (WAF)[1]	Livestock manure applied to land	Dairies, Farmers/Ranchers
Residential/Commercial/ Industrial	Build up of bacteria loads from wildlife, domestic pets, livestock, even humans from residential, commercial, and industrial activities in urban/rural, forestland or rangeland areas transported by rainfall events (storm water) to receiving streams	Municipalities, Counties, Landowners

1 = Permitted facilities

4.3 Direct Discharges

Direct discharges are those sources that can deposit bacteria or nutrients directly to a receiving stream. Municipalities in the watershed that operate a wastewater treatment facility (WWTF) discharge their treated effluent to creeks. The sewage collection system in an urban area is a closed system of pipes, but there are occasions where either of these systems can fail and untreated wastewater can be discharged to the surface, which, if near a creek, can be a direct source of bacteria and nutrients. There are records of events when WWTFs violate their permits and sewer collection systems overflow. Rural households, hunter camps, and difficult to connect facilities may not be on a centralized collection system and must have an onsite sewage facility (OSSF) to treat used water. If these systems are not maintained, inappropriately sized or are outdated, improperly treated leachate water can make its way to nearby creeks, contributing both bacteria and nutrient loads. Another type of direct discharge is the deposition of fecal waste from a warm-blooded species that has direct access to the riparian corridor. The bacteria and nutrient contributions from certain wildlife species (birds, mammals), invasive species (feral hogs), and livestock can be significant since each of these species has access to the riparian corridor of streams and creeks. Finally, animal feeding operations and the disposal of dead animals in creeks can contribute bacteria or nutrient loading to streams.

4.3.1 Wastewater Treatment Facilities

Permitted sources include point sources of pollution under the Texas Pollution Discharge Elimination System (TPDES) program, described as a discernable, confined, discrete conveyance from which pollutants are or may be discharged to surface waters. Nine of the fifteen watersheds have permitted WWTFs with three of them, the Cities of Comanche, Dublin, and Gustine, discharging to impaired subwatersheds. Table 4.3 lists all TPDES-permitted WWTFs within the Leon River watershed. As noted in Table 4.3, while the U.S. Department of Navy is issued a TPDES discharge permit, the effluent is not considered a source of bacteria loading. Only two of the WWTFs in the Leon River watershed currently have permit limits or monitoring requirements for bacteria.

When operated and maintained properly, WWTFs discharge effluent with bacteria concentrations much lower than the water quality standards. For example, in 2008 the City of Comanche voluntarily sampled its effluent for *E. coli* and recorded concentrations typically below 10 cfu/100 mL. However, when a collection system receives excessive infiltration/inflow, the WWTF may be overwhelmed and not have the capacity to properly treat the wastewater. No matter the reasons, the release of improperly treated wastewater from a WWTF is a permit violation. The consequence is that it is possible for the effluent stream to contain elevated levels of bacteria and other untreated pollutants. No effluent data were collected as part of this WPP to determine if bacteria levels were elevated during rain events.

Certain WWTFs (e.g., Hamilton WWTF, Dublin WWTF, and Fort Hood WWTF) have made significant operational changes in the past two years that will further decrease the probability of system failures. Figure 4.3 provides pictures of typical wastewater infrastructure associated with municipal WWTFs in the Leon River watershed.

Table 4.3 TPDES Permitted WWTFs in the Leon River Watershed

Sub-watershed	Permittee	TCEQ Permit #	EPA NPDES #	Facility Type	Receiving Stream	County	Permitted Flow (MGD)	Disinfection Requirement	Permit Issued Date	Permit Renewal Date	NH3 (mg/L)	Bacteria Monitoring Requirement
10	Upper Leon River Municipal Water District	14544-001	TX0128813	Domestic Sewage Treatment	Unnamed Tributary	Comanche	0.065	1-4 mg/L Cl2	4/20/2009	3/1/2014	3	—
30	City of Comanche	14445-001	TX0022730	Domestic Sewage Treatment	Indian Creek	Comanche	0.595	1-4 mg/L Cl2	10/17/2008	3/1/2013	3	—
70	Circle T Promotions Ltd.	14678-001	TX0128473	Domestic Sewage Treatment	Bear Creek	Hamilton	0.018	1-4 mg/L Cl2	11/8/07	3/1/2010	—	—
40	City of Gustine	10841-001	TX0117722	Domestic Sewage Treatment	South Leon River	Comanche	0.082	1-4 mg/L Cl2	5/4/2009	3/1/2014	3	—
60	City of Dublin	10405-001	TX0054348	Domestic Sewage Treatment	Resley Creek	Erath	0.45	n/a, oxidation pond	6/22/2009	3/1/2014	4	394 *E coli*, grab
80	City of Hamilton	10492-002	TX0026867	Domestic Sewage Treatment	Pecan Creek	Hamilton	0.88	UV	9/10/2008	3/1/2013	2	200 fecal coliform, daily avg
120	City of Gatesville	10176-002	TX0111791	Domestic Sewage Treatment	Stillhouse Branch	Coryell	2.2	>1 mg/L Cl2 + dechlor	6/10/2009	3/1/2014	2	—
130	City of Gatesville	10176-004	TX0024953	Domestic Sewage Treatment	Leon River	Coryell	1	>1 mg/L Cl2 + dechlor	10/7/2005	3/1/2010	3	—
150	City of Oglesby	10914-001	TX0100854	Domestic Sewage Treatment	Station Creek	Coryell	0.05	n/a, oxidation pond	4/3/2008	3/1/2012	na	—
150	US Dept of The Navy	02335-000	TX0034321	Groundwater	Station Creek	Coryell	n/a	n/a	7/13/2005	3/1/2009	na	—

Source: TCEQ, Water Quality Assessment Section, October 2009

Figure 4.3 Wastewater Treatment Facility Infrastructure

4.3.2 Sanitary sewer Overflows

The collection systems associated with each WWTF could be a contributing source of bacteria loading to streams that flow through the municipalities responsible for each collection system. If a sewer line were to collapse, become plugged, overcome with inflow/infiltration, or somehow lose its capacity to convey wastewater, sanitary sewer overflows (SSO) to creeks could occur and be a significant bacteria load. This lack of capacity is exacerbated during rain events if rainfall runoff can find its way to the system adding to existing wastewater flows. Overflows occur when sanitary sewer pipes fill up, back up, and overflow through manhole covers, which are unauthorized and a violation of a discharger's TPDES permit. Figure 4.4 displays a manhole that sits above grade and near a creek. Given its location, if this manhole were to spill, untreated wastewater would flow directly into the adjacent creek. Because SSOs have no treatment, they are particular dangerous to human health, safety, and the environment. SSOs that are recognized as permit violations have occurred and been reported in the Leon River watershed. Other miscellaneous sources near creeks include improperly functioning public restrooms and illicit discharge pipes to urban creeks. Collections systems fall under the responsibility of municipalities.

Figure 4.4 Wastewater Collection System Infrastructure

Manhole for Sanitary Sewer in Floodplain

4.3.3 Onsite Sewage Facilities

As a predominantly rural watershed, many residences and some businesses in the Leon River watershed have an OSSF. There are also OSSFs within the city limits of some of the towns with wastewater collection systems. In some of the small towns within the Leon River watershed all residences are entirely on OSSFs. Given that most of the residences in the Leon River watershed were built before 1975, it is possible that some of these aged OSSFs are not functioning properly. Failing or improperly functioning OSSFs can contribute bacteria and nutrients to receiving waters. Bacteria and nutrient loads from failing OSSFs can be considered as direct discharge sources or as part of nonpoint sources transported by rainfall runoff or infiltration. OSSFs can fail due to improper design or installation, age, component damage, or lack of maintenance.

Most OSSFs dispose of wastewater by subsurface dispersion. When subsurface dispersion is not an option due to groundwater or poor soil conditions, homeowners may use a small wastewater treatment plant followed by surface irrigation. It is possible that at times because of improper maintenance or operation of the OSSF, the irrigated wastewater applied to the ground surface may not be properly disinfected. OSSFs can also fail due to improper design or installation or component damage. Septic tank/drain field systems typically fail following a pipe break, lack of sludge removal, intensive use periods, saturation of the drain field by high ground water levels or rainfall, or simply from the gradual reduction in permeability of the drain field. Comanche, Coryell, Hamilton, and Erath Counties, like many other rural Texas counties, are receiving more and more applications for OSSFs in response to population growth. While all new OSSFs are presumed to be better functioning systems because of better design criteria and technology, there are still potential problems that could exist with systems. Other issues leading to failure are placement in floodplains, lapses in maintenance contracts, proximity of irrigation system to drainage swales, and lack of capacity to enforce current rules and regulations. Although the causes may be known, the magnitude of malfunctioning OSSFs is difficult to assess because limited data are available.

A variety of factors such as soil condition, age, environmental conditions, and design and maintenance issues can cause OSSF failures. System densities in some areas exceed the capacity of even suitable soil to assimilate wastewater flows and retain and transform their contaminants. The Hamilton County Soil Survey, updated in 1991 by NRCS, indicates that 38 of the 49 different soil types are severely limited for septic tank adsorption fields (NRCS 1991). In Comanche County, 45 of the 57 soil types identified in the 1974 Soil Survey are severely limited for septic tank adsorption fields (SCS 1977). In Coryell County, 24 of the 34 soil types identified in the 1983 Soil Survey are severely limited for septic tank adsorption fields (SCS 1983). About half of the occupied homes with OSSFs are more than 30 years old, and studies suggest that some OSSFs have failed. Special attention needs to be focused on OSSFs located in or near any floodplain. Lack of maintenance for OSSFs utilizing surface irrigation systems could also be contributing to bacteria and nutrient loading.

The magnitude of pollutant loading from OSSFs at the subwatershed scale was estimated in the TCEQ draft bacteria TMDL report using the 1990 U.S. Census and an assessment of failure rates. The census has an estimated 5,800 OSSFs within the study area (U.S. Census Bureau 2000). The TCEQ draft bacteria TMDL report estimated that only 10 of these systems in the riparian zone were considered failing based on a percent failure rate developed for the Texas

On-Site Wastewater Treatment Research Council (Reed, Stowe, & Yanke 2001). In focus group discussions, county officials considered this estimate to be too low. Landowners, farmers, and ranchers also agreed that the number of failing OSSFs in each county is underestimated. Landowners and farmers and ranchers further suggested that hunting trailers and camps may have septic facilities that are also operating ineffectively. In 2009 the Coryell County Attorney's Office began conducting surveys to evaluate communities experiencing performance and maintenance problems with OSSFs. Through these surveys Coryell County has identified the need for maintenance improvements, OSSF repairs, or replacement for select homes in Leon Junction, Flat, and select subdivisions around Gatesville. The frequency of residences requesting their septic tanks be pumped more frequently than stipulated in their 3 to 5 year maintenance requirement indicates that the systems are not functioning properly and therefore could be contributing pollutant loads if they are near streams. There are also reports in the watershed of illegal disposal of sewage from septage haulers.

While it was acknowledged by all stakeholders that the magnitude of bacteria and nutrient loading from OSSFs is dependent on a variety of factors, distance to receiving water being one of the most influential, all stakeholders agreed that additional data are needed to identify the number and location of failing OSSFs in each subwatershed as there was no other form of data that could be used as a basis for estimating loads. Figure 4.5 displays an example of a residence that is close to the floodplain of a creek.

Figure 4.5 OSSFs near Floodplains

4.3.4 Wildlife

There are no specific population estimates available for the wide array of wildlife species in the watershed. However, miscellaneous sources of information are available to demonstrate that wildlife populations are a source of bacteria loading throughout subwatersheds in the Leon River watershed. Some of these information sources include focus group feedback, TPWD deer population surveys, reconnaissance surveys, and BST data. Focus group members from all four counties, based on visual observation believe that deer, coyote, vultures (black and turkey), swallows, and raccoon populations have increased significantly over the past two decades. These species, as well as many other animals that live in the Leon River watershed, contribute urine and fecal matter to the riparian corridors as well as to most upland areas. TPWD conducted deer-population monitoring efforts in Coryell, Hamilton, Comanche, and Erath Counties between 2005 and 2007. The following excerpt was provided by TPWD to the project team to summarize estimates of the deer density in these counties.

> *TPWD does not have the resources to monitor deer populations at a watershed scale, however, they have provided estimates for Resource Management Units (RMU) which consist of multiple counties or watersheds and include several deer survey transects within a RMU. RMU 23 covers all of Coryell and Hamilton counties and RMU 24 covers the portions of Comanche and Erath County that are in the Leon River watershed. Assuming that the deer survey transects are representative of their respective RMUs, then the population density for the RMUs should fall within the limits shown in Table 4.4 below. Since the counts for the RMUs represent an average of several types of habitats, the values given may not be applicable for any single habitat type or subsample of habitat types (TPWD 2008).*

Table 4.4 TPWD Deer Density Estimates – 2005-2007

Deer / 1,000 ac									
	2005			2006			2007		
	Mean	95% LCL	95% UCL	Mean	95% LCL	95% UCL	Mean	95% LCL	95% UCL
RMU23 Coryell and Hamilton County	49.6	28.6	86.0	57.5	24.9	133.0	56.6	23.5	136.2
RMU24 Erath and Comanche County	13.8	7.2	26.8	14.6	7.2	29.9	8.4	4.3	16.3

LCL=lower confidence limit
UCL-upper confidence limit

The 2007 mean density from Table 4.4 was used to calculate a general estimate of the number of deer in the watershed. Using a density of 56.6 deer per 1,000 acres for Coryell and Hamilton Counties equates to approximately 29,700 deer. Using a density of 8.4 deer per 1000 acres for Comanche, and Erath, Counties equates to an additional 2,900 deer (TPWD, 2008). These numbers estimate there may be over 32,000 deer in the Leon River watershed. The TCEQ draft bacteria TMDL report provided wildlife density estimates for other species including ducks (30/square mile), raccoons (40/square mile), and opossum (160/square mile) (Miertschin 2006). These wildlife density values were derived from literature values and consultation with TPWD wildlife biologists. They are provided here only to demonstrate the presence of wildlife in rural watersheds.

Reconnaissance surveys and GIS were utilized to document that certain bird species nesting under road bridges contribute to direct deposition of fecal matter into creeks and rivers. While there were 119 avian species identified in a 2007 survey conducted by Texas A&M University in portions of Hamilton and Coryell Counties (Texas A&M University 2009), the key species known to nest under bridges include barn swallows and cliff swallows. Figure 4.6 displays a typical condition under major bridges where swallow nests are directly above a waterbody. Table 4.5 provides an estimate of the roads that cross waterbodies within each subwatershed. While bird species do not nest under every road crossing in every subwatershed, many of the major road crossings have a large number of birds that nest under these bridges on a seasonal basis.

Figure 4.6 Swallow Nests under Bridge over Leon River

Table 4.5 Number of Roads Crossing Streams by Subwatershed

Subwatershed	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	Totals
Total Road Crossings	1	12	82	96	36	93	53	65	30	7	38	33	22	12	53	633
Major Road Crossings	1	3	18	20	9	14	9	15	9	2	5	9	2	1	15	132

4.3.5 Feral Hogs (Invasive Species)

Feral hogs in Texas are an invasive species with populations estimated at over 2 million head (Texas AgriLife Extension Service 2008a). A high rate of reproduction, spending the majority of each day in secluded habitats of riparian corridors, and their destructive rooting activities make feral hogs particularly detrimental to water quality. Hogs prefer bottomlands such as rivers, creeks, and drainage swales when available. Hogs are generally found in dense vegetation cover often associated with water, but also do well in drought-prone environments (Taylor 2003). During hot weather, feral hogs enjoy wallowing in wet, muddy areas and are never far from dense protective cover (Taylor 2003). They tend to concentrate in areas of food availability, especially where there are nut-producing trees or agricultural crops (Taylor 2003). Typical of all wild mammals, urine and feces from feral hogs contribute bacteria and nutrients to streams. Their destructive foraging habits in riparian corridors can also be the cause of significant sediment loading to streams. Feral hogs have destroyed property and damaged crops throughout all parts of the Leon River watershed.

The Leon River watershed stakeholders acknowledged the significant economic and environmental impacts caused by this invasive species. Density and distribution data are scarce; however, all focus groups stated that within the last five years, populations have significantly increased throughout the entire Leon River watershed and in adjacent watersheds as well. The increase in the amount of hunting and trapping of feral hogs that has occurred in each county over the last several years (Figure 4.7) further substantiates the explosion in population. The TCEQ draft bacteria TMDL project estimated there were over 26,000 feral hogs in the Leon River watershed (Miertschin 2006). Focus group members state that feral hog numbers are particularly high in subwatersheds 10, 20, 30, 40, 70, and 100. Stakeholders of the Leon River watershed consider the feral hog population to be a major contributor of bacteria and nutrient loading.

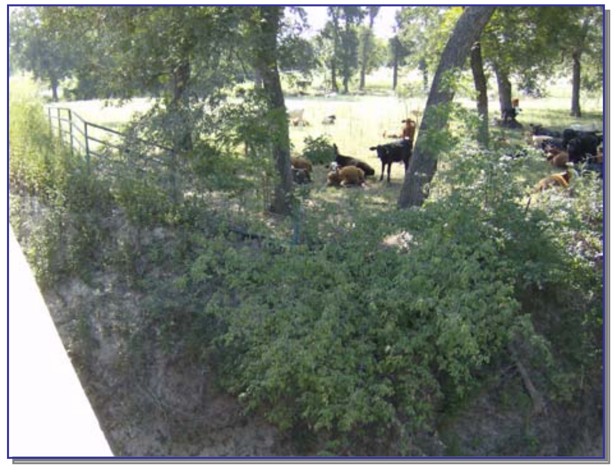
Figure 4.7 Feral Hog

Photo courtesy of Texas Wildlife Services 2010.

4.3.6 Livestock

The grazing of livestock, including cattle, goats, sheep, and horses occurs throughout the entire watershed. As with other free-roaming animals, the urine and feces from livestock contribute bacteria and nutrients loadings. Figure 4.8 shows cattle grazing in pasture and near a stream in the Leon River watershed. Where livestock have access to riparian corridors, drainage swales, creeks, and rivers, direct deposition of feces can occur to surface water, thereby increasing the concentration of bacteria and nutrient loading, which has a direct impact on water quality.

Figure 4.8 Livestock in the Leon River Watershed



Livestock census data are not available at the subwatershed level; but county census data are available for grazing cattle, dairy cattle, goats, and sheep for Comanche, Erath, Coryell, Hamilton, and Mills County from the USDA-NASS 2007. Livestock numbers for cattle, beef cows, milk cows, goats, and sheep are summarized by county for 1997, 2002, and 2007 in Table 4.6 (USDA-NASS 2007). Specific census numbers for horses were not available from the *Texas Agricultural Statistics 2007*, but it is estimated there are approximately 2,000 in Coryell County (Zoeller 2009). Livestock numbers have fluctuated from year to year over the past decade, but in many cases livestock numbers in 2007 decreased somewhat from 1997 numbers. From the census numbers, cattle represent the largest population of livestock in the Leon River watershed (USDA-NASS 2007).

Table 4.6 USDA Livestock Census Data – 1997-2007

Cattle and Calves				
Year	**County**	**All Cattle**	**Beef Cows**	**Milk Cows**
1997	Comanche	142,000	35,000	27,300
2002	Comanche	115,000	34,000	29,000
2007	Comanche	132,000	20,000	23,000
1997	Erath	219,000	20,000	93,300
2002	Erath	194,000	16,000	83,000
2007	Erath	157,000	16,000	58,000
1997	Coryell	134,000	42,000	—
2002	Coryell	68,000	36,000	—
2007	Coryell	110,000	38,000	—
1997	Hamilton	66,000	28,000	12,200
2002	Hamilton	68,000	22,000	8,800
2007	Hamilton	75,000	20,000	8,700
1997	Mills	58,000	23,000	2,600
2002	Mills	45,000	17,000	—
2007	Mills	54,000	15,000	—

Goats			
Year	**County**	**All Goats**	**Angora Goats**
1997	Comanche		3,500
2002	Comanche	7,000	1,500
2007	Comanche	6,500	—
1997	Erath		3,400
2002	Erath	6,000	—
2007	Erath	12,000	—
1997	Coryell		17,000
2002	Coryell	18,000	5,000
2007	Coryell	19,000	2,600
1997	Hamilton		12,000
2002	Hamilton	17,000	4,000
2007	Hamilton	16,000	1,800
1997	Mills		43,000
2002	Mills	52,000	7,000

Sheep and Lambs		
Year	**County**	**All Sheep and Lambs**
1997	Comanche	3,000
2002	Comanche	6,000
2007	Comanche	7,000
1997	Erath	4,000
2002	Erath	1,900
2007	Erath	2,200
1997	Hamilton	9,000
2002	Hamilton	14,700
2007	Hamilton	14,000
1997	Coryell	6,000
2002	Coryell	5,800
2007	Coryell	5,700
1997	Mills	20,000
2002	Mills	22,000
2007	Mills	28,000

Data Sources: 2007 Census from Texas Agricultural Statistics 2007, USDA Texas Field Office 1997 and 2002
Source - USDA National Agricultural Statistics Service
http://www.nass.usda.gov/QuickStats/Create_County_All.jsp

Table 4.7 provides an estimate of the number of free-roaming livestock based on the 2007 livestock census data presented in Table 4.6. The estimates in Table 4.7 were derived by calculating a density factor for cattle, goats, and sheep based on the acreage of rangeland and pastureland in each subwatershed using the 2001 National Land Cover Database (NLCD) land use data. To calculate the density for cattle, only young stock and mature beef cattle from Table 4.6 were used as the countywide population for free-roaming cattle.

Table 4.7 Estimated Livestock Populations Distributed by Subwatershed

Subwatershed	Free Roaming Cattle Only	Goats	Sheep
10	288	17	19
20	3,014	274	248
30	16,103	960	1,034
40	22,276	3,247	2,549
50	6,941	436	448
60	9,423	1,182	967
70	13,309	2,372	1,057
80	9,121	2,201	784
90	7,741	1,867	665
100	4,184	540	125
110	8,869	1,431	409
120	10,553	1,151	211
130	4,626	505	93
140	4,496	490	90
150	15,759	1,719	315
Watershed Totals	**136,704**	**18,392**	**9,014**

Livestock data source: 2007 Census from Texas Agricultural Statistics 2007, USDA Texas Field Office

4.3.7 Animal Feeding Operations

An animal feeding operation (AFO) is defined by TCEQ in rule (30 Texas Administrative Code Chapter 321, Subchapter B) as a lot or facility, other than an aquatic animal production facility, where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and the animal confinement areas do not sustain crops, vegetation, forage growth, or postharvest residues in the normal growing season over any portion of the lot or facility. Animal counts are then applied to determine if an AFO is a concentrated animal feeding operation (CAFO) and, therefore, a point source that requires a permit. There are dairy facilities in the Leon River watershed classified as CAFOs that meet the animal thresholds outlined by rule which are:

- A large CAFO: 700 mature dairy cattle (whether milkers or dry cows);
- A medium CAFO: 300 to 999 cattle other than mature dairy cattle or veal calves. Cattle includes but is not limited to heifers, steers, bulls, and cow/calf pairs; or 200 to 699 mature dairy cattle (whether milking or dry cows) (TCEQ 2009b).

Current CAFOs in the Leon River watershed are located in subwatersheds 20, 30, 40, 60 and 70; however, there were some in operation in watersheds 80 and 150 prior to 2004. These CAFOs have general permits and operate in accordance with the requirements and BMPs prescribed in the TCEQ General Permit to Discharge Wastes, General Permit Number TXG920000 (TCEQ 2009b). Manure and wastewater from CAFOs contain pollutants such as bacteria, phosphorus, and ammonia (USEPA 2009b). However, as CAFOs are recognized as no discharge facilities and, as such, when designed and operated properly, are not contributing pollutant loading in a subwatershed. As a result CAFOs are not considered a direct discharge source of bacteria. Under catastrophic events which are defined as the 25-year, 24-hour rainfall event, the potential exists for bacteria and nutrients loads to be discharged from CAFO retention facilities to a receiving water.

Over the past five years the population of dairy cattle in the upper Leon River watershed has decreased. In the TCEQ draft bacteria TMDL the permitted number of dairy cattle in the Leon River watershed was 69,000, which was based on numbers provided by TCEQ and TSSWCB (Miertschin 2006). The USDA *Texas Agricultural Statistics 2007* estimated there were 23,000 dairy cattle in Comanche County, which was down from an estimated 27,300 in 1997 (USDA-NASS 2007). In Hamilton County there were 8,900 dairy cattle in 2007, which was down from an estimated 12,200 dairy cattle in 1997 (USDA-NASS 2007). Erath County saw a significant decrease in the number of dairy cattle between 1997 and 2007 dropping from 93,300 to 58,000 (USDA-NASS 2007). Information for dairy cattle and other livestock based on CAFO permits does not include census data for the actual number of dairy cattle in operation at the subwatershed level. Only some percentage of the 23,000, 8,700, and 58,000 dairy cattle in the three-county area (Comanche, Hamilton, and Erath, respectively) actually reside within the Leon River watershed boundary. Table 4.8 provides a list of the TPDES-permitted CAFOs in the Leon River watershed based on the TCEQ 2007 Texas Land Application Permit (TLAP) database. The dairy cattle originally associated with the subset of facilities highlighted in yellow are no longer located in the Leon River watershed.

Table 4.8 CAFOs in Leon River Watershed

Subwatershed	TCEQ Permit #	Facility Type	County	Permitted Head[1]
20	04804-000	Irrigation	Comanche	—
20	TXG920150	Irrigation	Comanche	1784
20	TXG920230	Irrigation	Erath	—
20	TXG920641	Irrigation	Erath	4000
20	TXG920843	Irrigation	Erath	2900
30	TXG920034	Irrigation	Comanche	990
30	TXG920040	Irrigation	Comanche	6000
30	TXG920152	Irrigation	Comanche	1700
30	TXG920153	Irrigation	Comanche	990
30	TXG920271	Irrigation	Comanche	2000
30	TXG920380	Irrigation	Comanche	500
30	TXG920384	Irrigation	Comanche	—
30	TXG920767	Irrigation	Comanche	400
30	TXG920928	Irrigation	Comanche	1500
40	03202-000	Irrigation	Comanche	—
40	TXG920237	Irrigation	Comanche	699
40	TXG920277	Irrigation	Comanche	6000
40	TXG920297	Irrigation	Comanche	4000
60	03350-000	Irrigation	Erath	—
60	TXG920070	Irrigation	Erath	699
60	TXG920072	Irrigation	Comanche	2249
60	TXG920092	Irrigation	Erath	1799
60	TXG920149	Irrigation	Erath	990
60	TXG920162	Irrigation	Erath	—
60	TXG920193	Irrigation	Erath	2249
60	TXG920211	Irrigation	Erath	1200
60	TXG920263	Irrigation	Erath	4500
60	TXG920266	Irrigation	Erath	—
60	TXG920269	Irrigation	Erath	—
60	TXG920274	Irrigation	Erath	1865
60	TXG920276	Irrigation	Erath	3750
60	TXG920278	Irrigation	Erath	500
60	TXG920299	Irrigation	Erath	5200
60	TXG920729	Irrigation	Erath	990
60	TXG920877	Irrigation	Erath	
70	TXG920086	Irrigation	Hamilton	869
70	TXG920110	Irrigation	Hamilton	600
70	TXG920295	Irrigation	Comanche	2500
150	TXG920197	Irrigation	Coryell	—

Note: Facilities highlighted in yellow were operating prior to 2008 but are no longer active.
[1] Number derived from TCEQ Draft Leon River Bacteria TMDL 2008.

4.3.8 Dead Animal Disposal

Through the reconnaissance surveys and feedback from all focus groups, improper disposal of dead animals (wildlife, pets, or livestock) within riparian corridors, particularly at bridge crossings, occurs with a high frequency throughout the year. Specific data were not available to quantify the magnitude of bacteria contribution from the decay of animal carcasses. While it is recognized that bacteria loads from improper disposal of dead animals is not a continuous source of loading, stakeholders believe the number and frequency of animals disposed in creeks and rivers is sufficient to warrant actions aimed at diminishing this problem.

4.4 Polluted Storm Water Wash Off

All land cover types are recognized as areas where bacteria and nutrient loads can accumulate over time and therefore may be a source of loading to creeks and rivers. Although the accumulated material is not considered a pollutant until it enters a stream, reducing the amount that accumulates on land can reduce the degree of contamination if it were to enter a waterbody. Wash off occurs during a rain event at a point when velocities are sufficiently high to transport sediments and other pollutants that have accumulated on any land cover type. Thus, wash off can transport pollutants to waterbodies. In the Leon River watershed, storm water runoff is not a permitted pollutant source.

4.4.1 Forestland

Approximately 18 percent of the Leon River watershed is classified as forestland. Forested areas serve as high quality habitat for wildlife and also provide cover and forage for feral hogs. Therefore, wildlife and feral hogs tend to be the dominant source of bacteria or nutrient loading to forestland. Bacteria and nutrient loads on this land cover type can also originate from livestock, pets, and humans. The buildup of bacteria and nutrient loads and eventual transport from forestland to receiving streams depend on a wide array of factors, including, but not limited to, precipitation amounts and duration, slope, density, and vegetation type, soil, solar radiation, and proximity.

4.4.2 Cropland

Only four percent of the Leon River watershed is classified as cropland. Given the small percentage of land in the watershed and its limited habitat suitability for most wildlife species, cropland is not considered to be a significant source of bacteria loading to streams on an annual basis. Some wildlife species and feral hogs do traverse cropland, which would result in fecal matter deposition, but limited edge of field runoff data are available to adequately quantify bacteria loads from cropland. Cropland can contribute high levels of nutrients where manure or commercial fertilizers are used to enhance crop production. Two of the subwatersheds (30 and 60) with the highest percentage of cropland have been identified as having nutrient concerns (nitrate-nitrogen and orthophosphorus). However, there are many other factors such as crop rotation practices, vegetative buffers around cropland, fluctuations in fertilizer costs, and existing soil conditions that may have a greater influence on nutrient levels in these two subwatersheds.

4.4.3 Rangeland

Approximately 77 percent of the Leon River watershed is classified as rangeland. Rangeland includes improved and unimproved pastureland, some scrub vegetation, and fallow lands. Bacteria and nutrients loads associated with this land cover is influenced by wildlife populations, feral hog populations, livestock grazing, hunting camps, land application of sludge from WWTF, and land application of manure or effluent from CAFOs. As a result, bacteria and nutrient loading from grazing livestock, pets, wildlife, feral hogs, humans, WWTFs, and dairy cows are deposited on rangeland. Improper application of manure from CAFOs by third parties on private rangeland can also contribute bacteria and nutrient loading. As a result, bacteria and nutrient loading from pets, wildlife, livestock, feral hogs, humans, WWTFs, and manure from CAFOs can be transported to receiving waters by rainfall runoff. The amount of bacteria and nutrients transported from rangeland to receiving streams depends on a wide array of factors, including, but not limited to, precipitation amounts and duration, slope, vegetation type, soil, solar radiation, and proximity to a receiving water.

4.4.4 Waste Application Fields

CAFOs also utilize waste application fields (WAF) or land management units (LMU) as a critical component of a dairy operation. The following excerpt from the TCEQ General Permit describes a LMU.

> *A LMU is a necessary area of land owned, operated, controlled, rented or leased by a CAFO permittee to which manure, sludge, or wastewater from the CAFO is or may be applied. This includes land associated with a single center pivot system or a tract of land on which similar soil characteristics exist and similar management practices are being used. Land management units include historical waste application fields. The term "land management units" does not apply to any lands not owned, operated, controlled, rented or leased by the CAFO permittee for the purpose of off-site land application of manure, sludge, or wastewater wherein the manure/sludge is given or sold to others for land application (TCEQ 2009a).*

Since manure, sludge, or wastewater is applied to WAFs, these fields can be a source of bacteria or nutrient loading. If proper management practices of application rates and timely incorporation into the soil are not adhered to, WAFs and other improved pastureland where manure is beneficially used can contribute bacteria and nutrient loading when rainfall runoff transports these pollutants from the fields to a receiving water. Table 4.9 provides an estimate of the acres of WAFs in the Leon River watershed. The acres are separated into land area that receives manure application and land area that receives sprinkler waste application (Miertschin 2006). The majority of manure generated in the Leon River watershed is beneficially used by CAFOs on LMUs. Some amount of manure is transported for land application to third parties within the Leon River watershed and some is transported for use outside the watershed. These estimates are provided to demonstrate that manure from dairy operations can be a source of bacteria or nutrient loading when hauling and land application BMPs are not adhered to.

Table 4.9 Estimated Acres of Waste Application Fields in Leon River Watershed

WAF	Estimated Acreage
Manure application	6,159
Sprinkler waste application	7,344

4.4.5 Residential, Commercial, and Industrial

Although the percentage of urban, residential, commercial, and industrial land use/land cover in the Leon River watershed is small, bacteria and/or nutrient loads are produced from these areas when considering the watershed as a whole. As mentioned above, there are a variety of ways for the buildup of bacteria and nutrients to occur in these types of developed area. At a subwatershed scale within the city limits of Comanche, Dublin, Gustine, Hamilton, Proctor, Gatesville and other developed areas in the Leon River watershed, the buildup of bacteria and nutrient loading does occur. Comparisons of water quality data from urban areas (areas with impervious cover) around the country typically show runoff concentrations of bacteria at levels greater than the single sample criterion for *E. coli*.

Bacteria and nutrients in cities, towns and subdivisions that build up on the land can originate from domestic pets, livestock, wildlife, humans, and fertilizers. It is common for houses in small towns to have multiple dogs and cats where most homeowners do not typically pick up pet waste. During the reconnaissance survey, livestock such as sheep, goats, ponies, and horses were observed in urban areas in spaces less than what is typical on farms outside of cities. There are seasonal variations of animal concentrations that also affect the potential for bacteria loads to increase. For example, during certain periods of the year, youth are raising show animals at home. Wildlife is common in urban and residential areas due to the abundance of garbage and other food sources. Birds, raccoons, opossums, and other small animals are common, as well as deer. Human waste from failed OSSFs may also accumulate in urban or rural residential areas. It is possible for households and hunting camps to have OSSF failures go unnoticed for a considerable amount of time. The amount of bacteria and nutrients transported from urban and rural residential land use to receiving streams depends on a wide array of factors, including, but not limited to, precipitation amounts and duration, slope, vegetation type, soil, solar radiation, and proximity to a receiving water.

Bacteria and nutrient loading can originate from failing or improperly maintained OSSFs associated with businesses. High concentrations of bacteria and nutrient loads associated with livestock events result in a temporary condition where a large amount of manure in a confined location is generated and if not properly managed could be transported to a receiving water under a rainfall event. The potential for pollutant contributions from urban and commercial, and industrial land cover is mostly a factor during rain events. Given low to intermittent creek flows that occur in the small creeks and drainage swales that exist within the footprint of towns and residential areas, bacteria and nutrient sources can contribute a discernable amount of the overall pollutant load after rainfall runoff events.

4.5 Estimating Pollutant Source Loads

Bacteria pollutant categories identified in subsection 4.2 were evaluated in each subwatershed to understand the makeup of bacteria sources for better prioritizing implementation strategies. Bacteria pollutant sources were organized into nine categories based on the discussion above. Quantification of pollutant loads was derived from the existing watershed loading model, HSPF, established to support development of the draft TCEQ Bacteria TMDL. Additional information used to modify the approach to estimating pollutant loads by subwatershed included potential causes provided by stakeholders, various database sources, and information available in the literature. The loading model used in the TMDL was used as the base case.

To determine the contribution of bacteria loads in each subwatershed, direct discharge rates and fecal waste accumulation factors were reduced to zero and land use factors were maximized to mitigate washoff in each subwatershed. The difference in bacteria concentration between the base geometric mean in the loading model and the zero pollutant case is presumed to be the contribution to the overall bacteria concentration for that source. **Table 4.10 provides the estimated load contribution from each pollutant source category for each subwatershed. The sum of each subwatershed column provides the total potential load that could be reduced through the implementation of management measures. Table 4.11 presents the corresponding percent each pollutant source category contributes to the overall source load.**

Results of the model simulation indicate the major source of bacteria in the watershed is from direct discharges. Direct deposition is the major source of the total contribution in all subwatersheds. Direct deposition is primarily from warm-blooded animals, such as wildlife (41 to 55 percent of total) and livestock (18 to 33 percent of total), roaming near or in creeks where they deposit fecal matter directly in the water. Feral hogs also deposit potentially significant contributions of bacteria and nutrients directly into waterbodies as they spend the majority of their time near water. The other sources of direct discharges were low. SSOs in subwatersheds with municipalities (watersheds 30, 40, 60, 80, 120, and 130) were typically less than five percent. Sources such as WWTFs and OSSFs as a direct discharge each contributed less than one percent to the total load in each subwatershed

Loads on different land use types were modified to determine how decreasing the load available on the land would affect pollutant concentration in waterbodies. The second largest recurring pollutant source was from urban loads, which include residential and commercial/industrial land areas. Rangeland, residential, commercial, industrial, and WAF were areas where there was the potential for improvement through BMPs targeting roaming animals, operational improvements on WAFs, and enforcing regulations addressing human sewage. No single definitive source in urban areas was identified based on observations in the field. This load is considered to be a homogenous contribution resulting from the common sources found in urban areas as discussed above.

Table 4.10 Load Contribution of Pollutant Source (10^6 org/day)

Pollutant Source	Subwatershed														
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Direct Discharges of Pollutants to Waterbody															
WWTF	-	-	4	-	9	37	-	9	-	-	-	40	22	-	-
Wastewater Collection System	-	-	1,154	-	101	463	-	1,698	-	-	-	5,920	2,299	-	-
OSSF	12	1	305	137	9	73	52	286	25	61	57	107	423	44	109
Direct Deposition	21,672	5,101	45,552	25,131	32,463	12,282	33,089	47,570	14,544	25,742	12,637	80,495	68,250	21,887	21,012
Polluted Storm Water Wash Off															
Forest	13	6	85	56	64	17	123	122	84	76	92	236	150	256	356
Cropland	71	33	619	157	342	65	247	146	109	128	134	186	33	28	464
Rangeland	398	317	4,098	3,958	4,239	901	7,821	4,613	2,697	1,916	3,056	6,198	2,493	2,340	5,873
Waste Application Field	-	193	586	64	606	333	299	196	-	-	-	-	-	-	184
Residential/Commercial/Industrial	4,992	1,072	21,465	3,906	5,513	4,756	9,090	25,658	5,450	4,877	371	39,303	31,245	7,906	13,061
Total Source Loads	**27,157**	**6,723**	**73,868**	**33,410**	**43,348**	**18,925**	**50,720**	**80,299**	**22,909**	**32,800**	**16,346**	**132,485**	**104,914**	**32,461**	**41,059**

Table 4.11 Percent Contribution of Pollutant Source

Pollutant Source	Subwatershed														
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Direct Discharges of Pollutants to Waterbody															
WWTF			0.0%		0.0%	0.2%		0.0%				0.0%	0.0%		
Wastewater Collection System			1.6%		0.2%	2.4%		2.1%				4.5%	2.2%		
OSSF	0.0%	0.0%	0.4%	0.4%	0.0%	0.4%	0.1%	0.4%	0.1%	0.2%	0.3%	0.1%	0.4%	0.1%	0.3%
Direct Deposition	79.8%	75.9%	61.7%	75.2%	74.9%	64.9%	65.2%	59.2%	63.5%	78.5%	77.3%	60.8%	65.1%	67.4%	51.2%
Polluted Storm Water Wash Off															
Forest	0.0%	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	0.2%	0.4%	0.2%	0.6%	0.2%	0.1%	0.8%	0.9%
Cropland	0.3%	0.5%	0.8%	0.5%	0.8%	0.3%	0.5%	0.2%	0.5%	0.4%	0.8%	0.1%	0.0%	0.1%	1.1%
Rangeland	1.5%	4.7%	5.5%	11.8%	9.8%	4.8%	15.4%	5.7%	11.8%	5.8%	18.7%	4.7%	2.4%	7.2%	14.3%
Waste Application Field		2.9%	0.8%	0.2%	1.4%	1.8%	0.6%	0.2%							0.4%
R/C/I	18.4%	15.9%	29.1%	11.7%	12.7%	25.1%	17.9%	32.0%	23.8%	14.9%	2.3%	29.7%	29.8%	24.4%	31.8%
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Using the most recent data available these tables represent best possible estimates of the amount of bacteria originating from the major sources in each subwatershed.

4.6 Uncertainty Analysis

Various entities collected data and information to understand the current ambient water quality condition of streams in the watershed and, when combined with the reconnaissance survey, it is possible to provide a reasonable understanding of the sources of bacteria in the watershed. This is most evident with the various types of direct sources evaluated in this WPP. To address this uncertainty, it was necessary to explain how limitations with the available data and the assumptions made during the calibration process can introduce uncertainty in the prioritization of strategies. Three exercises were performed to address uncertainty: 1) a calibration review comparing existing fecal coliform data to calibrated simulations to understand the overall performance of the model, 2) a conversion factor of fecal coliform to *E. coli*, and 3) a comparison of model input data and the factors used to make adjustment for calibration to indicate how changes in these input data can change the priority of strategies.

In summary, the model is capable of simulating average conditions, but presents a greater level of uncertainty under high flow conditions. The model is relatively well-calibrated and for this WPP, it is well-suited for understanding the relative impact of strategies in each subwatershed. Because the HSPF model uses fecal coliform as the simulated parameter, the fecal coliform-based model will be converted using an average of values found in the literature (0.76) derived from a band of possibility (0.42 to 1.34 times the fecal coliform model output). This band will show a range of conceivable bacteria concentrations for a model scenario that can then be compared to the current geometric mean standard. Despite the difficulty in simulating some source categories such as OSSFs they are not excluded as an input parameter and should be targeted by specific management strategies to reduce their contributions to bacteria loading. The detailed discussion of the uncertainty analysis is presented in Appendix D.

4.7 Source Contributions

One way to learn more about the mix of contributions from all sources is to use the available BST data. Between 2004 and 2005, BST was conducted at three SWQM stations on the Leon River, one each in Comanche, Hamilton, and Coryell County. The locations of the SWQM stations where BST samples were collected are displayed in Figure 3.2. The data results from the BST analysis were summarized in two separate reports. The TCEQ draft bacteria TMDL report summarized data from two SWQM stations on the mainstem of the Leon River; one at Hwy 281 and one at County Road 1702. In a completely separate study done on Belton Lake, funded with a CWA §319(h) grant from the TSSWCB to http://www.tsswcb.texas.gov/managementprogram/bstwacobelton, BST samples were also collected from the Leon River below Gatesville at FM 1829. All BST samples collected for both projects were analyzed by the Texas AgriLife Research and Extension Center at El Paso. Figures 4.9 through 4.11 provide the species classification results of the BST analysis. The data analysis results indicate that between 41 and 55 percent of the *E. coli* found at these sites were derived from wildlife or avian species at the time these samples were collected (Casarez et. al 2007). The BST data analysis results further substantiate the qualitative information provided in Subsection 4.3.4 that wildlife species contribute a significant portion of the bacteria load in the Leon River and its tributaries (wildlife includes invasive species such as feral hogs). The amount of bacteria loading from direct deposition by the diverse wildlife in the Leon River watershed is influenced by the amount of time each species spends in the riparian corridor. Additional research on wildlife movement patterns is necessary to better quantify loadings from the direct deposition of fecal matter into waterbodies by wildlife.

BST data was used to disaggregate some of the pollutant sources in the HSPF model. For example, the load contribution from the various known sources for direct deposition was based on BST. It was also used to disaggregate sources for residential areas.

It should be noted that the TMDL states, "…since the [BST] samples were collected within a limited timeframe from only two sampling locations within a very large geographic area, the results must be interpreted with caution." Since, the TMDL did not offer any resolution as to the actual sources of bacterial loading; the WPP utilized the BST data to assist in targeting the most appropriate management strategies. In the fall 2010, the TSSWCB initiated a much more comprehensive BST project to help address this issue and better target future implementation activities. The project entitled, "Bacteria Source Tracking to Support Development and Implementation of WPPs for the Lampasas and Leon Rivers" is scheduled to be completed in August 2012. You can find more information on this project by visiting the TSSWCB website at http://www.tsswcb.texas.gov/en/managementprogram/lamleonbst.

Figure 4.9 BST Results from Leon River (Upstream)

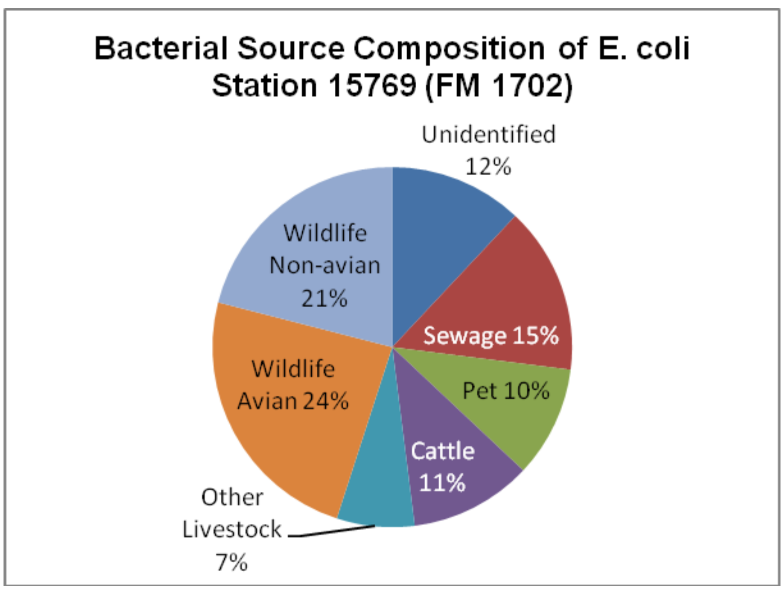


Figure 4.10 BST Results from Leon River

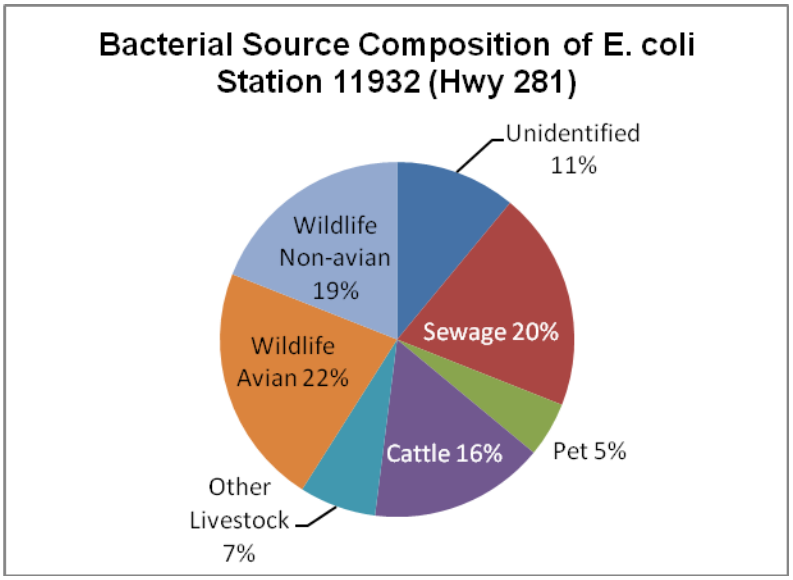
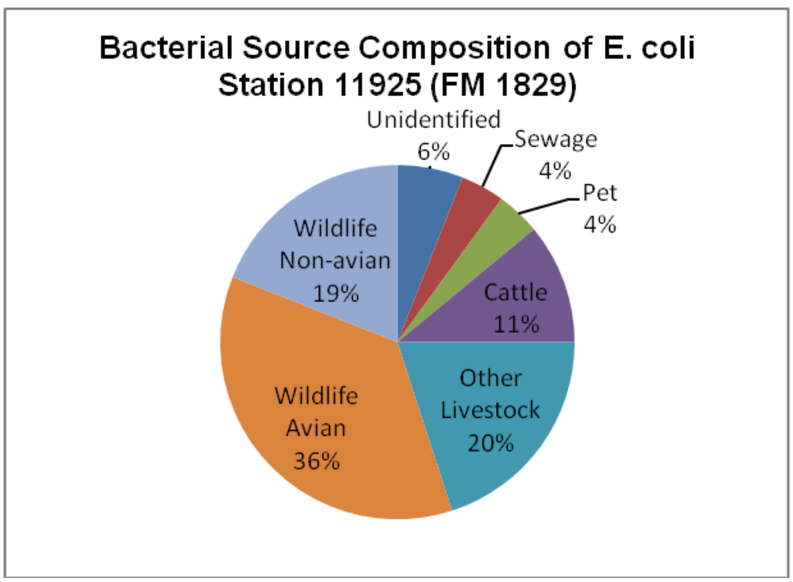
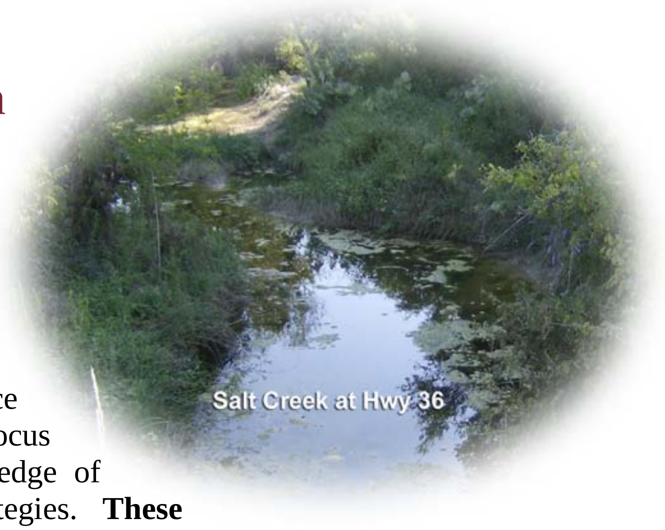


Figure 4.11 BST Results from Leon River (Downstream)



Chapter 5: Management Strategies, Implementation Schedule, and Estimate of Pollutant Load Reductions



Stakeholders of the Leon River watershed recognize the need to voluntarily implement management strategies over time to reduce bacteria loads to attain water quality goals. Focus groups were able to contribute their knowledge of potential bacteria sources and mitigation strategies. **These strategies address both point and nonpoint sources that contribute to bacteria loads in creeks and rivers.** The success of long-term implementation of this WPP is dependent on the ability to implement the proposed strategies and verify that water quality has improved. This chapter describes the recommended management strategies, the implementation schedule, and expected pollutant load reductions.

Based on management strategies suggested by stakeholders, pollutant source categories discussed in Chapter 4 were disaggregated so that particular sources of pollutant loads that are available for reduction (i.e., controllable) could be targeted. The subwatersheds with the highest level of bacteria concentrations are in the upper Leon River watershed above the City of Hamilton. The focus of implementation will be placed on subwatersheds 20, 30, 40, and 60, as they have the highest levels of bacteria concentrations. Although many suggestions were made, a group of viable strategies were selected for evaluation based on their ability to be implemented and their cost. Certain management strategies address multiple sources of bacteria. Qualitative information was gathered to provide additional information about each strategy. Stakeholders provided inputs to the DSS on strategy mitigation effectiveness, difficulty, likelihood of success, timelines, and costs. Nutrients are a concern in this watershed and it is expected that sources of nutrients in the watershed are likely to decrease as a result of implementing bacteria reduction strategies. Management strategies discussed in this chapter are listed in Table 5.1.

The DSS provided stakeholders the opportunity to set the level of effort implemented for each strategy to reduce bacteria and to provide other qualitative information needed to describe implementation challenges. The DSS allowed stakeholders to understand which sources were most prevalent and run different implementation scenarios. Stakeholders did not wish to reinvest in efforts to modify the existing loading model; rather, they recognized that time was better spent using the DSS to prioritize strategies and learn more about options for broad-based implementation.

Table 5.1 Management Strategies

Pollutant Source	Management Strategy (Percent of Pollutant Source)	Objective	RG
Direct Discharges of Pollutants to Waterbody			
WWTF	WWTF improvements Operational changes (100%)	Municipalities will enhance their treatment facilities to reduce the potential for releasing raw sewage	95%
Wastewater Collection System	Grease trap ordinance (40%)	Municipalities will develop and enforce an ordinance to reduce the buildup of grease that could block collection systems	80%
	Replace sewers (40%)	Municipalities will repair failing parts of the collection system	95%
	SSO plan (20%)	Municipalities will address issues that cause sanitary sewer overflows	95%
OSSF	Address failing OSSFs (100%)	Municipalities and counties can repair, replace, and remove failed OSSFs within city and rural areas	90%
Direct Deposition[1]	Feral hog management (23%-29%)	Local, county, and state efforts to reduce the number of feral hogs in the area	30%
	Deer population management (1%-3%)	Local, county, and state efforts to reduce the number of deer in the area	5%
	Alternative watering sources (29%-36%)	Ranchers can develop alternative watering sources for livestock away from creeks	35%
	Dead animal disposal facility (37%-42%)	County and city may provide places were dead animals can be disposed	15%
Polluted Storm Water Wash Off			
Forestland[1]	Deer population management (11%)	Landowners can work with the state to control the deer population	8%
	Feral hog management (78%)	Local, county, and state efforts to reduce the number of feral hogs in the area	35%
Cropland	Since only four percent of the watershed is classified as cropland this land use is not considered a significant source of bacteria loading therefore no management strategies are recommended.	Not applicable	—

Pollutant Source	Management Strategy (Percent of Pollutant Source)	Objective	RG
Rangeland[2]	Water quality management plans (WQMP) (86%-78%)	Ranchers can implement an appropriate suite of BMPs that will improve ranch operations and also improve water quality	35%
	Alternative watering sources (14%-22%)	Ranchers can develop alternative watering sources for livestock away from creeks	35%
Waste Application Field (WAF)	Manure management (100%)	CAFOs can improve operations through DOPA training, new technologies, operation and maintenance, and other practices	25%
Residential, Commercial, and Industrial[1]	Strategies for residential, commercial, and industrial developments: Address failing OSSFs, SSO Plan, and BMPs (16%-20%)	Municipalities and counties can reduce the number of failed OSSFs in the areas and introduce BMPs as needed to reduce the accumulation of sewage and runoff from developed areas	90%

RG = Reduction Goal. A reduction goal is defined as the level of reduction in pollutant loading expected to be achieve once a management strategy is fully implemented. Stakeholders will strive to reach each reduction goal, but there is uncertainty associated with the ultimate level of achievement given environmental, temporal and financial constraints that may exist.
[1] Other sources make up the remainder of the pollutant source (e.g., wildlife)
[2] Rangeland includes all pastureland.

Loads from each pollutant source previously provided in Table 4.10 represent the maximum theoretical amount of bacteria load that could be reduced. In reality, however, some portion of the total load cannot be controlled (e.g., bacteria load from birds). The reduction of a pollutant source is based on the effective reduction of all strategies associated with addressing that source load. The pollutant source was decreased according to the reduction goal and the percent make up of the pollutant source for all the strategies (see Table 5.1). The reduction goals from Table 5.1 establish how well the strategy is expected to reduce bacteria load once implemented and not necessarily the degree of program implementation. If a source load has more than one strategy, each strategy has a percent make up, which is how much a particular strategy can contribute to the reduction in source load. The effective reduction for each source is the percent make up of each strategy multiplied by its reduction goal, which is summed across all strategies associated with a particular source when there is more than one strategy.

Load reductions were estimated for each management strategy by simulating with the HSPF model the effect of only having that strategy in place with no other loads reduced. It was performed similar to the 100 percent sensitivity analysis except at a lower reduction level. The sensitivity analysis provided stakeholders some idea of the total load reduction potential from each pollutant source. For a detailed discussion on the impact of the strategies on a particular subwatershed based on uncertainty see Appendix D. The estimated load reduction of each strategy is presented in Table 5.2 and discussed in each subsection. Table 5.3 presents the percent contribution to total load reduction by a particular management strategy. Each strategy has a cut sheet that present the scope, location, critical areas, general description, as well the responsible parties, quantity estimates, unit costs, period of performance, and capital costs. Capital costs for each recommendation are total costs for the entire period of performance.

Table 5.2 Management Strategy Source Load Reduction

Management Strategy	Subwatershed (10^6 org/day)															Target Reduction
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
Direct Discharges of Pollutants to Waterbody																
WWTF improvements	-	-	3	<1	-	45	-	9	-	-	-	37	21	-	-	**116**
WW collection system																
Grease trap ordinance	-	-	364	1	-	193	-	539	-	-	-	1,873	727	-	-	**3,697**
Replace sewers	-	-	432	1	-	229	-	640	-	-	-	2,224	864	-	-	**4,391**
SSO Plan	-	-	216	<1	-	115	-	320	-	-	-	1,112	432	-	-	**2,195**
Address failing OSSFs	17	1	266	124	6	71	45	245	18	52	43	392	372	37	83	**1,772**
Direct deposition																
Feral hog control	2,603	419	3,545	2,034	2,304	927	2,368	3,243	1,064	1,752	782	5,293	4,787	1,663	1,559	**34,344**
Deer population management	376	61	512	294	333	134	342	469	154	253	113	765	692	240	225	**4,961**
Alternative watering sources	2,966	479	4,007	2,298	3,694	1,494	3,767	5,176	1,704	2,813	1,251	8,481	7,684	2,662	2,491	**50,967**
Dead animal disposal	44	7	60	34	44	18	45	62	20	34	15	101	92	32	30	**638**
Polluted Storm Water Wash Off																
Forestland																
Deer population management	<1	<1	1	1	1	<1	1	1	1	1	1	2	1	2	3	**16**
Feral hog management	5	2	22	17	21	6	33	34	26	20	22	61	45	73	94	**481**
Rangeland																
WQMPs	32	18	197	198	192	56	333	232	134	97	124	290	133	127	293	**2,458**
Alternative watering sources	8	6	58	63	61	17	106	68	38	27	37	78	32	24	69	**692**
WAF manure management	-	31	82	10	87	62	46	28	-	-	-	-	-	-	26	**371**
Strategies for R/C/I developments	798	124	4,366	882	728	1,465	1,207	6,013	722	642	46	9,338	7,551	1,051	1,779	**36,712**
Source load reduction achieved	**6,850**	**1,147**	**14,130**	**5,957**	**7,471**	**4,833**	**8,293**	**17,079**	**3,882**	**5,689**	**2,434**	**30,048**	**23,434**	**5,912**	**6,653**	**143,811**

R/C/I = Residential, commercial, industrial land use

This table presents the total potential bacteria source load that can be reduced in each subwatershed through the cumulative effect of implementing a suite of proposed management strategies. As more information is gathered over time about the performance of each management strategy, adjustments can be made to the when, where and how further implementation continues in an effort to meet water quality goals.

Table 5.3 Management Strategy Reduction Contribution

Management Strategy	Subwatershed (percent)															Overall Contribution
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	
Direct Discharges of Pollutants to Waterbody																
WWTF improvements			< 1%	< 1%		1%		< 1%				< 1%	< 1%			**< 1%**
WW collection system																
Grease trap ordinance			3%	< 1%		4%		3%				6%	3%			**3%**
Replace sewers			3%	< 1%		5%		4%				7%	4%			**3%**
SSO Plan			2%	< 1%		2%		2%				4%	2%			**2%**
Address failing OSSFs	< 1%	< 1%	2%	2%	< 1%	2%	< 1%	1%	< 1%	< 1%	2%	1%	2%	< 1%	1%	**1%**
Direct deposition																
Feral hog control	37%	36%	25%	34%	31%	19%	29%	19%	27%	31%	32%	18%	20%	28%	23%	**24%**
Deer population management	5%	5%	4%	5%	4%	3%	4%	3%	4%	4%	5%	3%	3%	4%	3%	**3%**
Alternative watering sources	43%	42%	28%	39%	49%	31%	45%	30%	44%	49%	51%	28%	33%	45%	37%	**35%**
Dead animal disposal	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	**< 1%**
Polluted Storm Water Wash Off																
Forestland																
Deer population management	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	**< 1%**
Feral hog management	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	1%	1%	**< 1%**
Rangeland																
WQMP	< 1%	2%	1%	3%	3%	1%	4%	1%	3%	2%	5%	1%	< 1%	2%	4%	**2%**
Alternative watering source	< 1%	< 1%	< 1%	1%	< 1%	< 1%	1%	< 1%	1%	< 1%	2%	< 1%	< 1%	< 1%	1%	**< 1%**
WAF manure management		3%	< 1%	< 1%	1%	1%	< 1%	< 1%							< 1%	**< 1%**
Strategies for R/C/I developments	12%	11%	31%	15%	10%	30%	15%	35%	19%	11%	2%	31%	32%	18%	27%	**26%**
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

R/C/I = Residential, commercial, industrial land use

5.1 Direct Discharge Management Strategies

Strategies to address direct discharges are focused on WWTFs, wastewater collection systems, OSSFs, and direct deposition from animals. The municipal and county focus groups worked on strategies to address human-based bacteria discharges from WWTFs, OSSFs, and wastewater collection systems, and all focus groups made suggestions to address direct deposition by animals. Management strategies in subsection 5.1 for direct discharges will reduce both point and nonpoint sources of pollution.

5.1.1 Wastewater Treatment Facility Strategies

All WWTFs in the Leon River watershed collect wastewater from urban areas and treat the wastewater prior to discharge to a receiving waterbody. The municipalities in the Leon River watershed recognize the importance of improving the maintenance and operation of their WWTFs. Table 5.4 provides a summary of recent upgrades to some of the WWTFs.

Table 5.4 WWTF Improvement Strategies

Municipality	Capital Improvement	Status	Costs to Date
General			
Comanche (30)	Replace WWTF de-grit equipment	Completed	$38,000
Gatesville (120, 130)	North Stillhouse WWTF rehabilitation	2010	$4,000,000
	Leon WWTF rehabilitation	2010	$1,500,000
Gustine (40)	Chlorination system improvements	2010	$50,000
Hamilton (80)	Increase WWTF capacity, repair main lift station, install UV disinfection system, screening and grit system upgrade	completed	$1,700,000
ULRMWD (10)	New WWTF	completed	$1,100,000
Land Application			
Dublin (60)	Eliminate wastewater discharge; convert WWTF to no-discharge facility, 100 percent land application facilities.	2010	$1,000,000

The Cities of Hamilton and Gatesville and the Upper Leon River Municipal Water District have spent millions of dollars on facility improvements that increase treatment capacity and improve the treatment processes of their WWTF. The City of Gatesville is in the process of taking over the treatment of Ft. Hood's wastewater. This will improve the quality of the treated wastewater discharged to subwatershed 120. The City of Dublin has finalized the conversion of its WWTF to a no discharge facility and acquired property to land-apply its treated effluent. When the city ceases the discharge from its WWTF to Resley Creek in 2010, this will eliminate a continuous source of *E. coli* to the receiving water in subwatershed 60. The land Dublin will use for land application of effluent and sludge is south of town within the Leon River watershed.

In addition to these capital investments, stakeholders believe that future improvements to WWTFs and their associated wastewater collection systems are necessary for reducing bacteria from municipal sources. The municipal focus group suggested strategies to address treatment during wet weather conditions, WWTF improvements, and enhanced effluent disinfection. The following cut sheet provides the recommendations for immediate improvements to some of the WWTFs in the Leon River watershed. Each municipality has other improvements planned for their respective WWTFs over the next 10 years; however, cost estimates are not available for these potential improvements at this time.

It should be noted that on an annual basis bacteria reductions from these types of projects are negligible because WWTFs meet their permit obligations the majority of the time. Reductions are less than 50 million organisms of *E. coli* per day (herein referred to as 10^6 orgs/day) and contribute less than 1 percent of the reduction by all strategies. However, these improvements also increase the capacity of the WWTF to handle peak flows more effectively and contribute to the reduction of SSOs.

WWTF Improvements

Scope:

- Identify process, capacity and operational deficiencies
- Develop alternatives and final designs
- Secure financing and construct projects

Location: All permitted WWTFs

Critical Areas: Cities of Comanche, Dublin, and Gustine which are located in subwatersheds with the highest concentrations of bacteria.

Goal: Improve the capacity and operational efficiency of WWTFs to handle more flow, treat effluent more efficiently, and have higher quality effluent discharge.

Description: Treatment efficiency and capacity is improved when tanks are sufficiently sized to allow the proper amount of time for a chemical/physical process to take place. The equipment in tanks must be of sufficient capacity to achieve proper treatment. If maintained properly, a WWTF removes suspended and floatable material, biodegradable organics, and eliminates pathogenic organisms. Improvements in maintenance, operations, technology and effluent monitoring can further improve effluent quality. Each municipality has or is in the process of implementing a variety of treatment plant upgrades and is seeking funding to support construction.

Implementation Strategies

Participant	Recommendations	Period	Capital Costs
Comanche (30)	Replace clarifiers, and replace sludge drying beds with digesters	2011-2015	$738,000
Dublin (60)	Acquisition of additional land for land application	2011-2015	$100,000
Gatesville (120, 130)	Accept wastewater from Ft. Hood	2012	$4,000,000
Gustine (40)	Replace clarifier, update SCADA	2015	$100,000
7 WWTF	Incorporate new effluent limit and monitoring requirement for *E. coli* in TPDES permits in all cities ($600 per WWTF per year)	2014-2020	$4,200

Load Reductions

On an annual basis, bacteria reductions from WWTF are minimal because WWTFs meet their permit obligations the majority of the time. Although during rain events bacteria concentrations could be high and in particular contain pathogens that are particularly harmful to humans, the load throughout the year is less than 1% of the load reduction provided by all strategies in each subwatershed.

Effectiveness:	High: WWTF treatment processes are highly effective at reducing bacteria loads wastewater.
Difficulty:	Medium: Small municipalities will require financial assistance to accelerate construction of recommendations.
Certainty:	High: Permit requirements and compliance and enforcement provide assurances that recommendations will be implemented.

5.1.2 Sanitary Sewer Overflow Strategies

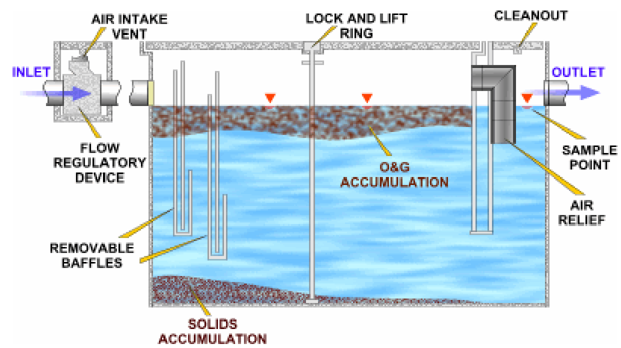
Of the nine TPDES-permitted WWTFs in the Leon River watershed, there are five municipalities (Comanche, Dublin, Gustine, Hamilton, Gatesville) committed to addressing SSOs associated with their sewer collection systems. There are miles of pipelines in a municipal system. For example, the City of Dublin has approximately 7 miles, the City of Comanche has approximately 150 miles, the City of Hamilton has 26 miles, and the City of Gatesville has 70 miles. The municipal focus group identified strategies that will reduce the potential for SSOs. The goal for all the municipalities is to decrease SSOs from occurring to the greatest extent possible. Three strategies were recommended: grease trap ordinance development, compliance, and enforcement; identification of problems, rehabilitation, and repairs to the collection system; and participation in the TCEQ SSO initiative, which includes implementation of an SSO plan. The Cities of Comanche and Hamilton have already prepared and submitted an SSO plan to TCEQ and are already implementing certain recommendations.

The cumulative effect of implementing these management strategies is expected to reduce the number of SSO occurrences and therefore reduce bacteria and nutrient loads in subwatersheds 30, 40, 60, 80, 120 and 130. An SSO plan also includes studies to find and eliminate illicit connections, faulty sewer connections, and other failures at the household level that will reduce not only direct discharges, but also reduce the accumulation of bacteria on the land. This effect is considered for polluted storm water wash off from commercial, industrial, and residential areas (costs are shared equally for these two strategies). Most of the municipalities in the Leon River watershed have received administrative orders from TCEQ in the past in response to enforcement action associated with SSOs. For these reasons, municipalities have initiated efforts to repair their existing systems where needed and maintain and improve operation of the other parts of the system. The recommended strategies to address SSOs are detailed in the following cut sheets.

Grease Trap Ordinance Development, Compliance, and Enforcement

Scope:

- Modify existing ordinance**;** draft proposed ordinance; adopt ordinance
- Promote compliance and enforce ordinance
- Establish reporting database



Location: All cities

Critical Areas: Comanche, Dublin, Gustine, Hamilton, Gatesville

Goal: Improve existing or establish new efforts to reduce problems resulting from blockages in sewer collection system caused by excessive oil and grease.

Description: Grease collecting in any part of a wastewater collection system can cause blockages resulting in SSOs and be problematic to wastewater treatment facilities. For this BMP to be effective each municipality must agree to apply the level of effort and resources necessary to be sure that the ordinance can actually be implemented. This requires outreach and education, inspection and enforcement, and data management associated to demonstrate benefits. Each municipality has an enforcement officer and additional priority can be placed on inspections for compliance and enforcement. A grease trap ordinance would require all nondomestic food service and motor vehicle facilities to install interceptors to keep grease, oil, wax and fats out of the wastewater collection system. The ordinance could require installation of interior interceptor or more advanced traps including underground systems. Existing ordinances, enforcement programs and data tracking methods from other municipalities can be used as templates to mimic. This wastewater is untreated and it is important to eliminate the potential for SSOs given the high concentrations of bacteria they contribute and the fact they are illegal discharges that pose a significant threat to human health.

Implementation Strategies

Participant	Recommendations	Period	Capital Costs
Gustine (40),	Grease trap ordinance development, review, adoption and promotion	2014	$10,000
Comanche (30) Dublin (60) Hamilton (80) Gatesville (120, 130)	Accelerate Compliance, Enforcement, and Reporting service	2011-2020	Existing Budget
Gustine (40)	Compliance, Enforcement, and Reporting service	2015-2020	Existing Budget

Load Reduction

Excluding Gustine, reduction in loads can range from 193 to 1,873 x 10^6 orgs/day (2.6% to 6.2% reduction contribution). Gustine has a minimal load reduction contribution because it is far removed from a tributary to the Leon River.

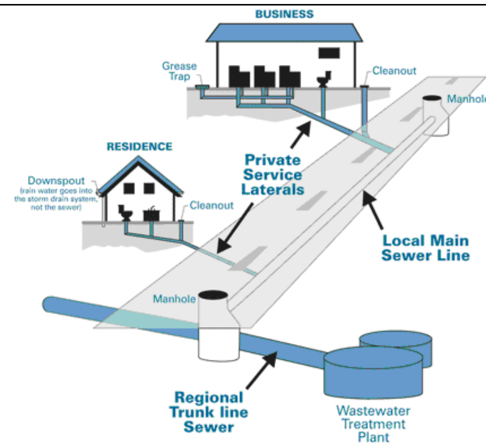
Effectiveness:	High: With resources to enforcement compliance with ordinance this is an effective BMP for reducing blockages that lead to SSOs.
Difficulty:	Medium: The difficulty of implementing ordinances depends on availability of resources to enforce ordinance.
Certainty:	High: Municipalities with existing ordinance are increasing compliance/enforcement.

Replacement of Failing Wastewater Collection System Infrastructure

Scope:

- Identify known bottlenecks from operator experience
- Conduct engineering evaluations to determine existing and potential failures
- Evaluate capacity and prepare design
- Perform rehabilitation

Location: Comanche, Dublin, Gustine, Hamilton, Gatesville



Goal: Identify and replace deteriorated, collapsed, and failed parts of the collection system as well as areas that do not have sufficient flow capacity to reduce the potential for SSOs.

Description: Some of the failing sections of the wastewater collection system have been identified for replacement by Comanche and Dublin. Availability of funding will influence how fast initial projects can be constructed. Additional improvements in the collection system infrastructure for all five cities will be identified and implemented as an outcome of participation in the TCEQ SSO initiative. Because this wastewater is untreated it is important to eliminate the potential for SSOs given the high concentrations of bacteria they contribute and the fact they are illegal discharges that pose a significant threat to human health.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
Comanche (30)	Replace 2,200 feet of sewer lines (6” to 8”) to improve capacity ($60/ft)	2011-2015	$132,000
	Replace two manholes per year ($38,000 per manhole) and two manhole covers per year ($2,000 per manhole) to decrease inflow and infiltration (I&I)	2011-2015	$400,000
	Replace 12 leaking service connections ($2,500 per connection) per year	2011-2015	$150,000
Dublin (60)	Replace 2 miles of sewer lines (6” to 8”) to repair sewer under rail road crossing and address two areas of known blockages ($60/ft)	2016-2020	$600,000
Hamilton (80)	Single project to replace 1,000 feet of 6” sewer line and 28 manholes in Cole and Weiser Streets beginning in the Summer of 2008 (funding already acquired)	2008-2010	$257,000

Load Reduction

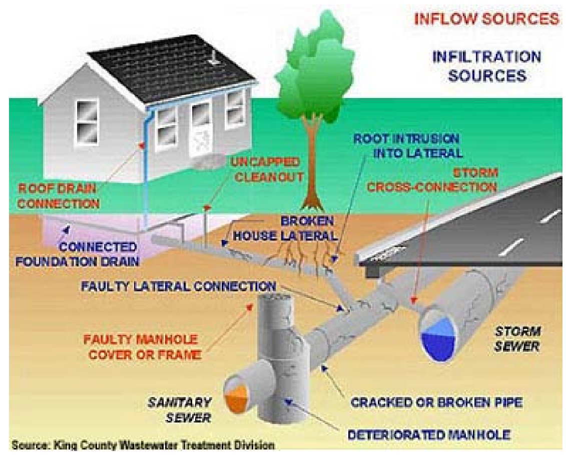
Excluding Gustine, reduction in loads range between 229 and 2,224 x 10^6 orgs/day (3.1% to 7.4% reduction contribution). Gustine has a minimal load reduction contribution because it is far removed from a tributary to the Leon River.

Effectiveness:	High: Repairing failing infrastructure decreases I&I and SSOs which will decrease bacteria and nutrient loading in urban areas to waterways.
Difficulty:	High: High costs and extensive technical support is needed.
Certainty:	High: All cities legally bound to decrease the potential for SSOs.

Develop and Implement SSO Plans

Scope:

- Collaborate with TCEQ to prepare a SSO plan
- Conduct a detailed sanitary sewer system evaluation survey
- Develop a plan, that cannot exceed 10 years, to address SSOs that includes corrective measures and milestones for completion
- Perform rehabilitation and submit compliance reports



Location: All cities with collection systems that have reported SSOs

Goal: Develop and implement SSO plans to reduce the potential for releases of untreated sewage.

Description: The term of the SSO plan cannot exceed 10 years. The plan should include the following elements:

- A description of the cause of the SSOs and interim measures the facility will take to mitigate the effects of continuing SSOs.
- A comprehensive evaluation of the sewer system (smoke testing, flow monitoring, and inspection).
- A description of specific corrective measures, with milestones for addressing continuing SSOs.
- The timeline for completing each corrective action.
- Provisions for the development and implementation, or the improvement, of an operations and maintenance program to ensure continued permit compliance.
- A description of all funding sources.
- A statement describing how the facility will evaluate the effectiveness of the improvements.

While a SSO plan is in effect, the municipality can avoid any fines associated with an SSO so long as the source is being addressed in the SSO Plan, but TCEQ still reserves the right to take enforcement action. However, because this wastewater is untreated it is important to eliminate the potential for SSOs given the high concentrations of bacteria they contribute and the fact they are illegal discharges that pose a significant threat to human health.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
Comanche (30)	Prepare and submit SSO Plan to TCEQ	Completed[1]	$75,000
	Implement SSO plan corrective measures and prepare compliance reports	2011-2020	NA
Gustine (40)	Prepare and submit SSO Plan to TCEQ	2012	$75,000
	Implement SSO plan corrective measures and prepare compliance reports	2013-2023	NA
Dublin (60)	Prepare and submit SSO Plan to TCEQ	2012	$75,000
	Implement SSO plan corrective measures and prepare compliance reports	2013-2023	NA
Hamilton (80)	Prepare and submit SSO Plan to TCEQ	Completed[1]	$75,000
	Implement SSO plan corrective measures and prepare compliance reports	2011-2020	NA

Develop and Implement SSO Plans			
Gatesville (120, 130)	Prepare and submit SSO Plan to TCEQ	2012	$75,000
	Implement SSO plan corrective measures and prepare compliance reports	2013-2023	NA
Load Reduction			
Excluding Gustine, reduction in loads can range between 115 and 1,112 x 10^6 orgs/day (1.5% to 3.7% reduction contribution). Gustine has a minimal load reduction contribution because it is far removed from a tributary to the Leon River.			
Effectiveness:	High: Having a master plan to repairing failing infrastructure decreases I&I and SSOs will decrease bacteria and nutrient loading in urban areas to waterways.		
Difficulty:	High: Costly, time consuming and technical assistance is needed.		
Certainty:	High: All cities except Gustine have already submitted plans or are in progress		

Reference: TCEQ 2008. Sanitary Sewer Overflow (SSO) Initiative. Online. Available: http://www.tceq.texas.gov/publications/gi/gi-389.html/at_download/file. Accessed: October 29, 2009.

[1] SSO Plans available by contacting City.

5.1.3 Onsite Sewage Facilities Strategies

The State of Texas has adopted rules under Title 30, Texas Administrative Code, Chapter 285, that regulate the management of OSSFs, setting minimum requirements for the establishment, repair, operation, maintenance, permitting, and inspection of OSSFs (TCEQ 2010). In most cases, permitting and inspection responsibilities have beendelegated to counties as Authorized Agents by TCEQ. Rather than having an individual on staff, Comanche and Hamilton Counties have contracted with a Designated Representative to oversee permit applications, site evaluations, or planning materials, or conduct inspections for OSSFs. Owners (homeowners or businesses) of OSSFs are ultimately responsible for the maintenance, repair, or replacement of an improperly functioning system. Landowners who lease their lands for hunting are also responsible for the OSSFs or privies that are associated with hunting cabins or campgrounds. Hunting cabins or sleeping quarters that do not properly dispose of wastewater are violating the law. Septic system inspectors and sludge haulers who also play an important role in the life cycle of OSSFs must also be licensed. Texas AgriLife Extension Service plays an important role in providing technical assistance and outreach.

With so many different players responsible for the implementation of OSSF management strategies, there are number of activities already underway that need to be recognized to better frame recommended future actions. Municipalities have and will continue to connect households on septic systems to the wastewater collection system where practical. For example, within the last 10 years, the City of Hamilton has connected 42 homes to its central collection system. The City of Comanche has also integrated 74 homes into its central collection system with plans to connect 25 more through a USDA grant. The cost of connecting these homes depends on the distance to the collection system where it could cost a few hundred dollars to several thousand based on the depth of the collection system, soil conditions, and number of connections made at any given time.

Coryell County has taken an important and valuable step toward addressing pollution from OSSFs by hiring an Environmental Officer to conduct inspections of OSSFs and provide technical assistance to homeowners and businesses. This position was established in fall 2008 by the Coryell County Attorney's Office to allow the County to take a more aggressive role in implementing the county-wide OSSF program and other management measures aimed at improving water quality that are within the jurisdiction of Coryell County. The Coryell County Environmental Officer is responsible for implementing the county's OSSF program rather than contracting it out to a designated representative. The county has already made significant progress in investigating OSSF complaints and issues in the county and the Environmental Officer has initiated an effort to acquire funding for the repair or replacement of OSSFs within the floodplain.

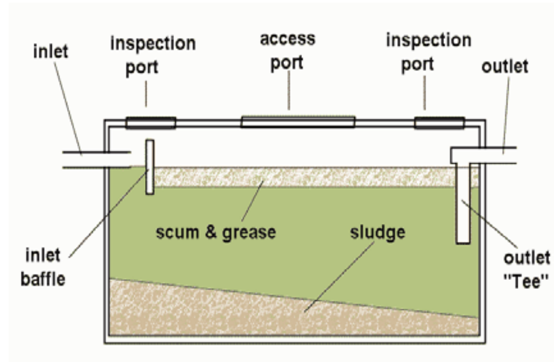
Reducing bacterial contamination by assuring that sewage from temporary housing is properly treated is the responsibility of individuals who lease their lands for seasonal activities such as hunting. There are limitations to the number of inspections that occur on existing systems. Limited resources are available for inspection and enforcement actions to be conducted on OSSFs, which makes it difficult to initiate corrective actions. The TCEQ does not have the resources available to inspect OSSFs. Other inspectors, such as those from a lending industry that hire private OSSF inspectors, typically are not equipped to conduct comprehensive inspections of OSSFs.

There is consensus among stakeholders that the estimate of failing OSSFs provided in the TCEQ draft bacteria TMDL is low. Management strategies targeted at OSSFs should be considered a priority since removing or repairing failed facilities reduces human pathogen sources from the environment. An effective suite of management strategies for decreasing pollutant loads from failing or improperly functioning OSSFs include:

1. investigate, locate, and prioritize failing or noncompliant OSSFs;
2. acquire funding sources to connect OSSFs to a centralized wastewater collection system where possible and/or repair or replace failing OSSFs;
3. provide technical assistance to landowners, contractors, inspectors, septage haulers, and counties to improve all aspects of installation, repair, maintenance, and inspection of existing and new OSSFs; and
4. provide technical support for improving data acquisition and management in each county for tracking OSSFs.

Items 1 and 2 above are defined in the following cut sheet. Items 3 and 4 are defined in a cut sheet as part of education and outreach strategies in Chapter 7.

Repair/Replace/Remove Failing OSSFs



Scope:

- Determine hot spots of failing OSSFs through geo-location, inspections, and BST
- Investigate reported OSSF failures
- Prioritize failing OSSFs for repairs/replacements
- Repair/replace failing OSSFs or connect to municipal sewer system

Location: All subwatersheds

Critical Areas: Target unincorporated towns located in subwatersheds 20, 30, 40, 50, 60, 80, 120, 150; special focus on OSSFs within riparian areas and flood plains

Goal: Identify and prioritize then remove, replace or repair failing OSSFs to protect and restore water quality.

Description: All four counties in the Leon River watershed acknowledge that they do not have sufficient information on where failing OSSFs may exist and agree more needs to be done to address contributions of bacteria and nutrient loading from this source. Therefore each county can work to target additional resources and effort to obtain the information necessary to identify failing OSSFs and prioritize which systems are most in need of repair or replacement. Counties can also identify malfunctioning OSSFs or systems in need of operations and maintenance support. Counties can develop of a comprehensive set of information and data to document OSSF locations, technology type, and functionality. Other relevant information to be included is proximity to waterways, development density, soil type, land surface elevation, system age, floodplain elevation, depth to groundwater, and compliance history. Once this information is available, the next steps are 1) preparation of a preliminary cost estimate of the systems recommended for replacement, repair, or connection to an existing wastewater collection system; and 2) acquisition of funding to establish a cost-share program for homeowners and businesses with failing OSSFs. Based on a prioritized list of failing OSSFs, cost-share assistance can be provided to replace or repair failing OSSFs, or connect to a centralized system when possible.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
Comanche, Hamilton, Erath, Coryell Counties	Comprehensive approach for documenting, locating, inspecting, prioritizing, failing OSSFs. Data collected during initial 4-year ($150,000 per county)	2011-2015	$600,000
Comanche, Hamilton, Erath, Coryell Counties	Refine cost estimates for tracking and identifying additional failing OSSFs after 2015 ($75,000 per county)	2016-2020	$300,000

Repair/Replace/Remove Failing OSSFs			
Comanche, Hamilton, Erath, Coryell Counties	Each county estimates that a short-term target of 20 OSSFs per county can be repaired or replaced. Each county can place emphasis on identifying failing OSSFs near waterways particularly in small communities like Proctor, Newburg, Lamkin, Jonesboro, Flat, Leon Junction. Each county can determine how to structure a cost-share program based on the amount of funds acquired. New cost estimates will be prepared for replacement/repair program in 2016-2020 based on data findings from 2011-2015 ($120,000 per county)	2011-2015	$480,000
Coryell County	Environmental Officer ($50,000 per year, already funded)	2011-2020	$500,000
City	Comanche, Dublin, Hamilton, Gustine, and Gatesville have each committed in the next 5 years to connect up to 15 households on OSSFs within their respective jurisdictions to the centralized wastewater collection system ($2,500 per connection)	2011-2015	$187,500
Homeowners	Address facilities for hunting leases ($2,500 per hunting facility with approximately 476 hunting facilities)	2011-2020	$1,195,000
Load Reduction			
For direct discharges, removing, replacing, and repairing OSSFs can reduce over 250 x 10^6 orgs/day in some watersheds with a heavy residential area. Other more rural watersheds are likely to see reductions of less than 100 x 10^6 orgs/day. OSSFs will also have an impact on wash off; therefore a portion of the reduction in some watersheds can be attributed to addressing OSSFs. When combined with an SSO plan, removing the human component of wash off in residential, commercial, and industrial areas can result in reductions close to 10,000 x 10^6 orgs/day (30 percent of the total reduction contribution).			
Effectiveness:	High: New, repaired or eliminated OSSFs will remove bacteria or nutrient loads from human sources.		
Difficulty:	Medium: Establishing a cost-share program will increase likelihood homeowners or businesses will take step to connect to sewer system or replace/repair failing OSSF.		
Certainty:	High: Enforcement is possible and Counties are committed to implementation.		

5.1.4 Direct Deposition Strategies

Management strategies are needed to address a wide array of direct deposition sources throughout the Leon River watershed. The direct deposition sources include wild animals (e.g., birds, water fowl, deer, raccoons, and opossums), feral hogs, livestock (cattle, goats, sheep, and horses), and the disposal of dead animals in creeks. Although animals with access to riparian corridors contribute the majority of the loading attributed to direct deposition, it is possible a portion of the loading could emanate from humans or domestic pets.

Management strategies aimed at reducing bacteria and nutrient loads from domestic animals and wild animals range from strategies that are easy and effective to difficult and costly. Stakeholders identified an initial set of management strategies focused on controlling feral hogs, deer, and livestock, as well as recommendations to promote proper disposal of dead animals.

5.1.4.1 Feral Hog Management

Invasive species such as feral hogs have become a major concern in Texas. This is evident from efforts in other Texas watersheds such as the Plum Creek Watershed Partnership that "has identified feral hogs as a significant potential source of water pollution in their watershed" (Texas AgriLife Extension Service 2008b). Bacterial source tracking data indicate that 19 to 21 percent of the load in the watershed is attributed to wild mammals (Casarez E. A. et.al 2007). Feral hogs, along with deer, make up the largest of these animals, and feral hogs likely contribute the largest proportion of direct deposition load due to their tendency of migrating along the riparian corridor. Stakeholders are actively doing work to eradicate this invasive species because of the detrimental impact it has on the environment and its contribution to bacteria load. Agencies have been working together using a variety of tactics to reduce the proliferation of feral hogs, which includes research, lethal and non-lethal management strategies, and education. Stakeholders are committed to working with any agencies to make gains in quantifying and reducing the feral hog population.

Feral hog control will be a challenge as efforts by the Texas AgriLife Extension Services' Texas Wildlife Services (TWS) show that there are many factors affecting feral hog management (Muir and McEwen 2007). Hunting has long been in practice, but it is most effective at night, around water sites, after crop harvests, and in areas with low cover. Snares are effective on fences as it makes hogs hesitant in crossing fences. Various types of traps are used, which typically use bait, with most being effective after harvest as there was less of an available food supply. Recent studies by TWS also demonstrated that fencing around deer feeding stations can be effective at restricting access to this common food source for feral hogs (Burns 2010). TWS concludes that coordinated efforts are effective in reducing damage to crops by reducing feral hog numbers and causing changes in behavior (TWS 2010). To date, specific correlations between reductions in hog populations and reductions in instream bacteria concentrations have not been quantified. For more information on an evaluation of the importance of reducing direct discharges from feral hogs review Appendix D. The recommended strategies to address feral hogs are detailed in the following cut sheet.

Feral Hog Management

Scope:

- Advance a comprehensive multi-county approach to reduce feral hog population
- Identify incentives for reducing feral hog population
- Integrate technical assistance, education and outreach into approach
- Quantify benefits of population reduction

Location: All subwatersheds

Critical Areas: All subwatersheds

Goal: Decrease feral hog population in and around Leon River watershed and quantify benefits.

Description: County government officials collaborating with select state agencies would implement a variety of existing and new programs aimed at culling and trapping feral hogs to reduce the population.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
Comanche, Erath, Hamilton, Coryell Counties, Texas AgriLife Extension Service	Hire 1 additional county trapper to assist all four counties	2011-2020	$700,000
	Purchase additional hog control equipment	2011	$10,000
	Investigate feasibility of establishing a trial bounty program ($3,000 per year per county)	2011-2013	$36,000
	Coordinate with TWS to conduct aerial hunting of hogs once per year in each county	2011-2015	NA
	Formulate and implement use of online tracking tools to improve data management and demonstrate progress at reducing feral hog population	2012	$20,000
Texas Wildlife Services	Reduce feral hog population through hunting and trapping	2011-2020	$30,000
Landowners	Construct fencing around deer feeding stations to deny hog access at $187 per deer feeder (number of deer feeders in watershed unknown)	2011-2015	NA

Load Reduction

Reductions in feral hog populations will reduce bacteria loading to the landscape (rangeland, forestland, cropland) and direct deposition to waterbodies. This program will be most effective in addressing direct deposition as these animals spend the majority of their time in the riparian corridor. This program is expected to bring a reduction as high as 5,293 x 10^6 orgs/day in one watershed with an average over 2000 x 10^6 orgs/day for all watersheds. The program is the second highest contributor to source reduction with a range of 18% to 38% contribution to total load reduction. The strategy has less an effect for wash off as the reductions are expected to be less than 100 x 10^6 orgs/day with no more than 1% for load reduction contribution for any given subwatershed.

Effectiveness: High: Reduction in feral hog population will result in a direct decrease in bacteria and nutrient loading to the streams.

Feral Hog Management	
Difficulty:	High: Proliferation of hogs, coordination of multiple activities to achieve success is difficult and the number of willing players must be high to achieve success.
Certainty:	Low: Cost factors can limit implementation and the ability to engage the majority of landowners to participate in culling the hog population is uncertain.

5.1.4.2 Deer Population Management

Stakeholders commented during public meetings that deer and small mammal populations throughout the watershed have increased in the past decade and TPWD deer census show increases of deer population from 2005. Although deer on an individual basis do not produce as much fecal matter as cattle and hogs, the ease with which they can access the riparian corridor make them a known source of direct deposition that creates management challenges. Stakeholders agreed that it is important to manage the deer population in all parts of the watershed to the extent possible. Landowners can collaborate with the TPWD to determine practical approaches that could be applied to managing deer populations in forestland and rangeland. Through this collaboration landowners can stress to the TPWD the need for wildlife management strategies that can have a direct positive effect on water quality. The recommended strategies to manage the deer population are detailed in the following cut sheet.

Deer Population Management

Scope:

- Work to address deer population
- Promote options for reducing deer population
- Conduct deer census
- Provide technical assistance to landowners

Location: All subwatersheds

Critical Areas: Subwatersheds 10, 20, 30, 40, 50, 60, and 70

Goal: Reduce deer population in the watershed.

Description: Diverse wildlife populations live in the forestland, rangeland and riparian corridors throughout the Leon River watershed. This strategy can focus on the overpopulation of deer throughout the watershed by promoting an increase in the acreage of forestland and rangeland operating under Wildlife Management Plans and Wildlife Management Associations. Landowners can receive technical guidance from TPWD on matters pertaining to wildlife habitat management and deer population management. Landowners, with assistance from TPWD, can establish wildlife management associations or co-ops to create wildlife management plans for large contiguous areas. Landowners can also seek to acquire Managed Land Deer Permits from TPWD to allow hunting seasons to be extended. This management strategy requires ongoing commitment and collaboration by landowners in each county. Landowners and deer processing facilities can collaborate to evaluate possible incentives for culling the deer population.

Implementation Strategy

Participation	Recommendations	Period	Capital Costs
45% of landowners within forestland and rangeland areas; TPWD	Control deer population through proper deer population management, expansion and establishment of new Wildlife Management Associations, and the use of all legal means and available programs to achieve the recommended deer harvest	2011-2020	NA
Landowners within forestland and rangeland areas; TPWD	Refining and tracking deer census and reporting changes in deer population; identifying incentives for culling deer population ($10,000 per year)	2011-2020	$100,000

Load Reduction

This program is expected to bring a reduction between 61 and 765 x 10^6 orgs/day (a contribution to total load reduction between 3% and 5%) for direct deposition.

Effectiveness:	Medium: The greater the reduction in deer population the more bacteria reductions on land and through direct deposition can be achieved.
Difficulty:	High: Reducing the deer population over the entire watershed requires substantial coordination and commitment and may also create concerns among the hunting community; mobility of deer population from adjacent counties can impeded localized progress.
Certainty:	Low: Success of establishing wildlife management associations depends on willingness of owners of contiguous rangeland parcels to agree to collaborate and participate.

5.1.4.3 Alternative Watering Sources

Livestock Watering Source off Hwy 36

Ranching in the Leon River is one of the economic hubs of the region and a way of life for many. Providing an adequate, quality source of water to livestock is a fundamental component of any ranching operation or farm with livestock. While creeks and some rivers can provide a viable water source for livestock, ranchers and farmers recognize that livestock can have an impact on water quality and riparian habitat. Ranchers also suggest that allowing cattle in creeks, and especially larger rivers, has the potential to harm cattle as they may become stuck or get swept away during rain events. For these reasons the farm/ranch focus group recommended constructing alternative watering sources to draw them away from the creeks as a practical best management practice (BMP) for reducing bacteria loads from direct deposition by cattle in the riparian corridor. Alternative watering sources are one of many different BMPs integrated into water quality management plans. A WQMP is a site-specific plan developed through and approved by soil and water conservation districts for agricultural or silvicultural lands. A WQMP includes appropriate land treatment practices, production practices, management measures, technologies, or combinations thereof and is certified by the TSSWCB as to be consistent with SWQS (TSSWCB 2009*a*). WQMPs are subject to status reviews conducted by the TSSWCB to check on implementation progress. Additional information on the importance of implementing WQMPs in the Leon River watershed is provided under Rangeland Strategies.

Installing an alternative watering source is possible when a good quality water supply for cattle can be established. Different types of alternative watering sources are in place in the watershed, which includes ponds, troughs, and other forms of storage. The major element of establishing an alternative watering source is providing a permanent water supply (e.g., groundwater, creek, pond, or rainwater) and a means to transfer the water to the storage area that could meet the demand of cattle watering needs (typically 20 gallons/day). A single watering system for a field can cost approximately $20,000 with some maintenance cost as well and can provide around 1 gallon per minute of water, providing service to 72 head of cattle. Given that there are 136,704 free roaming cattle in the watershed and assuming that 10 percent of ranches have water access and 50 percent of ranchers already have alternative watering sources in place. For each watershed, based on a rounded up value, this would require 104 wells and an investment of approximately $2 million for new alternative watering sources.

This high priority strategy recommended for reducing direct discharge from cattle is detailed in the following cut sheet.

Alternative Watering Sources

Scope:

- Landowners and Ranchers inventory all access points for livestock to creeks and streams; evaluate sites for alternative watering sources based on creek access and number of cattle
- Coordinate with SWCD to obtain technical support and identify cost share opportunities
- Include as part of a water quality management plan

Location: All subwatersheds

Critical Areas: Subwatersheds 20, 30, 40, 50, 60, 70

Goal: Establish a water supply for cattle away from a river or creek to decrease direct deposition of bacteria and nutrient loads from cattle.

Description: The major element of establishing an alternative watering source is providing a permanent water supply (e.g., groundwater, river, or rainwater) and a means to transfer the water to the storage area that could meet the demand of cattle watering needs (typically 40 gallons/day).

Implementation Strategy

Participation	Recommendations	Period	Capital Costs
Ranchers, Landowners, SWCD	Install alternative watering sources away from creeks ($20,000/ranch) with 104 alternative watering sources needed	2011-2020	$2,080,000

Load Reduction

This management strategy has a high contribution to load reduction and should be a priority. Load reductions can be over 8,000 x 10^6 orgs/day with an average of 3,400 x 10^6 orgs/day (between 28% and 51% reduction contribution) for direct deposition. The reductions contribution for wash off was less than 2 percent for any given subwatershed.

Effectiveness:	High: Cattle prefer an alternative watering source over creek water.
Difficulty:	Medium: Costs and willingness to establishing a well may not be available to all and costs are high.
Certainty:	High: Synergies with operation make the program convincing, has been in place for a long time.

5.1.4.4 Dead Animal Disposal

The reconnaissance survey verified that carcasses of small livestock, deer, dogs, and a wide variety of wildlife are commonly found in creeks. Often they are thrown into creeks from bridges. At present only the City of Comanche offers a location where citizens can take small animal and pet carcasses for disposal at a dumpster. The Comanche City animal control officer does assist citizens with the disposal of animal carcasses when requested. County officials recommended further investigating strategies that could decrease the occurrence of illegally disposing of dead animals in creeks. Key elements of a dead animal disposal strategy would generally include equipment for burial, land acquisition for dumpsters in a convenient location, access to a regional disposal facility (landfill), operational costs, and public education and outreach. Although there is uncertainty as to the overall effectiveness of these strategies county officials could consider this program at some time in the future because it has potential health benefits. Preliminary strategies recommended for investigation to decrease improper disposal of dead animals are detailed in the following cut sheet.

Dead Animal Disposal

Scope:

- Provide equipment for burial on private land
- Acquisition of land to provide convenient location for dumpsters
- Contract for disposal by area landfill
- Educate public about proper disposal of animals carcasses

Location: Municipalities and counties

Critical Areas: All subwatersheds

Goal: Improve alternatives and convenience for disposal of dead animals and discourage people from disposing of dead animals in creeks and rivers.

Description: The reconnaissance survey and anecdotal evidence indicate that carcasses of small livestock, deer, dogs, and a wide variety of wildlife are commonly found in creeks. Often they are thrown into creeks from bridges. County government officials would investigate the feasibility of programs to provide alternatives for individuals to dispose of dead animals in a way that would encourage people not to dispose of carcasses in creeks. A low cost recommendation to consider would be the purchase a poultry incinerator that would be operated by each County. This option would require obtaining a permit from TCEQ and acquisition of a land parcel to locate dumpster(s) and operate the incinerator. A strategy could include purchase of equipment for burial, access to a regional disposal facility (landfill), and public education and outreach. County officials could also post signs on roads crossing creeks notifying public that fines can be issued for disposal of carcasses or litter in creeks. Municipalities might also investigate how they can contribute to this effort by providing dumpsters or locations where citizens can dispose of dead animals.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
Comanche, Hamilton, Coryell Counties	Investigate feasibility of constructing dead animal disposal facility (incinerator and dumpsters) and conduct an outreach program ($17,000 per county)	2016-2020	$68,000
	Provide county-owned equipment (backhoe, trailer, truck) to help landowners dispose of animal carcasses on private property ($85,000 per county)	2016-2020	$340,000

Dead Animal Disposal			
Comanche, Hamilton, Coryell Counties	Consider posting signs at bridges warning of fines for disposal of carcasses in creeks. ($12,000 per county)	2011-2015	$48,000
Comanche, Hamilton, Coryell Counties	Provide additional resources to County animal control officers for travel time and outreach to work with citizens to dispose of dead animals. ($1,000 per county)	2011-2015	$4,000
Cities of Dublin, Hamilton, Gatesville	Operate dead animal disposal facility for small animals (incinerator and dumpsters) and conduct an outreach program ($8,000 per municipality)	2011-2020	$24,000

Load Reduction	
While reductions in bacteria associated with this management strategy is minimal (less than 1 percent contribution to load reduction for any given subwatershed), stakeholders are willing to pursue these management strategies because they address known pollutant sources and aesthetic nuisances along creeks.	
Effectiveness:	Low: Difficult to quantify the extent of contribution from this source and not much known about dead animals in creeks and it is difficult to change behavior.
Difficulty:	High: Program is costly, legal constraints need to be resolved and program needs to be promoted to achieve effectiveness.
Certainty:	Low: Ability to change human behavior is difficult to predict and the high cost to low benefit may decrease the priority of implementing this management strategy.

5.2 Polluted Storm Water Washoff

Stakeholders agree it is appropriate to address land-based bacteria pollutant sources related to activities in forestland, rangeland, WAFs operated by CAFOs and urban/rural residential, commercial and industrial land uses. Unlike direct deposition, these land-based sources are a result of fecal matter that accumulates on the land and then under storm water runoff events is transported to receiving waters. The origin of the bacteria is from the build-up of waste deposited by wildlife, pets, feral hogs, livestock, manure application, and OSSFs. The goal of management strategies outlined in this subsection is to reduce the accumulation of pollutants on the land and treat or reduce polluted storm water as it flows from the landscape into a creek or river. Therefore, the management strategies in subsection 5.2 will reduce nonpoint source pollution. Some of the strategies for direct discharges discussed above also address storm water wash off.

Strategies were presented for forestland, rangeland, WAF, and residential, commercial, and industrial areas. No specific management strategies are provided for cropland because only four percent of the Leon River watershed is classified as cropland and it has limited habitat suitability for most wildlife species. Therefore, the farm/ranch focus group considered cropland not to be a significant source of bacteria loading to streams on an annual basis.

5.2.1 Forestland Strategies

Bacteria and nutrient loading to forestland originates primarily from wildlife, feral hogs, and possibly livestock and OSSFs. The ability of forestland to uptake bacteria and nutrient loading and mitigate transport of these pollutants to a receiving water is high. This is the exact opposite of direct deposition of bacteria loads which offers no potential for treatment prior to entering the receiving water. While bacteria accumulation rates from animals on forestland may be high pollutant loads are mitigated by the effective treatment capacity of forestland, which has very low runoff coefficients for transporting bacteria or nutrient loads to receiving streams. The loading on forestland is low while the mitigation capacity of forestland is high, resulting in an overall effect that reducing deer and feral hog loads on forestland only reduces bacteria concentration in streams by no more than 100 10^6 org/day (less than 1%) in all watersheds. Nonetheless, BMPs that target sources of bacteria loading to forestland are important for achieving reductions in direct deposition (summarized in the direct deposition subsection 5.1.4). Therefore, as BMPs for OSSFs, deer population management, and feral hog management are beneficial in other areas, the modest gains in reductions of wash off load from forestland is considered an added benefit of these programs.

5.2.2 Rangeland Strategies

With over 70 percent of the watershed classified as rangeland, support for voluntary management strategies to address nonpoint source pollution is critical to successfully improving instream water quality. Stakeholders representing the farm/ranch and large lot landowners focus groups recognize the importance of addressing the buildup of bacteria and nutrient loads on rangeland and the eventual transport of those pollutants to receiving waters by storm water runoff. The management strategies include BMPs that will attempt to mitigate bacteria and nutrients originating from non-permitted livestock and manure application. It should also be noted that management strategies already identified for targeting wildlife and feral hogs can also reduce bacteria and nutrient loads on rangeland. The success of management strategies for rangeland will be driven by the goal to maximize rangeland operating in accordance with WQMPs. The purpose of WQMPs is to achieve a level of pollution prevention or abatement necessary, in consultation with local soil and water conservation districts and determined by the TSSWCB, to be consistent with state SWQS (TSSWCB 2009a). The requirements for a WQMP are derived from the criteria outlined in the Field Office Technical Guide (see http://efotg.nrcs.usda.gov/treemenuFS.aspx), a publication of the NRCS (TSSWCB 2009a). Currently there are 123 certified WQMPs in the Comanche County portion of the Leon River watershed, 32 in Hamilton County portion, and 16 in Coryell County portion, which equates to approximately 72,000 acres within the three counties.

A WQMP can include any of the following: land treatment practices, production practices, management measures, or innovative technologies. A WQMP covers an entire ranch, and includes examination of appropriate grazing systems, water facility considerations, livestock carrying capacity, nutrient management BMPs, soil erosion control, and beneficial use of agricultural wastes. Some of the key BMPs from the Field Office Technical Guide that should be considered for incorporation into WQMPs include:

- Prescribed Grazing- 528A
- Ponds - 378
- Fencing- 382
- Filter Strip – 393
- Riparian Herbaceous Buffer- 390

- Riparian Forestland Buffer- 391
- Pasture and Hayland Planting- 512
- Pipelines- 516
- Watering Facilities- 614
- Wells- 642
- Water and Sediment Control Basin – 638
- Nutrient Management – 590.

The farm/ranch focus group placed high priority on the need for WQMPs to incorporate alternative watering sources, grazing management, cross fencing, filter strips, and buffers. These BMPs, along with other efforts that are customized to address individual farm conditions can advance conservation and stewardship of rangeland resulting in bacteria load reductions. Local SWCDs, TSSWCB and NRCS are available to provide technical and financial assistance for developing and implementing WQMPs. The management strategies recommended to decrease storm water washoff from rangeland are detailed in the following cut sheet.

The number of WQMPs was based on an estimate of the total number of farms in each watershed, which was derived from the number of cattle (136,703) and the average number of cattle each farm stocks in each county. This averaged 78, 51, 68, and 79 head of cattle per ranch for Comanche, Erath, Hamilton, and Coryell Counties, respectively. Assuming there is a significant amount of bacteria reduction when a farm operates under a WQMP, then the number of WQMPs are equal to the strategy level (35%). To accomplish the reduction goal, 35 percent of the farms need to obtain a WQMP.

Develop and Implement WQMPs

Scope:

- Work with ranchers, property owners to develop WQMPs
- Customize whole-farm plans
- Provide cost share incentives
- Implement WQMPs
- Increase future annual status reviews of WQMPs

Location: All subwatersheds

Critical Areas: Rangeland in subwatersheds 20, 30, 40, 50, 60, 70

Goal: Achieve the highest percentage possible of acreage covered under WQMPs which implement BMPs on rangeland and pastures to minimize soil erosion and nonpoint source runoff.

Description: Overgrazing leads to less desirable plants available for grazing, bare ground with soil erosion, and change in soil minerals, all of which lead to a decline in pasture productivity and less capacity to absorb bacteria. The goal is to manage livestock and land cover over time to sustain herds while maintaining the land and watershed in a healthy condition. A WQMP is designed to cover an entire operating unit and includes essential practices applicable to the planned land use.

Implementation Strategies

Participation	Recommendations	Period	Capital Costs
TSSWCB, SWCD	Increase number of status reviews to 25% of WQMPs in Leon River watershed	2015-2020	NA
Priority Subwatersheds 20, 30, 40, 50, 60, 70	Develop, cost share, and implement livestock WQMPs $15,000 per plan with 336 plans	2011-2020	$5,040,000
Other subwatersheds	Develop, cost share, and implement livestock WQMPs $15,000 per plan with 306 plans	2011-2020	$4,590,000

Load Reduction

This program is most effective at addressing direct deposition; however, it also has benefits for reducing bacteria loads from storm water wash off and can be an important strategy for mitigating nonpoint source pollution. The wash off load reduction is not as high as with direct deposition, but can contribute close to 7 percent for some subwatershed. Load reductions average close to 200 10^6 orgs/day with some watershed close to 300 x 10^6 orgs/day.

Effectiveness:	High: Decreasing soil erosion and effectively managing rangeland vegetation cover significantly reduces nonpoint source runoff including bacteria and nutrient loads to receiving waters.
Difficulty:	Medium: Ranchers support land stewardship practices and are familiar with constraints associated with standard conservation practices. Not all are supportive of the additional level of effort needed to implement WQMPs
Certainty:	Medium: Rangeland owners acknowledge the importance of WQMP objectives but all will require technical support and financial incentives to accelerate implementation of WQMPs.

5.2.3 WAF Strategies

The management strategies suggested in this section are aimed at continuous refinements by the dairy industry to address bacteria and nutrient loadings at both the animal facility and at WAFs. For CAFOs, managing the volume, location, and beneficial use of manure and wastewater is central to their daily operations. The management strategies for WAFs are defined in a dairy operations' nutrient management plan (NMP) and other requirements included in the TPDES CAFO General Permit. NMPs, prepared in accordance with the NRCS Practice Standard Code 590, can help ensure that agricultural production goals are achieved and natural resource concerns such as bacteria and nutrient loading and their adverse impacts on water quality are minimized (TCEQ 2009b). Detailed criteria exists for operating and managing the amount, source, placement, form and timing of the application of solid and liquid manure to WAFs (TCEQ 2009b). Other requirements aimed at mitigating impacts to water quality include soil testing and record keeping to effectively document and demonstrate implementation activities associated with NMPs. NMPs are required under the TCEQ CAFO general permit and subject to inspection. TCEQ currently is involved in this oversight and the focus group believes that if there is an operation not abiding by its permit, an enforcement action will be taken. An example of the dairy industry's commitment to stewardship was their participation in the Dairy Manure Export Support (DMES) program that resulted in approximately 368,970 tons of manure being removed from the watershed between 2000 and 2006. The DMES program offered financial incentives to commercial manure haulers to support the transport of raw manure from dairy farms in the North Bosque and Leon River watersheds to commercial composting operations. The raw manure was then improved through a composting process for beneficial use outside the watershed. Entities such as Texas Department of Transportation and municipalities, as well as agricultural producers and the general public were some of the target purchasers of the composted product (TSSWCB 2010).

In addition to the extensive requirements CAFOs adhere to under the TPDES General Permit, there is further commitment by the industry to refine current practices aimed at operations and maintenance of facilities and collaboration with third parties to maximize the beneficial use of manure. The management strategies recommended by the dairy focus group that could further reduce bacteria or nutrient sources associated with animal facilities and the use of manure are summarized in the following cut sheets.

CAFO – Facility Operations & Maintenance

Scope:

- Assure maximum protection by following general permit
- Work with other CAFOs and associations to learn of ways to enhance operation
- Proactive collaboration with TCEQ to promote success of inspections and compliance

Location: Subwatersheds 20, 30, 40, 60, and 70.

Critical Areas: Subwatersheds 20, 30, and 60

Goal: Comply with CAFO general permit requirements and continue to refine operations and maintenance to eliminate potential for release of bacteria or nutrient loads from facility.

Description: Detailed permit requirements exist for operating and managing CAFOs as no-discharge facilities. Permit requirements are designed to mitigate impacts to water quality. Key components of the General Permit which define management strategies for the dairy operators include: Pollution Prevention Plans, effluent limitations, monitoring requirements, strict design criteria for retention control structures and evaporation systems, wastewater treatment, manure and sludge storage, dead animal disposal, irrigation system criteria, criteria for land application of manure (nutrient management plans), buffer requirements, soil sampling criteria, preventative maintenance program, inspections, continuing education requirements, record keeping and reporting requirements. TCEQ inspections and CAFO response to those inspections will continue to be a critical ongoing component of implementation

Implementation Strategies

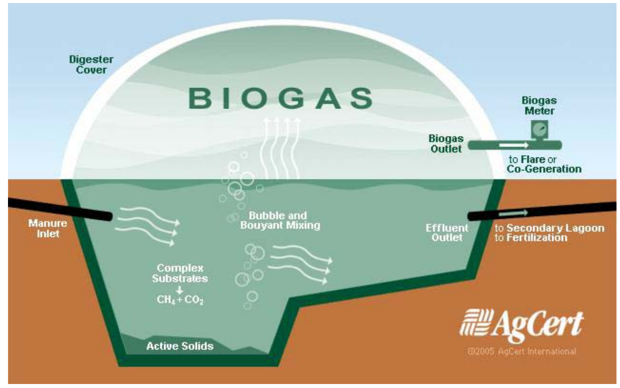
Participation	Recommendations	Period	Capital Costs
CAFOs, Texas Association of Dairymen	Enhanced operation and maintenance of facilities, equipment and storage techniques ($10,000 per facility per year with 32 facilities in the watershed)	2011-2015	$1,600,000
CAFOs, TCEQ	Technology transfer between CAFOs derived from inspection findings	2015-2020	NA

Load Reduction

CAFOs operating under a general permit in the Leon River watershed are implementing all of the necessary management strategies for controlling bacteria and nutrient loads. Reductions estimated from CAFOs are low because they are treated as a no discharge facility. This strategy contributes to the overall WAF manure management load reductions that are less than 100×10^6 orgs/day with no more than a 3 percent contribution to load reduction for any single subwatershed.

Effectiveness:	High: Pollutant loads in runoff from properly operated CAFOs are minimal.
Difficulty:	High: Facilities operating at margins and any additional requirements would be costly in current economic climate.
Certainty:	Medium: CAFO industry is committed to continual refinements in operations and maintenance in accordance with TCEQ inspections.

CAFO New Technology



Scope:

- Collaborative efforts between dairy industry and research institutions to develop new technology for beneficial use of manure that is economically viable
- Evaluate potential expansion of Huckaby Ridge facility pilot project
- Seek investment opportunities

Location: Subwatersheds 20, 30, 40, and 60

Critical Areas: Subwatershed 20, 30, and 60

Goal: Continue to develop and evaluate technical and economic feasibility of bio-digesters for beneficial use of manure that decreases annual amount of manure that is land applied.

Description: Diary operators are interested in new technologies to provide cost savings, higher production efficiency, or any other tool that would increase profitability. The ideal situation would be one that would both improve operations and also reduce bacteria contributions. One such technology being explored by a dairy operator in the watershed is the use of a bio-digester to manage manure. This would allow the operator to generate electricity through the beneficial use of manure. Many factors make it difficult to achieve, costs could be well over $1 million per facility, and development could take years. However, if this type of technology becomes more economically viable it could be used to decrease the amount of available manure and thereby diminish the amount bacteria or nutrient loading occurring in the Leon River watershed from dairy operations.

Implementation

Participation	Projects	Period	Capital Costs
CAFOs, Texas AgriLife Research	Further investment in new technologies such as bio-digesters; other to be determined.	2015-2020	NA

Load Reduction

It is not possible at this time to model potential reductions in bacteria or nutrients based on the implementation of this management strategy.

Effectiveness:	Medium: This technology has proven to be effective a beneficial use of manure however the construction and maintenance costs continue to be high limiting the use of this implementation strategy.
Difficulty:	High: Technology is expensive and requires additional research
Certainty:	Low: Without incentives and improvement in the economic conditions of agribusiness this strategy cannot be aggressively pursued by individual operators.

Manure Management

Scope:

- Work with third party users of manure to insure optimum benefits
- Encourage similar safeguards as CAFOs
- Identify incentives for beneficial use of manure

Location: Subwatersheds 20, 30, 40, 60, 70, and 80

Critical Areas: Subwatershed 20, 30, and 60

Goal: Establish industry-led solution for third party use of manure to minimize potential for bacteria and nutrient impact to receiving waters.

Description: Options for the beneficial use of manure by CAFOs consist of continued application to WAFs in accordance with CNMP requirements, and where economically practical transferring manure to a third-party or manure compost facility. The dairy industry can continue to work with third parties interested in the use of manure to promote the proper use and timing of land application. They can also encourage the use of soil testing by third parties to obtain better information on where manure is most needed for farming and pasture lands. The CAFO industry can identify implications of establishing incentives, conducting outreach to third parties, and tracking beneficial use of manure.

Implementation Strategy

Participation	Recommendations	Period	Capital Costs
Third party, CAFO industry, Texas Association of Dairymen	Conduct industry-led coordination meetings to define strategy for enhanced manure management by third parties	2012	$15,000
Third party, CAFO industry, Texas Association of Dairymen	Prepare and distribute best practices recommendations manual for inclusion in NMP and WQMPs	2014	$50,000

Load Reduction

This management strategy is effective at reducing for bacteria loads from storm water washoff and mitigating nonpoint source pollution. This strategy contributes to the overall WAF manure management load reductions that are less than 100 x 10^6 orgs/day with no more than a 3 percent contribution to load reduction for any single subwatershed.

Effectiveness:	High: Consistent, watershed-wide adherence to application of manure using agronomic rates will decrease bacteria and nutrient loading to receiving waters.
Difficulty:	High: Lack of available incentives, costs to CAFOs and lack of support from third-parties must be overcome.
Certainty:	Low CAFO operators have little influence over how third parties use manure.

5.2.4 Residential, Commercial, and Industrial Strategies

Wash off loads from developed residential, commercial, and industrial (R/C/I) areas can contain a variety of sources due the many activities that occurs on these properties. The foundation of this management strategy lies within a city's jurisdiction and their willingness to adopt ordinances and practices that establish storm water BMPs, setbacks, or buffers, as well as the many strategies discussed above that also address wash off loads and direct discharges. The highest concentration of citizens live in the urban and residential areas of subwatersheds 30, 40, 60, 80, 120, and 130. Data from urbanizing areas are available to demonstrate storm water runoff has high concentrations of bacteria and nutrients. Therefore, municipal leaders are willing to find opportunities to use BMPs to try to mitigate storm water loads to receiving waters.

As new neighborhoods are developed, an ordinance requiring low impact development strategies could be established. There may also be ways to create incentives for property owners to establish setbacks on their own or consider installing rain gardens or other small urban BMPs. BMPs aimed at storm water runoff in small towns/cities need to be carefully and thoroughly considered given the upfront capital costs and long-term maintenance. The goal is to identify viable BMPs that can be integrated into residential properties so that wash off from properties is treated to some degree before it reaches creeks. Setbacks could be highly effective when implemented, but if the land adjacent to creeks is privately owned, it will be particularly difficult for cities to establish continuous, adequate buffers. It may take several years to establish right-of-ways, develop vegetative buffers, and to convince homeowners of benefits.

Commercial and industrial land uses are similar to residential land uses in that they too can be subject to bacteria loading from people, pets, wildlife, and livestock. Examples of these types of land uses in the Leon River watershed include Circle T Arena, exotic pet breeders, county livestock arenas, and 4-H livestock facilities. These types of facilities are scattered around the Leon River watershed but are generally located near the urban centers. These facilities at various times throughout the year have high concentrations of animals in relatively confined areas. The Circle T Arena near the City of Hamilton for example, has to manage large volumes of manure, storm water runoff, and wastewater when they host a variety of public events related to livestock shows and concerts. City leaders in targeted subwatersheds are willing to work with these facilities to establish specific BMPs that can be more effective at reducing bacteria and nutrient loads. Site specific BMPs similar to those discussed as residential strategies need to be customized for these types of facilities. Setbacks, detention ponds, wetlands, and manure management are all examples of management strategies that could be considered for commercial or industrial facilities. The total area of commercial and industrial land use is smaller than residential, but because of the potential for excessive bacteria loads originating from such properties there is a higher potential for achieving reductions.

The management strategies recommended by the municipality focus group that could further reduce bacteria or nutrient loads from storm water runoff are summarized in the following cut sheet. Strategies such as removing OSSFs and project identified through an SSO Plan also address bacteria loads in residential, commercial or industrial areas. These costs were identified above, but are shared with the overall strategies for addressing wash off from R/C/I areas. The cut sheet below includes specific strategies aimed at mitigating polluted wash off from land adjacent to creeks in urban areas.

Storm Water Strategies and BMPs

Scope:

- Inventory storm water conveyance system and critical contribution areas within cities
- Work with residents to establish ordinances for setbacks
- Provide incentives for landowner to establish vegetative buffers

Location: Subwatersheds 30, 40, 60, 80, 120, and 130

Critical Areas: Dublin, Gustine, Comanche, Hamilton

Goal: Advance storm water BMPs with primary focus on buffers along creeks adjacent to residential and commercial properties so that storm water runoff is treated before it reaches creeks.

Description: Cities can inventory the storm water conveyance system within their jurisdiction to identify critical areas to target for BMPs aimed at reducing transport of bacteria and other pollutants to creeks and drainage ways. Work with citizens and businesses to establish ordinances establish buffers adjacent to creeks running through existing and new developments. Identify incentives for property owners and commercial and industrial businesses to establish setbacks.

Implementation

Participation	Projects	Period	Capital Costs
Municipalities	Conduct inventory and develop maps of storm water conveyance system and critical areas throughout municipality	2011-2015	$75,000 per city
Municipalities	Develop ordinances for setbacks and buffers adjacent to urban creeks; develop list of other BMPs for future consideration	2015	$75,000 per city

Load Reduction

This strategy provides high potential for bacteria reduction, especially in areas with large concentration of people. Load reduction can be as high as 9,000 x 10^6 orgs/day and contribute over 30 percent to overall reduction for some subwatershed.

Effectiveness:	High: BMPs that can mitigate current high concentrations of bacteria in storm water runoff will improve instream water quality.
Difficulty:	High: Cities not well equipped to develop and implement storm water management programs and retrofitting of BMPs in developed areas is not always feasible.
Certainty:	Low: Cities do not have financial resources to implement BMPs, citizenry and businesses may not support BMPs on their own property and it can be hard to change human behavior.

5.3 Implementation Schedule

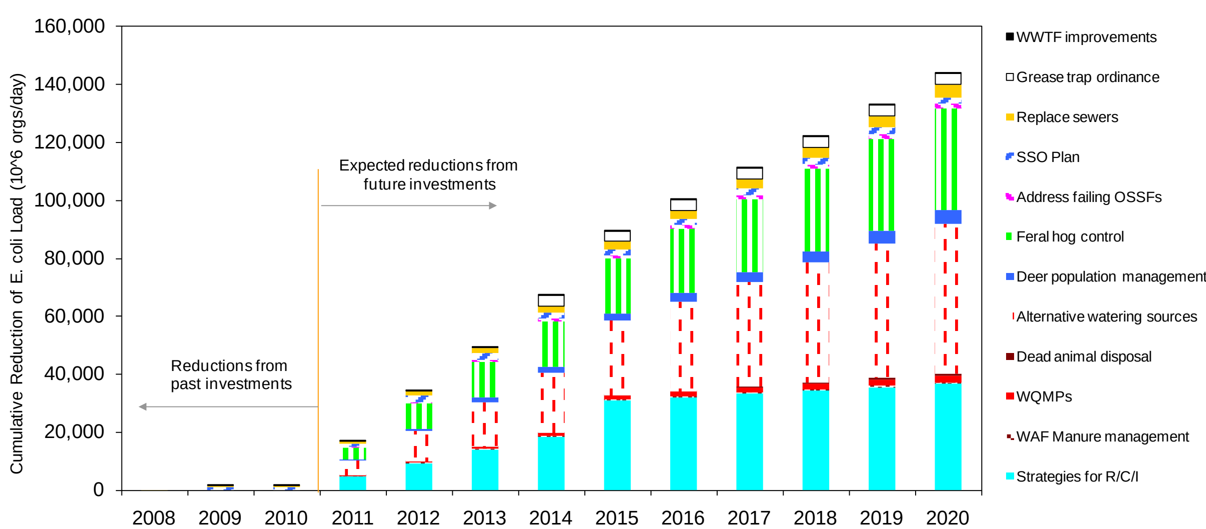
Recommended timeframes for the implementation of the management strategies are provided in the cutsheets above. These timeframes were derived from the feedback of each focus group using the DSS and from other information gathered during the WPP process. A 10-year timeline was proposed for the implementation of management strategies but some could take longer or less than the estimated timeframes provided in the cutsheets. Stakeholders categorized management strategies into the following groups which are differentiated by start dates:

- Management strategies currently being implemented, planned, or constructed,
- Management strategies that should be initiated between 2011 and 2015 (1-5 years), and
- Management strategies that should be initiated between 2016 and 2020 (6-10 years).

Stakeholders grouped management strategies into these categories based on their interpretation of when each strategy might be practically implemented given all external factors. Some management strategies will require time for planning, legal or permit approvals, acquisition of funding, and potentially hiring staff.

Figure 5.1 displays a temporal summary of implementing future management strategies between 2011 and 2020. This schematic implementation schedule shows how reduction increases over time as strategies are implemented and the relative amount each strategy contributes to reduction over time. Starting in 2011 a rise in reductions occurs that ultimately achieves a removal of source load totaling 143,811 x 10^6 orgs/day.

Figure 5.1 Cumulative Reductions for Leon River Watershed



5.4 Pollutant Load Reductions

When various segments of the Leon River watershed were placed on the §303(d) List, stakeholders' key concerns were obtaining a better understanding of the bacteria sources in each subwatershed, the appropriateness of the existing SWQS for the Leon River and its tributaries, and how bacteria reductions can best be achieved given the level of scientific uncertainty associated with bacteria concentration in rivers. The fundamental question during development of this WPP was how much pollutant reduction is necessary in each subwatershed to meet water quality goals and SWQS. At the closure of this process the question is: has enough implementation been planned to achieve the water quality goal of maintaining an *E. coli* geometric mean of 206 cfu/100mL? Through the DSS and sensitivity analysis performed, it was possible to allow stakeholders to make informed decisions, and give some insight as to how implementation of all the strategies would affect water quality in relation to the existing water quality goal and numeric standard for *E. coli*. **This subsection presents a final summary of the expected pollutant load reduction results based on the level of implementation of strategies. Table 5.5 presents a summary of the expected load reductions from the suite of management strategies and how compliance is met.**

The base source load originating from all 15 subwatersheds from all pollutant sources is 717,315 x 10^6 orgs/day. An average of 39 percent of this source load cannot be controlled. This includes wild birds and some warm-blooded animals, which can be between 19 to 21 percent and 22 to 36 percent, respectively, of the total load contribution based on BST data. This suggests that more than 50 percent of the load is uncontrollable. However, some warm-blooded animals include feral hogs, which presumably can be controlled. This is the reason why more than 50 percent of the load is available for reduction (61% on average). Management strategies recommended by stakeholders addressed the source loads that were available for reduction (439,535 x 10^6 orgs/day).

The reduction achieved is the amount of load removed from the subwatershed from strategies suggested by the stakeholders; once fully implemented, this totals 143,811 x 10^6 orgs/day. This is a total source load reduction of approximately 20 percent, ranging between 16 and 26 percent. Subwatersheds with larger urban contributions had higher reductions. The reduced source load is base source load less the reduction achieved from implementation, which is what enters waterbodies and accumulates downstream. The cumulative effect was addressed using the HSPF model because it takes into account all the natural processes that make a simple mass balance inappropriate for determining compliance.

The base daily load is the load based on the measured *E. coli* concentration and the flow in a given subwatershed. The reduction achieved removes source loads from each subwatershed, thus the collective reduction is the cumulative reduction achieved when taking into account all upstream management strategy effects and natural processes. The reduced daily load is the resulting daily load that has had a portion of the source load removed from the base daily. The collective reduction varies more once there are upstream subwatersheds (e.g., subwatershed 30 had a reduction achieved of 14,130 x 10^6 orgs/day and the collective reduction was 18,873 x 10^6 orgs/day because it took into account the reduction from subwatershed 10 and 20). Therefore, the available capacity of subwatershed 150 represents the effect of all the strategies in place in the entire Leon River watershed. This effect was evaluated using the HSPF model.

Compliance can be determined by comparing the reduced daily load to the maximum daily load limit under a given standard. The maximum daily load is calculated assuming the base flow has the water quality standard as an average concentration. The daily load based on the simulation for the period between 2001 and 2004 indicates that four subwatersheds (20, 30, 40, and 60) were not compliant based on current *E. coli* standards. Three were not compliant based on the water quality goal (subwatershed 30 becomes compliant). As a result of the strategies, the daily load was reduced between 15 and 25 percent for the subwatersheds and subwatershed 40 and 60 became compliant with the water quality goal and subwatershed 30 became compliant under the existing water quality criterion. Although subwatershed 20 had reduced daily load of 17 percent, it did not become compliant with the water quality goal. Under the water quality goal, subwatershed 20 had an excess daily load of 900 x 10^6 orgs/day with subwatersheds 30, 40, and 60 having significant additional capacity. It should be noted subwatershed 70 below subwatershed 60 had over 60 percent load capacity under the water quality goal and 30 percent capacity under the water quality standard.

The expected geometric mean for each subwatershed is also provided in Table 5.5. Again, these data show that the geometric mean for subwatershed 20 will still be slightly higher than the goal of 206 cfu/100mL. Subwatershed 20 would become compliant if all the strategies are implemented and the *E. coli* goal was 248 cfu/100 mL. All other subwatersheds indicate eventual available capacity at full implementation. Figure 5.2 provides a schematic flow diagram of the cumulative pollutant load reductions by subwatershed based on full implementation.

Table 5.5 Expected Pollutant Load Reductions from Implementation of Management Strategies

	Subwatershed Source Loads[1]						Cumulative Effect[2]				Compliance Summary							
											MDL at 206 cfu/100mL			MDL at 126 cfu/100mL			*E. coli* Geomean	
SW	Base Source Load	Available for Reduction[3]		Reduction Goal		Reduced Source Load[4]	Base Daily Load[5]	Collective Reduction	Reduced Daily Load		Limit	Capacity	Excess	Limit	Capacity	Excess	Existing[6]	Reduced
	10^6org/d	10^6org/d	%	10^6org/d	%	10^6org/d	10^6org/d	10^6org/d	10^6org/d	%	10^6org/d			10^6org/d			cfu/100mL	
10	27,157	15,093	56%	6,850	25%	20,307	27,157	6,672	20,307	25%	65,663	45,356	**-**	40,163	19,856	**-**	85	64
20	6,723	3,938	59%	1,147	17%	5,576	6,723	1,138	5,576	17%	4,677	-	**900**	2,860	-	**2,716**	301	248
30	73,868	42,369	57%	14,130	19%	59,738	85,775	18,873	66,902	22%	135,722	68,821	**-**	83,015	16,113	**-**	130	102
40	33,410	20,711	62%	5,957	18%	27,453	33,410	5,839	27,453	18%	32,411	4,958	**-**	19,824	-	**7,629**	229	188
50	43,238	27,953	65%	7,471	17%	35,767	105,642	21,279	84,363	20%	196,758	112,395	**-**	120,347	35,984	**-**	111	88
60	18,925	11,702	62%	4,833	26%	14,091	18,925	4,639	14,091	26%	15,081	990	**-**	9,224	-	**4,867**	253	191
70	50,720	33,338	66%	8,293	16%	42,428	140,855	27,523	113,332	20%	274,987	161,655	**-**	168,196	54,864	**-**	106	85
80	80,299	48,415	60%	17,079	21%	63,220	148,434	31,496	116,938	21%	328,597	211,658	**-**	200,986	84,048	**-**	93	73
90	22,909	14,439	63%	3,882	17%	19,027	103,410	20,964	82,447	20%	350,791	268,344	**-**	214,561	132,114	**-**	61	48
100	32,800	20,441	62%	5,689	17%	27,112	108,282	21,388	86,895	20%	361,806	274,912	**-**	221,299	134,405	**-**	62	49
110	16,346	11,410	70%	2,434	15%	13,912	16,346	2,421	13,912	15%	34,598	20,686	**-**	21,162	7,250	**-**	97	83
120	132,485	81,113	61%	30,048	23%	102,436	209,022	42,650	166,371	20%	461,432	295,061	**-**	282,235	115,864	**-**	93	74
130	104,914	62,485	60%	23,434	22%	81,480	257,450	53,907	203,544	21%	484,055	280,511	**-**	296,072	92,529	**-**	110	87
140	32,461	19,994	62%	5,912	18%	26,549	239,463	49,165	190,299	21%	496,694	306,395	**-**	303,803	113,504	**-**	99	79
150	41,059	26,133	64%	6,653	16%	34,406	199,266	39,152	160,114	20%	545,528	385,414	**-**	333,673	173,558	**-**	75	60
Total	717,315	439,535	61%	143,811	20%	573,504												

Simulation is based on the HSPF model that is calibrated on flows and concentrations between 2001 to 2004
1 = Source loads only take into account the load for each subwatershed without considering the cumulative upstream effects.
2 = This load is based on the simulation of the entire system and takes into account all of the effects upstream of a subwatershed. Only headwaters may have the same load as source loads.
3 = This excludes loads that can not be controlled
4 = The resulting source load input once strategies are implemented
5 = Derived from HSPF base case model run for 2001 to 2004
6 = Geometric mean *E. coli* concentration for the base case model run for 2001 to 2004
MDL = Maximum daily load
SW = subwatershed
not compliant at proposed *E. coli* water quality criterion of 206 cfu/100mL
not compliant at existing *E. coli* water quality criterion of 126 cfu/100mL

Figure 5.2 Example of Mass-flow Diagram of Cumulative Load Reduction for Subwatershed 30 (10^6 org/day)

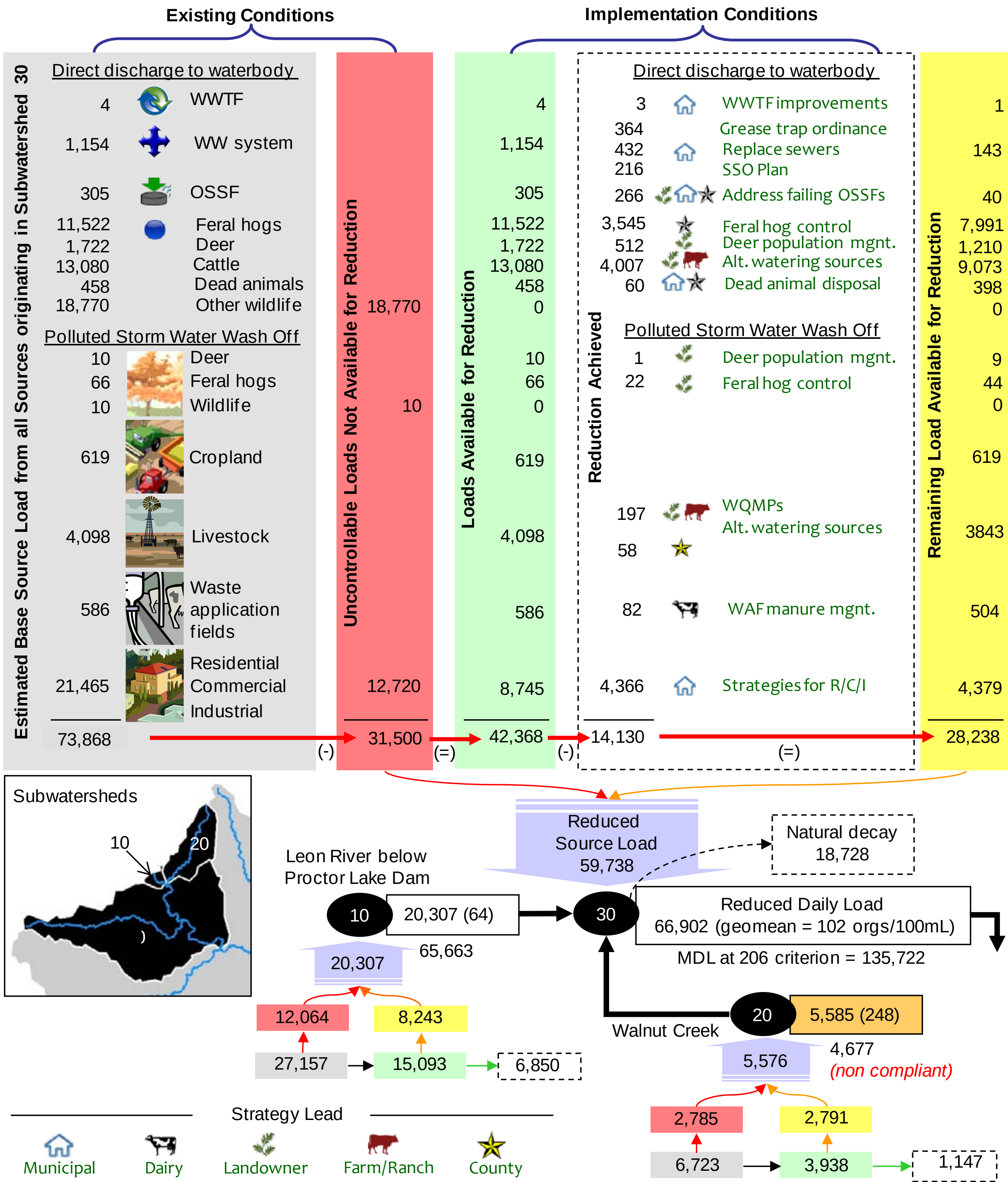


Figure 5.2 demonstrates the impact of implementation on base loads. It shows that a portion of the load in each subwatershed are "**Uncontrollable Loads Not Available for Reduction**" (represented in red on Figure 5.2). All source loads where management strategies were identified are then considered to be "**Loads Available for Reduction** (represented in green in Figure 5.2). Since few of the management strategies can be or were 100% effective at reducing ALL of the source loading, there is a "**Remaining Loads Available for Reduction**" (Represented in yellow in Figure 5.2).

Figures 5.3 to 5.5 provide examples using subwatersheds 20, 40 and 60 of how the base daily loads are reduced through implementation of strategies over time. A steady reduction of load begins in 2011. Watershed 20 does not become compliant when compared to the water quality goal, but subwatershed 40 becomes compliant by 2012, and in 2017 subwatershed 60 becomes compliant. Alternative watering sources, strategies for residential, commercial and industrial areas, and feral hog control contribute the most to load reduction.

Some projects provide more benefits than others, but all should proceed forward. They are all important because stakeholders found synergies between the estimated percent reduction and some economic or social goal. Some projects were already underway, had been implemented in the past, or were already required by law. There was consensus among the stakeholder groups that the list of management strategies summarized in this chapter were acceptable projects to implement and could be possible with available funding, education, and other motivating incentives. Except for subwatershed 20, the implementation level of all the strategies is likely to achieve at least the *E. coli* goal of 206 cfu/100mL. **Stakeholders wish to proceed with caution and fully support an adaptive management approach throughout implementation. As such, the stakeholders support implementing management strategies over time while using additional studies to better pinpoint sources and evaluate progress and effectiveness of each strategy.** With this type of information, implementation efforts can be refined to achieve more strategic and cost effective results. The list of projects presented herein is a start and the more information available the better adjustments can be made.

Figure 5.3 Cumulative Reduction of Load for Subwatershed 20

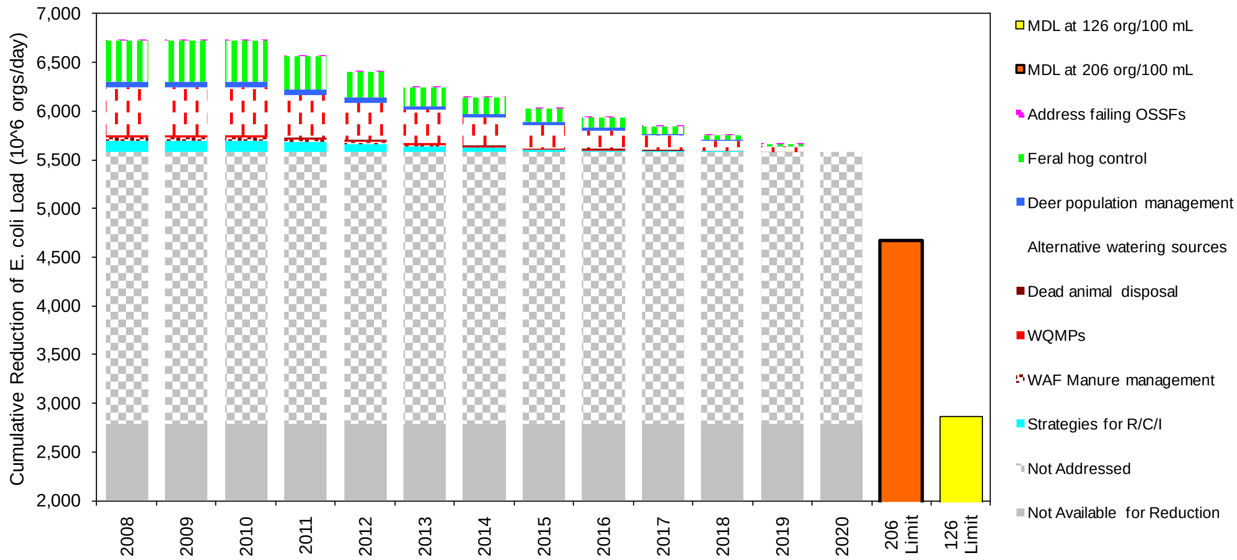


Figure 5.4 Cumulative Reduction of Load for Subwatershed 40

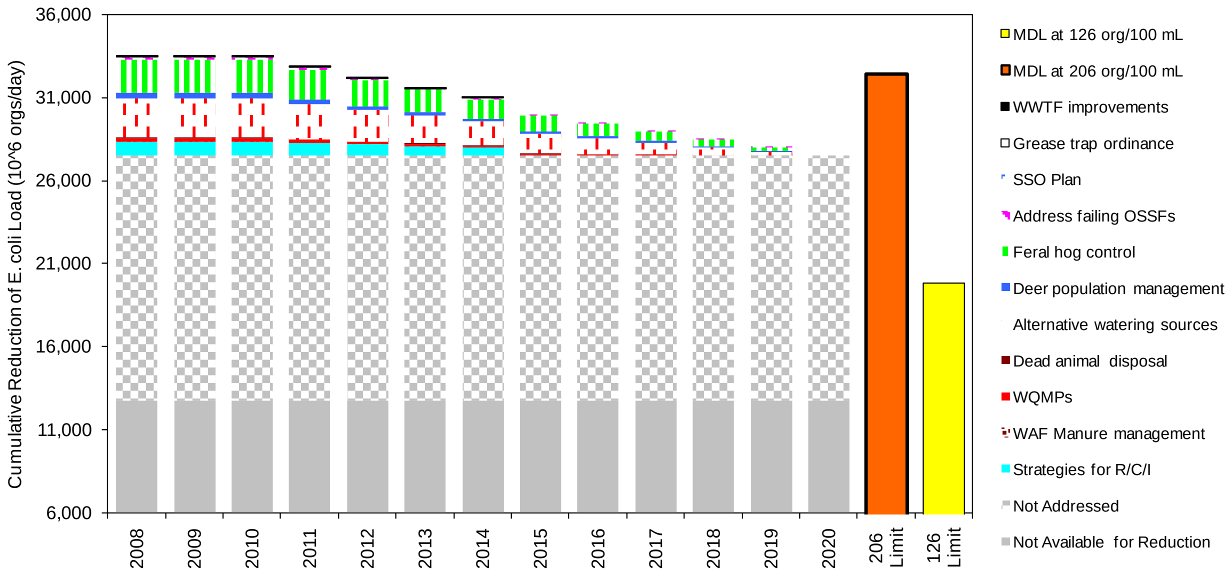
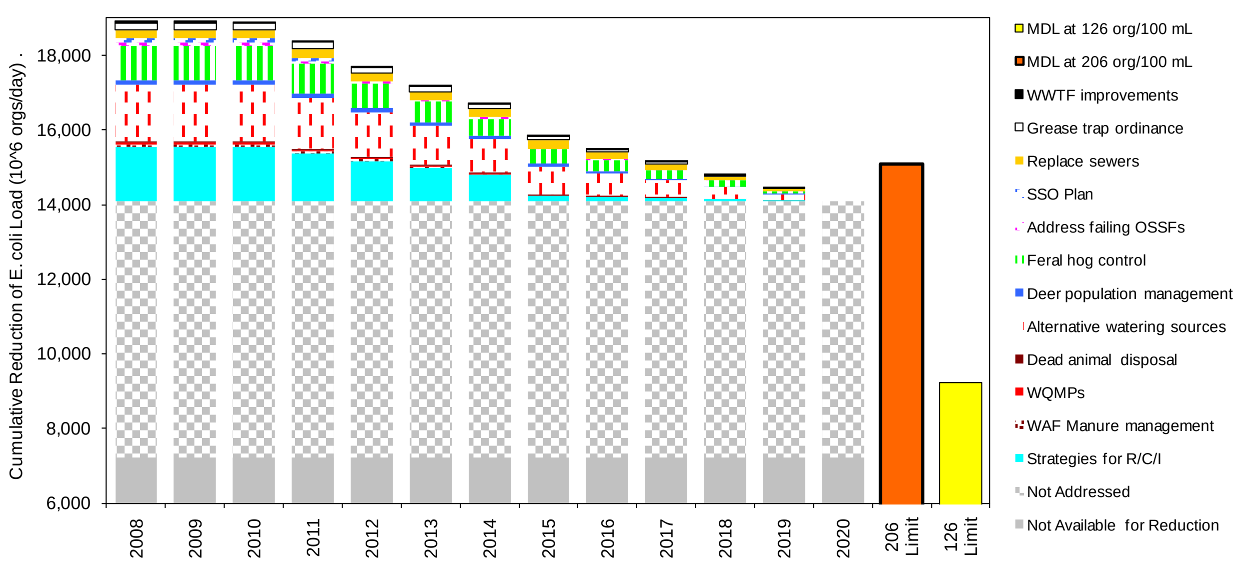


Figure 5.5 Cumulative Reduction of Load for Subwatershed 60



Chapter 6: Institutional Framework for Implementation

Through development of this WPP stakeholders of the Leon River watershed recognized the need to formulate an organizational entity that could provide equitable representation of watershed stakeholders and guide future decision-making regarding implementation of management strategies. **The success of long-term implementation of the recommendations in this WPP will depend on the establishment of an institutional framework that can secure support and commitments necessary to implement management strategies, conduct outreach and education, and evaluate progress toward attaining water quality goals.** This organizational entity called the Leon River Watershed Steering Committee (WSC) evolved from members selected from focus groups during development of this WPP.

6.1 Leon River Watershed Steering Committee

The Leon River WSC will evolve over time as the WPP is implemented. To formalize the WSC, the Working Committee members will collaborate with TSSWCB to develop a charter, roles and responsibilities and any additions to the preliminary list of WSC representatives summarized in Table 6.1. The individuals serving as Steering Committee members will be derived from volunteers who participated in the focus groups during preparation of the WPP. Once formalized the WSC can determine if other key individuals should be added to the committee to provide additional representation of local stakeholder interests (e.g., a representative from the Central Texas Council of Governments, soil and water conservation district director, and a local banking or chamber of commerce official).

Table 6.1 Leon River Watershed Steering Committee

Committee Member	Focus Group
County Farmer	Farm/Ranch
County Farmer	Farm/Ranch
County Rancher	Farm/Ranch
Dairy Operator	Dairy
County Landowner	Large Lot Landowners
City Representative	Municipality
County Representative	County Government
County Representative	County Government

The WSC will guide implementation of the management strategies and actions outlined in this WPP. The WSC will also serve as the liaison to the TCEQ, TSSWCB, BRA, and other cooperating entities for communication on water quality issues and progress. The WSC will call upon the five focus groups to assist them with deliberation of activities or issues on implementation strategies where appropriate. The roles of the WSC include:

- Ongoing clarification and updating of water quality goals;
- Communicating the progress of the WPP to interested parties and agencies within and outside the Leon River watershed;
- Advancing principles of adaptive management to better target and prioritize implementation projects throughout the Leon River watershed;
- Updating the WPP over time to advance water quality improvements; and
- Promoting the addition of stakeholders in the watershed to each of the five focus groups and advancing the role and effectiveness of the WSC.

In fulfilling these various roles, the WSC will provide the long-term guidance and local leadership necessary to advance implementation of management strategies and local support for improving and protecting water quality. The WSC anticipates meeting three times per year to conduct the business of advancing implementation of the WPP.

6.2 Technical Support for WSC – Establishing a Watershed Coordinator

The business of implementing the WPP over the next 10 years and beyond will require a consistent level of commitment to promote BMP implementation, conduct outreach and education, acquire funding support, and track, evaluate and communicate water quality improvements. To apply the level of effort necessary to accomplish these important and time-demanding activities, the WSC has identified the need for a full-time watershed coordinator position. This individual will attend to the day-to-day business of providing communication, coordination and technical assistance support to the WSC and Leon River watershed stakeholders involved in implementing the WPP. The watershed coordinator will participate in all WSC meetings and assist the WSC in organizing and conducting its business meetings each year. The watershed coordinator will advise the WSC on technical, financial, scheduling, outreach, and educational aspects associated with existing or future management strategies in the WPP. In addition, the watershed coordinator will participate in any and all activities held in the Leon River watershed to promote water quality improvements and implementation, Clean Rivers Program meetings, and serve as a liaison to all local, regional, state, and federal agencies participating in water quality management activities in the watershed.

The concept of establishing a watershed coordinator to advance the WPP evolved out discussions among the working committee members. Establishing a full-time watershed coordinator position is considered a critical building block of the infrastructure needed by the WSC to accelerate implementation of management strategies identified in the WPP. Members of the WSC will collaborate with the TSSWCB to explore options <u>for</u> funding the watershed coordinator position through federal, state, or local grants in addition to local matching contributions. The WSC and TSSWCB will also collaborate to formalize the hiring process for a watershed coordinator and agree upon an appropriate solution for office space, administrative support, and basic oversight of the full-time position.

Establishing a watershed coordinator position is a practical and effective strategy to assist both stakeholders and the WSC with implementing the WPP.

Figure 6.1 provides a schematic organizational diagram showing the relationships between the WSC, watershed coordinator, watershed stakeholders, and other key agencies that will provide additional technical support to advance implementation. Achieving the water quality goals of this WPP will depend on the on-going contributions, collaboration, and commitment between all the individuals, agencies, and organizations identified in Figure 6.1.

Figure 6.1 Institutional Organizations to Support Implementation of the Leon River Watershed Protection Plan

Chapter 7: Outreach and Education Strategy

As stated in subsection 2.1, a principal factor in achieving water quality improvement is to have strategies that are locally developed, supported, and implemented, which can only occur if those affected receive benefits from the implementation. Improving watershed stewardship among citizens, businesses, and local governments depends on the knowledge they have about water quality problems and their willingness to promote stewardship. To advance these principles, a public outreach and education strategy customized to the environmental and social characteristics of the Leon River watershed will need to be funded. Some outreach and education efforts are an integral part of different management strategies identified in Chapter 5, and others are conducted separately. **Regardless, outreach and education efforts are necessary to advance stewardship aimed at reducing bacteria and nutrient levels.** Implementing various outreach and education components in a coordinated manner will have a positive benefit on the stewardship ethic of Leon River watershed stakeholders, which can lead to reductions in bacteria and nutrients and improvements in water quality over time.

7.1 Recent Activities

Outreach and education efforts that have occurred in the Leon River watershed over the past three years provide an initial starting point for an effective public outreach and education strategy. The key outreach and education activities that have occurred in the Leon River watershed are outlined in the following paragraphs.

The WPP process has effectively expanded participation by stakeholders in Coryell, Hamilton, Erath and Comanche Counties. Through over 20 different WPP-sponsored meetings, stakeholders' awareness of bacteria and nutrient issues has increased throughout the Leon River watershed. Most importantly, through participation in these meetings, stakeholders turned their attention and energy toward solving water quality problems.

In December 2007 at the regularly schedule Extension Program Council Leadership Advisory Board meeting in Comanche, sponsored by Texas AgriLife Extension Service, dairy operators, cattle ranchers, and farmers participated in discussions about bacteria issues and how the WPP process would be conducted. Special emphasis was placed on how to connect the ongoing preparation of the WPP and education about bacteria issues to future locally organized meetings and outreach efforts.

On October 28, 2008, the Texas AgriLife Extension Service held a Texas Watershed Steward workshop in the City of Comanche. The Texas Watershed Steward program is a partnership between Texas AgriLife Extension Service and TSSWCB to provide science-based, watershed education to help citizens identify and take action to address local water quality impairments. CWA §319(h) grants from TSSWCB and USEPA to Texas AgriLife Extension Service support the statewide implementation of the Texas Watershed Steward Program. At the one-day workshop there were over 40 participants learning about the nature and function of watersheds, water quality impairments, and watershed protection strategies to minimize nonpoint source pollution (Texas AgriLife Extension Service 2009b).

Through a CWA §319(h) nonpoint source grant from TSSWCB and USEPA to ARS and Texas AgriLife Extension Service, "The Impact of Proper Organic Fertilizer Management on Production Agriculture," two different field day sessions were conducted near Aleman, Texas. Both of these events demonstrated the soil and water quality benefits of using proper organic fertilizer management techniques on cropland and pastureland.

- The Multi-County Rangeland Field Day at Rail Heart Ranch - September 16, 2008 - attended by 44 local farmers and ranchers and one dairy owner/operator.
- Cropland Field Day at Wilburn Farm - July 13, 2009 - attended by 32 local farmers and ranchers.

This project educated landowners on proper organic fertilizer management practices by implementing various organic fertilizer management practices on cultivated and pasture fields relating to application method, timing, and rate. Demonstration and educational activities were conducted on the importance of proper organic fertilizer management for areas impacted by excessive nutrients (TSSWCB 2010). http://www.tsswcb.texas.gov/managementprogram/impact.

Comanche County held a Feral Hog Management Seminar on May 21, 2009 attended by 45 people. Presentations were provided by the Texas AgriLife Extension Service to summarize recent issues, management strategies, and options associated with reducing the feral hog population in the region.

The Dairy Outreach Program Area (DOPA) is a technical training and continuing education program targeted towards dairy operators in the eight-county area, which includes Comanche, Hamilton, Erath, Bosque, Hopkins, Johnson, Rains, and Woods Counties. Attendance in the training and education program is required for any AFO with more than 300 animal units (more than 200 mature dairy cows) located in the DOPA. Table 7.1 provides a summary of the sessions attended by the dairy operators from Erath, Comanche, and Hamilton Counties over the last three years.

Table 7.1 List of Dairy Outreach Program Area Technical Training Sessions

DOPA Training Sessions	Date
Central Texas Tour	4/10/07
Environmental Compliance Training	8/9/07
TCEQ Updates and Carbon Credits	10/24/07
Dairy Manure Technology Tour	4/8/08
Dairy Seminar	5/6/08
Texas Ag Expo	10/22/08
Dairy Manure Technology Tour	4/14/09
Southwest Dairy Day	5/8/09

7.2 Integrated Outreach and Education Strategy

The watershed coordinator can collaborate with Texas AgriLife Extension Service and other agencies to implement a short- and long-term strategy for outreach and education aimed at water quality issues in the Leon River watershed. As recommended by the TSSWCB, the WSC and watershed coordinator can utilize the USEPA guidance *"Getting in Step"* to help develop an integrated outreach and education strategy. *"Getting in Step"* is a guide that offers advice on how watershed groups, local governments, and others can maximize the effectiveness of public outreach campaigns to reduce nonpoint source pollution (USEPA 2003b). All focus group discussions acknowledge that better and more targeted outreach and education efforts are essential to effectively address sources and causes of bacteria and nutrient loading.

The key driver that influences the design of an effective, integrated outreach and education strategy for the Leon River watershed is the promotion of implementation strategies to reduce bacteria and nutrient levels. Guided by this WPP, the watershed coordinator, in conjunction with the Texas AgriLife Extension Service, can carry out the outreach and education strategy to meet the following objectives:

- Increase public awareness of water quality problems in the Leon River watershed.
- Increase public awareness of water quality goals in the Leon River watershed.
- Develop a campaign to promote the intrinsic value the Leon River and its tributaries provide to the citizens within and outside the Leon River watershed.
- Identify and build linkages with other outreach and education opportunities and programs structured for the region.
- Customize outreach and education efforts for issues identified by each of the five focus groups and assist the focus groups in expanding the distribution of information.

While these objectives are fairly typical of most well-designed outreach and education strategies, Figure 7.1 displays a unique set of informational and educational feedback stakeholders requested specifically. Educating the WSC, watershed coordinator, and stakeholders about these specific topics will provide them information to further substantiate the need for implementing management strategies. Addressing the first two issues - designing and selecting appropriate indicators and reporting techniques - can provide the technical underpinnings to build a social marketing approach as part of the long-term education and outreach strategy. A social marketing approach can lead to the establishment of social indicators that demonstrate changes in human behavior to advance the goals of the WPP. The combination of additional social, programmatic, and environmental indicators is described in more detail in Chapter 9. The WSC and watershed coordinator will work closely with Texas AgriLife Extension Service county agents, TSSWCB, and TCEQ to include information addressing these topics as part of the integrated outreach and education strategy.

Figure 7.1 Key Topics for Outreach and Education to Address Stakeholder Concerns

7.3 Outreach and Education Actions

Numerous existing programs, tools, and materials are already available that can be used or customized to accelerate outreach and education efforts aimed at improving water quality in the Leon River watershed. A list of outreach and education ideas was prepared through brain storming sessions with focus groups. These ideas, provided in Table 7.2, serve as an initial starting point for an outreach and education program targeted to different stakeholder groups.

Table 7.2 Focus Group Ideas for Outreach and Education Efforts

Homeowners	**Landowners**
• Nutrient management for turfgrass • Pesticide safety and use • Rainwater harvesting • Water conservation • OSSF maintenance/repair	• Wildlife habitat management • Feral hog management workshops • Ecological benefits of utilizing brush management

Dairy	Rancher/Farmer
• Maintenance of buffer zones • Estimating manure volumes and storage capacity • Calibrating irrigation and sprayer systems • Managing and utilizing compost as a nutrient source • Understanding nutrient and bacteria loading of manure	• Conservation tillage practices • Maintenance and design of soil erosion BMPs • Alternative watering sources design and placement • Grazing management • Utilizing dairy compost as a soil amendment

During the focus group meetings, specific outreach and education efforts that correspond to both individual management strategies and other general environmental education programs were recommended and are summarized in Table 7.3. All these strategies require some level of technical and financial support to be fully carried out. Table 7.3 summarizes strategies aimed at addressing sources of bacteria and nutrients, all of which will provide building blocks for conducting an effective outreach and education strategy. To the extent possible the recommendations need to be customized for each target audience identified in the table. These various ideas will evolve as individual or linked projects to be implemented over the next 10 years. Pollutant load reductions were not estimated for any of the outreach and education efforts identified in Table 7.3.

Table 7.3 List of Targeted Outreach and Education Efforts to Address Bacteria and Nutrient Sources

Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
▪ Alternative watering sources and WQMPs	Campaign to expand participation in the development and implementation of water quality management plans.	▪ TSSWCB, SWCDs, NRCS, Texas AgriLife Extension Service	2011-2020 All subwatersheds	▪ Farmers/Ranchers ▪ Landowners
▪ Dead animal disposal facility	Campaign to promote availability of new county services for dead animal disposal; and benefits of proper disposal. Posting of signs at bridges listing fines for illegal dumping or disposal of dead animals.	▪ County Judges ▪ TxDOT	2011-2020 All subwatersheds	▪ Farmers/Ranchers ▪ Dairy Operators ▪ Landowners ▪ Hunters
▪ Feral hog management strategies	Promote and conduct feral hog management workshops and distribute data summarizing populations and the number of hogs removed from watershed (or county). Construct a multi-county strategy linking feral hog outreach and education efforts. Develop an online tracking system to advance communication sharing about feral hog populations, movement, and locations.	▪ Texas AgriLife Extension Service ▪ Texas Wildlife Services	Current, Continuous All subwatersheds	▪ Farmers/Ranchers ▪ Dairy Operators ▪ Landowners ▪ County Governments
▪ WWTF improvements	Campaign to promote the need for local public support to continue investing in WWTF improvements.	▪ TCEQ ▪ City Mayors	2011-2015 Subwatersheds: 30, 40, 80, 120, 130, 60	▪ City of Comanche ▪ City of Gustine ▪ City of Gatesville ▪ City of Dublin ▪ City of Hamilton ▪ Circle T Ranch

Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
▪ Repair of private hunting camp OSSFs	Engage in an educational campaign aimed at landowners who lease land for hunting by strengthening contracts with hunters to include more stewardship requirements including restrictions on dead animal disposal, and disposal of effluent from hunting camps. Work with TPWD to distribute more water quality stewardship materials that promote proper disposal of human waste at hunting camps with all hunting licenses.	▪ Texas AgriLife Extension Service ▪ TPWD	2011-2015 All subwatersheds	▪ Landowners ▪ Farmers/Ranchers
▪ Repair/Remove failing OSSFs ▪ Connect to municipal lines	Schedule training and outreach meetings for septic system owners and disseminate existing Texas AgriLife Extension Service technical assistance services and materials. Schedule training and for inspectors, installers, and maintenance providers of septic systems to disseminate existing Texas AgriLife Extension Service technical assistance services and materials and improve installation, maintenance and tracking of OSSFs. A key role of the Texas AgriLife Extension Service is to provide information on the technologies available for managing wastewater so that people can make informed decisions when selecting, operating and maintaining their onsite wastewater treatment system (Texas AgriLife Extension Service 2009a). Special emphasis can be placed on targeting outreach and education efforts to the small communities and households located near creeks and rivers in the watershed. http://ossf.tamu.edu/educational-materials-2/	▪ TCEQ ▪ Counties ▪ Texas AgriLife Extension Service	2011-2015 Subwatersheds: 20, 30, 40, 50, 60, 100, 120, 130, 150	▪ Landowners ▪ Comanche County ▪ Erath County ▪ Hamilton County ▪ Coryell County ▪ (Proctor, Hasse, Newburg, Lamkin, Jonesboro, Arnett Flat, Leon Junction)

Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
▪ Replacement of sewer lines ▪ SSO plans	Campaign to promote the need for local public support to continue investing in wastewater collection system improvements. Promote the value and benefits of existing SSO plans. TCEQ SSO training sessions provided to the municipalities in the Leon River watershed. **Wastewater Treatment Operator and Wastewater Collection System Operator Training:** TCEQ provides technical support to wastewater treatment and wastewater collection system operators. All operators will continue to adhere to the licensing and training requirements defined by TCEQ rules. The WSC can collaborate with the municipality focus group and TCEQ to determine how additional training could be targeted to small cities and towns to continue improving the capacity of wastewater treatment and wastewater collection system operators to reduce bacteria and nutrient loading from plants, collection systems and sludge or irrigation systems. http://m.tceq.texas.gov/agency/licensing/licenses/wwlic	▪ TCEQ ▪ City Mayors	2011-2015 Subwatersheds: 30, 40, 60, 80, 120, 130	▪ City of Comanche ▪ City of Dublin ▪ City of Hamilton ▪ Gatesville ▪ Gustine

Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
▪ Wildlife & Livestock Management	Campaign to provide absentee landowners with information about bacteria and nutrient problems in subwatersheds and conservation management and stewardship strategies aimed at wildlife and livestock. Promote availability of various scientific studies, technical guides, and technical support services available to landowners, farmers and ranchers that can provide assistance with managing deer and other mammal populations. The watershed coordinator can work with regional TPWD staff to develop an outreach plan to determine the value and effectiveness of participation by landowners in wildlife management practices. http://www.tpwd.state.tx.us/landwater/land/private/#	▪ SWCDs, NRCS ▪ Texas AgriLife Extension Service ▪ TSSWCB ▪ TPWD	2011-2015 All subwatersheds	▪ Landowners ▪ Farmers/Ranchers ▪ Dairy Operators
Forestland ▪ Wildlife management strategies aimed at deer population control	Actively promote, enhance and educate landowners about TPWD's programs for wildlife habitat and deer population management. Develop and distribute informational materials to hunters and property owners who lease land for hunting summarizing how proper hunting practices can minimize the potential for bacteria or nutrient loading to streams.	▪ TPWD ▪ Texas AgriLife Extension Service	Continuous All subwatersheds	▪ Hunters ▪ Landowners ▪ Farmers/Ranchers ▪ Chambers of Commerce (Municipalities)
WAF ▪ Operation and maintenance ▪ DOPA modifications	Collaboration among agencies to modify the DOPA training modules to fully incorporate bacteria sources and appropriate BMPs to reduce bacteria loading. Integrate outcomes of the TSSWCB Lone Star Healthy Streams project as a key component of the revisions to the DOPA training.	▪ TCEQ ▪ Texas AgriLife Extension Service ▪ TSSWCB	2011-2013 Subwatersheds: 20, 30, 40, 60	▪ Dairy Operators ▪ Farmers/Ranchers

Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
Rangeland ▪ WQMP ▪ Expand use of soil testing	Conduct workshops to provide technical support and recommendations to educate ranchers on proper grazing management BMPs, such as riparian buffers, grazing management. Campaign to promote the need and benefits of soil testing for proper nutrient management in agricultural areas.	▪ Texas AgriLife Extension Service ▪ SWCDs ▪ NRCS ▪ TSSWCB	2011-2015 All subwatersheds	▪ Farmers/Ranchers ▪ Landowners ▪ Dairy Operators
Commercial ▪ Setback from drainage ways	Conduct training workshops for municipal and county leadership on streambank and riparian protection and preparation of ordinances that can mitigate nonpoint source runoff. Evaluate the appropriateness of utilizing the Sports and Athletic Field Education program to educate golf course and other sports and athletic field managers and personnel on nutrient management practices.	▪ TCEQ ▪ Texas AgriLife Extension Service ▪ City Mayors	2011-2015 Subwatersheds: 30, 40, 60, 80, 120, 130	▪ City of Comanche ▪ City of Dublin ▪ City of Hamilton ▪ City of Gatesville ▪ Golf Courses
Residential (municipal) ▪ Ordinance for setbacks from drainage ways	Connect with training workshops for municipal and county leadership on streambank and riparian protection and preparation of ordinances that can mitigate nonpoint source runoff. There are technical support services available from various organizations like the Texas Municipal League that can help municipal leaders with the refinement or development of ordinances that can strengthen local efforts to manage or protect riparian corridors along urban creeks and streams. The WSC and watershed coordinator can collaborate with the municipality focus group to setup workshops in 2012 and 2013 to obtain training and guidance on ordinance development and community education about the need for changes in local ordinances aimed at water quality improvement. http://www.tml.org/legal_guide.asp#ordinance	▪ Texas Municipal League ▪ City Mayors	2013-2015 Subwatersheds: 30, 60, 80, 120, 130	▪ City of Comanche ▪ City of Dublin ▪ City of Hamilton ▪ City of Gatesville

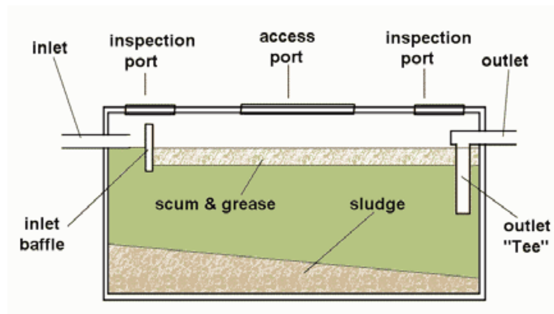
Management Measures	Outreach and Education Recommendation	Lead Organizations	Recommended Time Frame and Priority Subwatersheds	Target Audience
Residential (municipal) ▪ Ordinance for setbacks from drainage ways	**Nonpoint Education for Municipal Officials (NEMO):** The goal of every NEMO workshop is to give local decision makers tangible action items toward protecting their municipality's resources. These actions span a wide range, from revisions to overall town policies to very specific changes to regulations or development practices (Texas Sea Grant 2009). The watershed coordinator can collaborate with Texas Sea Grant to hold a NEMO workshop in the Leon River watershed that will focus on assisting municipalities with communication to the city residents about future implementation strategies aimed at improving water quality. http://www.rpts.tamu.edu/urban-nature/landuse/landuse.htm	▪ Texas Sea Grant ▪ Texas AgriLife Extension Service	2012-2015 Subwatersheds: 30, 60, 80, 120, 130	▪ City Mayors ▪ Texas Municipal League

The following cut sheets provide additional detail on two different education and outreach strategies that were identified by stakeholders as high priority. Coordination between the watershed coordinator, Texas AgriLife Extension Service, and TCEQ will be necessary to ensure the effective implementation of these two recommended education and outreach strategies.

OSSF Outreach and Education

Scope:

- Target homeowners, businesses and landowners with camps for hunters to provide information on improving design, maintenance, and repair of OSSFs
- Target training for contractors, inspectors, septage haulers
- Provide technical assistance to Erath, Comanche, Hamilton and Coryell County governments to improve data collection, evaluation, and management associated with identifying failing OSSF



Location: All subwatersheds

Critical Areas: All subwatersheds

Goal: Provide technical assistance to improve all aspects of installation, repair, maintenance, inspection, and data management for tracking OSSFs which will decrease potential for bacteria and nutrient discharges.

Description: This strategy uses education and outreach materials and approaches currently available through Texas AgriLife Extension Service to target key aspects of installation, repair, maintenance, inspection, and data management that are important for long-term improvements in the management of OSSFs. This strategy will also focus on coordinating all education and outreach activities with each county and providing them technical assistance for prioritizing OSSFs for repair and replacement.

Implementation Strategy

Participation	Recommendations	Period	Capital Costs
Comanche, Hamilton, Erath, Coryell Counties; homeowners and businesses; Texas AgriLife Extension	Education and outreach can target homeowners, businesses as well as landowners with camps for hunters that own and operate an OSSF.	2011-2015	$5,000 per county
Comanche, Hamilton, Erath, Coryell Counties; inspectors, installers, septage haulers, and maintenance providers; Texas AgriLife Extension	Training can be scheduled to disseminate existing Texas AgriLife Extension Service technical assistance services, materials, and online training opportunities aimed at improving installation and maintenance of OSSFs.	2011-2015	$5,000 per county

OSSF Outreach and Education			
Comanche, Hamilton, Erath, Coryell Counties; Texas AgriLife Extension; TCEQ	Conduct a workshop for Authorized Agents and Designated Representatives for all four counties to provide training and technical assistance on how to build tools and capacity to track OSSFs and management data associated with prioritizing OSSFs.	2011-2015	$8,000 per county
Effectiveness:	Medium: Education and training efforts can be effective at improving practices that advance environmental stewardship.		
Difficulty:	Low: Texas AgriLife Extension Service have existing, effective education and outreach materials and training sessions already available. Getting sufficient participation to make individuals to change their habits can be difficult.		
Certainty:	High: There are valuable, available education and outreach and training approaches and materials already available for use.		

Dairy Outreach Program Area Training Modules

Scope:

- Revise existing modules for DOPA training to incorporate information that lead to better management of bacteria sources from AFOs/CAFOs
- Accelerate operators attendance for new training

Location: Subwatersheds 20, 30, 40, 60, and 70

Critical Areas: Subwatershed 20, 30, 40, 60 and 70

Goal: Expand the knowledge of dairy operators through enhanced DOPA educational courses.

Description: In 2005, TCEQ and Texas AgriLife Extension Service collaborated to establish the Dairy Outreach Program Area (DOPA). DOPA is a technical training and continuing education program targeted towards dairy operators in the eight-county area, which includes Comanche, Hamilton, Erath, Bosque, Hopkins, Johnson, Rains, and Woods Counties. Attendance in the training and education program is required for any AFO with more than 300 animal units (more than 200 mature dairy cows) located in the DOPA. The training provides valuable technical assistance and education to dairy operators on operational techniques and BMPs that improve nutrient management. As part of the dairy outreach program area (DOPA) existing education modules can be modified to enhance and incorporate information that will directly address bacteria sources related to dairy operations. The level of effort necessary to modify existing training modules may be time consuming, but once revised future required DOPA training sessions would result in immediate implementation of the recommendation and high certainty that all operators would receive the training over time. The revised DOPA training modules can establish feedback surveys that can be used to help measure the value of the education to operators and whether operators are making changes to facilities, maintenance and operations as a result of the training.

Implementation Strategies

Participation	Recommendation	Period	Capital Costs
CAFOs, TCEQ, Texas AgriLife Research	Modify existing training modules to incorporate bacteria as pollutant of concern and expand BMPs; incorporate surveys to evaluate behavioral changes in response to education	2011-2015	$100,000

Dairy Outreach Program Area Training Modules				
TCEQ, Texas AgriLife Research		Compile and integrate new research findings on fate and transport and mitigation of bacteria into DOPA program materials	2011-2015	$300,000
Load Reduction				
Reductions associated with education and outreach activities are difficult to quantify but dairy industry supports the need for this management strategy.				
Effectiveness:	High: Pollutant loads in runoff from properly operated CAFOs are minimal.			
Difficulty:	Low: Most operators attend training and once a program is developed it is easy to disseminate.			
Certainty:	High: All CAFO and AFO operators must attend classes.			

Some additional broad-based water quality-oriented educational programs that can be incorporated into the outreach and education strategy and targeted throughout the Leon River watershed between 2012 and 2017 are listed below in order of priority, contingent upon available funding.

<u>Texas Watershed Steward Program</u>: A key goal of this science-based watershed education program is to engage as many citizens as possible in workshops designed to help citizens take local actions to address water quality problems. A Texas Watershed Steward workshop is a one-day program designed to improve the quality of Texas' water resources by educating and informing local stakeholders about their watershed, potential impairments, and steps that can be taken to help improve and protect water quality in their watershed (Texas AgriLife Extension Service 2009b). The Texas Watershed Steward Program is supported through a CWA §319(h) grant from TSSWCB and USEPA to Texas AgriLife Extension Service. Building on the success of the first Texas Watershed Steward workshop held in Comanche on October 18, 2008, additional future workshops can be held in the Leon River watershed over the next five years.

<u>Lone Star Healthy Steams Program – Dairy Cattle and Grazing Cattle Components</u>: Through the cooperative efforts of the Texas Water Resources Institute, TSSWCB, and NRCS, pilot projects are underway to expand the overall knowledge of how to improve the management of grazing lands by beef cattle producers and dairymen in an effort to reduce nonpoint source pollution around the State. This project seeks to educate landowners and promote voluntary adoption of BMPs to reduce bacterial contamination of streams as well as reduce the likelihood of increased regulatory oversight of production practices and systems. Based on results of these projects, educational programs and technical assistance for BMP implementation can be targeted in key watersheds around the State. The Lone Star Healthy Streams Program is supported through CWA §319(h) grants from TSSWCB and USEPA to TWRI, Texas AgriLife Extension Service, and Texas AgriLife Research. The Leon River watershed will be a high priority watershed for the application of the lessons learned from these valuable pilot projects in 2012 (Texas Water Resources Institute 2010).

<u>Watershed Signage</u>: Contingent upon funding, signs can be developed and posted along major roads notifying travelers that they are entering the Leon River or specific subwatersheds of tributaries to the Leon River. Illegal dumping signs can also be placed at bridges to the extent funding is available.

Texas Stream Team: Texas Stream Team is a network of trained volunteers and supportive partners working together to gather information about the natural resources of Texas and to ensure that information is available to all Texans. Volunteers are trained to collect quality-assured information that can be used to make environmentally sound decisions. The Texas Stream Team can be called upon by the WSC or watershed coordinator to improve communication and facilitate environmental stewardship by empowering a network of concerned volunteers and partners within the Leon River watershed (Texas State University-San Marcos 2010).

Existing or new outreach and education programs and materials can be made available to advance the different management strategies recommended in the WPP. Outreach and education efforts can initially be targeted to support landowners, ranchers/farmers, and municipal and county governments, particularly in subwatersheds 20, 30, 40, 50, 60, and 100. The WSC and watershed coordinator can collaborate with other agencies to advance multiple outreach and education strategies listed above simultaneously in a coordinated manner and adjust the strategies over time to better meet the needs of stakeholders. The WSC and watershed coordinator can work to formulate partnerships where possible to expedite and save costs when implementing education and outreach recommendations and communicating with target audiences. The education and outreach recommendations summarized above establish a comprehensive strategy to increase public awareness and support as well as foster local stewardship of land and water resources.

Water Quality Regulations: Chapter 26, Section 26.121 of the Texas Water Code prohibits Illegal discharges of sewage into waters of the state. "Water" or "water in the state" means groundwater, percolating or otherwise, lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, wetlands, marshes, inlets, canals, the Gulf of Mexico, inside the territorial limits of the state, and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or nonnavigable, and including the beds and banks of all watercourses and bodies of surface water, that are wholly or partially inside or bordering the state or inside the jurisdiction of the state. Chapter 7 of the Texas Water Code provides state and local government officials the means to assess civil and criminal penalties for illegal discharges into waters of the state.

Chapter 8: Technical and Financial Assistance Resource Needs

Chapters 5 through 7 identify a wide array of BMPs, municipal wastewater infrastructure projects, outreach and education recommendations, and the WSC and watershed coordinator position, all of which will require technical and financial support to be successfully implemented. Technical and financial support are available to varying degrees from federal, state, regional, and local government agencies, universities, non-governmental organizations (NGO), council of governments, and business and trade associations. The keys to acquiring technical and financial assistance that will advance the actions outlined in this WPP are knowledge of where to go to get assistance, when the assistance is available, and investing the time and energy necessary to obtain and utilize the assistance. This chapter provides the types of technical and financial assistance needed to implement the Leon River WPP and where this assistance can be obtained.

8.1 Technical Resource Needs

The technical expertise and manpower required for the strategies outlined in Chapters 5 through 7 are beyond the capacity of the Leon River stakeholders to implement alone. Stakeholders will require various types of technical assistance to effectively pursue the goal of restoring water quality in the Leon River watershed. The WSC will require technical assistance to carry out its role of implementing the WPP. Initially, the WSC will obtain technical support from the watershed coordinator with setting up formalized operating procedures for conducting WSC business, meetings, and communication requirements. Through meetings held by the WSC, the watershed coordinator can identify other state, regional, or federal agencies that can provide technical or financial support to the WSC for accelerating implementation of management strategies or evaluating success of individual projects.

8.1.1 WWTF and Wastewater Collection Systems Management Strategies

The wastewater utility staffs of small cities will require additional technical expertise, training and financial resources to implement industry advancements in treatment technology, operations, maintenance, materials and construction. In some cases the identification and design of specific improvements to wastewater infrastructure are outside the scope of existing municipal staff. Each municipality in the Leon River watershed has its own unique issues that influence their site-specific strategies to reduce bacteria and nutrient loads to the greatest extent practical. Technical assistance in the form of professional engineering, infrastructure financing, public education and outreach, and operations and maintenance will be needed for design, construction, maintenance or operation of wastewater treatment and collection systems improvements. Additional resources are needed by each municipality to improve and expand the level of effort for outreach, compliance inspections and enforcement of ordinances and rules aimed at addressing wastewater treatment and conveyance.

The WSC, watershed coordinator, and the utility staffs of each municipality will work together to seek technical assistance for wastewater management solutions in urban, residential, commercial, and industrial areas. Technical assistance may be sought from entities such as USEPA, TCEQ, BRA, TWDB, Texas AgriLife Research, engineering and community outreach consulting firms, and universities.

8.1.2 Onsite Sewage Facility Management Strategies

A comprehensive approach, including both technical assistance and outreach and education assistance, is necessary to implement management strategies targeted at decreasing pollutant loads from OSSFs throughout the Leon River watershed. The County Judges of Coryell, Hamilton, Erath, and Comanche County will need to expand their technical capacity to determine whether existing septic systems are operating effectively, or whether they require maintenance, repair, or replacement. These counties will need additional technical assistance beyond that which can be provided by their current designated representative. These counties need technical assistance with delineation of floodplains, improving databases tracking OSSFs, identifying where resources for repair or replacement would be best spent, modifying inspection procedures and frequency, prioritizing systems needing pumping of septage, outreach and education to homeowners, training for OSSF contractors and inspectors, modifications to design standards, and updated estimates of pollutant load reductions resulting from repaired or replaced OSSFs.

The WSC, watershed coordinator, the Coryell County Environmental Officer and designated representatives from the other three counties and municipal leaders can work together to seek technical and financial assistance for OSSF improvements from TCEQ, Texas On-site Wastewater Treatment Research Council, Texas AgriLife Extension Service, Texas Engineering Extension Service, and engineering consulting firms.

8.1.3 Hunting Camps and Septic Management Strategies

Public education programs regarding the proper management and disposal of septic generated at hunting camps will be necessary to help achieve water quality improvement goals. Those engaged in hunting and camping activities will need to be aware that proper disposal of human waste is important to avoid pollution of water sources, avoid the negative implications of someone else finding it, minimize the possibility of spreading disease, and maximize the rate of decomposition (Leave No Trace, 2008). Water quality can be negatively affected due to the lack of, or improper installation of on-site sewage facilities at camp sites or inadequate disposal methods. Those responsible for illegal discharges into waters of the state are subject to civil and criminal penalties under the Texas Water Code.

Disposal methods can vary depending on length of stay and volume generated at hunting camps. In some locations, burying human feces in the correct manner is the most effective method to avoid impacts on water quality. Catholes are the most widely accepted method of waste disposal. Locate catholes at least 200 feet (about 70 adult steps) from water, trails and camp. Select an inconspicuous site where other people will be unlikely to walk or camp. With a small garden trowel, dig a hole 6-8 inches deep and 4-6 inches in diameter. The cathole should be covered and disguised with natural materials when finished. If camping in the area for more than one night, or if camping with a large group, cathole sites should be widely dispersed.

Though catholes are recommended for most situations, there are times when latrines may be more applicable, such as when camping with young children or if staying in one camp for longer than a few nights. Use similar criteria for selecting a latrine location as those used to locate a cathole. Since this higher concentration of feces will decompose very slowly, location is especially important. A good way to speed decomposition and diminish odors is to toss in a handful of soil after each use (Leave No Trace, 2008).

Longer-term hunting camp facilities may benefit from a properly installed and managed on-site sewage facility (OSSF). Regulations regarding on-site sewage facilities can be found in Chapter 366 of the Health & Safety Code and Chapter 285 of the Texas Administrative Code. Comanche, Coryell, and Hamilton Counties may find it advantageous to administer OSSF regulations at the local level as an Authorized Agent through delegation of authority from the TCEQ. The removal of the waste materials from the site and disposal at a permitted facility via pump and haul equipment is another alternative.

Enforcement of laws regarding illegal discharges into waters of the state will need the full support of local government entities in Comanche, Coryell, and Hamilton Counties. Close coordination between county and city governing bodies with local law enforcement agencies and judicial bodies will be necessary to ensure successful implementation septic disposal regulations. County court orders and city ordinances may need to be adopted that require documentation of proper disposal methods from landowners. Other actions may include coordination with local game wardens on investigations related to illegal discharges into waters of the state.

8.1.4 Wildlife Management Strategies

Technical assistance, coupled with outreach and education assistance, is necessary to advance implementation of strategies aimed at wildlife management. Efforts can be customized based on stakeholder requests to address deer population management and possibly other wildlife species in targeted areas. Since the deer population over the past decade has increased throughout the watershed, a cooperative approach may be the most effective way to manage deer populations.

TPWD works with private landowners to conserve wildlife populations for all Texans. Through its Private Lands Program, TPWD provides technical guidance to landowners interested in wildlife habitat and population management. TPWD biologists perform site visits and offer guidance on management practices in the form of written recommendations or Wildlife Management Plans (WMPs). TPWD also works with Wildlife Management Associations (WMAs) or groups formed by landowners to improve wildlife habitats and populations.

If landowners choose to adopt a formal wildlife management program, extra assistance with managing deer populations may be available through Managed Lands Deer Permits, which allow landowners involved in a formal management program to have the state's most flexible hunting seasons and bag limits. TPWD Wildlife Division staff is available to provide information concerning local wildlife populations and their management. Information on locating the Wildlife Division biologist, District, or Regional office that serves a particular area can be obtained on the TPWD web site at http://www.tpwd.state.tx.us/landwater/land/habitats/. Information on technical assistance with wildlife management issues can be obtained on the TPWD web site at http://www.tpwd.state.tx.us/landwater/land/private/. TPWD wildlife management programs are voluntary based on landowner requests. TPWD can also collaborate with TSSWCB to develop and distribute educational materials that promote proper disposal of human waste at hunting camps. TPWD responds to requests on a "first-come, first serve" basis.

Note that "wildlife" has a statutory definition that limits TPWD's authority to wild animals, wild birds, and aquatic animal life of the State. TPWD's authority does not include exotic livestock, such as feral swine, axis deer, and sika deer. Engineering assistance from the Texas Department of Transportation and consulting engineers and biological advice from TPWD will be necessary if bird displacement structures are considered a practical BMP for key bridges with large numbers of nesting birds.

NOTE: Cliff and Barn Swallows as well as other migratory birds may not be disturbed and must be dealt with in a manner consistent with the Migratory Bird Treaty Act (MBTA). The MBTA prohibits taking, attempting to take, capturing, killing, selling/purchasing, possessing, transporting and importing of migratory birds, their eggs, parts and nests, except when specifically authorized by the Department of the Interior. Any potential bird management strategies or bird controls must be coordinated with the U.S. Fish and Wildlife Service and TPWD.

Technical assistance will be required from Texas AgriLife Extension Service, TDA, and Texas Wildlife Services to advance a coordinated effort aimed at managing the feral hog population in Comanche, Erath, Hamilton, Coryell and surrounding counties. For the feral hog management effort to be successful, special emphasis on inter-governmental coordination is necessary between county extension agents, the Brownwood and Fort Worth District offices of the Texas Wildlife Service, TDA, and the Coryell County Environmental Officer. Technical assistance will include conducting feral hog control seminars, trapping, recommending options for transporting live hogs, hog hunting, including use of helicopters, dead hog disposal options, and evaluations of the role feral hogs play in *E. coli* loading to receiving waters. Technical assistance can also be provided to the WSC and watershed coordinator on methods to assist them in building reporting tools to demonstrate locations that feral hogs frequent and to quantify the impact management strategies are having on decreasing hog populations as well as quantifying the effect those decreases are having on instream water quality.

Through a CWA §319(h) nonpoint source grant from the TSSWCB, Texas AgriLife Extension Service has hired a Extension Assistant to provide technical assistance to landowners on feral hog management strategies to increase the abatement of feral hogs in the Plum Creek watershed. The Extension Assistant not only works one-on-one with landowners but has developed a series of publications on feral hog abatement techniques, an online tracking system to track feral hog damage and sightings (http://plumcreek.tamu.edu/FeralHogs), as well as organize annual feral hog management workshops. Texas AgriLife Extension Service has also worked in close coordination with Texas Wildlife Services on conducting feral hog abatement efforts in the watershed. A similar program to provide technical assistance on feral hog management could be implemented in the Leon River watershed through grant funding.

8.1.5 Forestland, Cropland, Rangeland, WAF Management Strategies

Management strategies in this WPP are targeted at rangeland, forestland, pastureland, and WAFs all occurring at various scales throughout the watershed. Rangeland, forestland, and pastureland account for over 824,000 acres of land throughout the watershed. Implementing conservation practices and agricultural BMPs will have a direct effect on improving water quality of the Leon River and its tributaries. Given the diversity of agricultural activities occurring in the Leon River watershed, a significant commitment of technical assistance will be required. Technical assistance will have a primary focus in subwatersheds 20, 30, 40, and 60 because they have the highest geometric means for *E. coli* and thus warrant immediate attention to accelerate implementation of management strategies. A secondary focus of technical assistance will be targeted at all remaining subwatersheds.

Livestock management strategies in this WPP are recommended for both permitted (CAFOs) and non-permitted livestock operations. Therefore, dairy operators, ranchers, farmers, and landowners can all benefit from receiving technical assistance and education to improve their ability to reduce bacteria and nutrient loads through the proper implementation of BMPs. Each livestock manager will require site-specific technical assistance to better address the unique characteristics of his land that may prevent or exacerbate transport of bacteria or nutrient loads to receiving waters during rainfall runoff events.

Technical assistance for agricultural management strategies in the Leon River watershed will primarily come from TSSWCB, local SWCDs, Texas AgriLife Extension Service and NRCS. Technical assistance from the TSSWCB, NRCS, and local SWCDs for development of WQMPs based on NRCS Field Office Technical Guides will be necessary. TSSWCB will provide technical assistance directly to specific land owners in each subwatershed to expand participation in management strategies that advance agricultural stewardship recommended in the WPP. There will be a significant resource demand on the TSSWCB to provide technical support for WQMP preparation, recommend cost share options, and on-farm assistance and education. The local SWCDs need resources to hire Technicians to provide technical assistance to landowners and lessen the demand on TSSWCB to provide direct technical assistance. A key area of technical assistance from Texas AgriLife Extension Service is to provide dairy operators, ranchers, farmers, and landowners technical support to promote the benefits of soil testing and proper application of manure by third parties. Technical assistance will also be needed to assist agribusinesses with the development, testing, and implementation of innovative technologies such as bio-energy options.

8.1.6 Residential, Commercial, Industrial Management Strategies

All of the municipalities in the Leon River watershed will benefit from obtaining technical assistance on strategies that can help mitigate storm water pollution. All municipalities can benefit from technical assistance aimed at developing approaches to prepare city-wide maps that depict the storm water conveyance system. Technical assistance on how to develop setback ordinances and other strategies to mitigate storm water flow to urban creeks can be obtained from TCEQ, USEPA, Texas Municipal League, universities, consulting firms and other cities with model ordinances. Community relations and legal support will be necessary to garner local support for modifications to or development of ordinances aimed at reducing bacteria or nutrient loading from urban storm water runoff and elimination of illicit discharges.

8.2 Financial Resource Needs

Discussions with the focus groups, working committee representatives, and the Technical Advisory Committee provided general information that was used to estimate financial needs. Financial support will be needed by the WSC to fund the position for a watershed coordinator. A preliminary estimate of the annual costs (salary, benefits, and other direct costs) associated with one full-time position to serve as a watershed coordinator is $75,000. Table 8.1 provides a summary of the estimated financial assistance needed to support implementation of the Leon River WPP from 2011-2020. Some initial investments in wastewater infrastructure that have already been made by the cities of Dublin, Hamilton, and Gatesville are also provided in Table 8.1 since these improvements can result in bacteria load reductions. The estimated future costs provided do not incorporate increases expected from inflation and market changes. Ongoing costs for operations and maintenance are not included. **Successful acquisition of funding sources that can sustain implementation is essential if the goals of the WPP are to be achieved.** Figure 8.1 displays the costs from Table 8.1 to show cumulative comparisons overtime associated with each management strategy.

Table 8.1 Summary of Financial Assistance Needed to Support Implementation

Management Strategy	Completed Investments			Future Capital Costs (Dollars)										Capital Cost
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
WWTF improvements	-	1,738,000	5,050,000	167,600	4,167,600	167,600	168,114	268,114	514	514	514	514	514	**$ 11,729,600**
Grease trap ordinance	-	-		0	0		10,000		0	0	0			**$ 10,000**
Replace sewers	85,667	85,667	85,667	136,400	136,400	136,400	136,400	136,400	120,000	120,000	120,000	120,000	120,000	**$ 1,539,000**
SSO Plan	-	150,000	-	-	225,000	-	-	-	-	-	-	-	-	**$ 375,000**
Address failing OSSFs	-	-	-	275,000	275,000	275,000	275,000	275,000	174,500	174,500	174,500	174,500	174,500	**$ 2,247,500**
Feral hog control	-	-	-	95,000	105,000	85,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	**$ 796,000**
Deer population management	-	-	-	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**$ 100,000**
Alternative watering sources	-	-	-	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	**$ 2,080,000**
Dead animal disposal	-	-	-	12,800	12,800	12,800	12,800	12,800	84,000	84,000	84,000	84,000	84,000	**$ 484,000**
WQMPs	-	-	-	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	963,000	**$ 9,630,000**
WAF Manure management	-	-	-	320,000	335,000	320,000	370,000	320,000	-	-	-	-	-	**$ 1,665,000**
Strategies for R/C/I	-	-	-	223,000	223,000	223,000	223,000	598,000	55,000	55,000	55,000	55,000	55,000	**$ 1,765,000**
Subtotal	**$ 85,667**	**$1,973,667**	**5,135,667**	**$2,410,800**	**$6,660,800**	**$2,400,800**	**$2,449,314**	**$2,864,314**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$1,688,014**	**$ 32,421,100**
Outreach and Education[1]				$289,000	$258,000	$294,000	$258,000	$284,000	$168,000	$184,000	$168,000	$184,000	$168,000	$2,255,000
Water Quality Monitoring[2]				60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	600,000
Total Costs				**2,759,800**	**$6,978,800**	**$2,754,800**	**2,767,314**	**$3,208,314**	**$1,916,014**	**$1,932,014**	**$1,916,014**	**$1,932,014**	**$1,916,014**	**$ 35,276,100**

[1] For detailed breakdown of outreach and education strategy costs and WSC and watershed coordinator operating costs see Table 8.2.
[2] For SWQM stations resulting in future monitoring costs see table 9.4.

Figure 8.1 Summary of Estimated Annual Financial Assistance Needed to Support Implementation

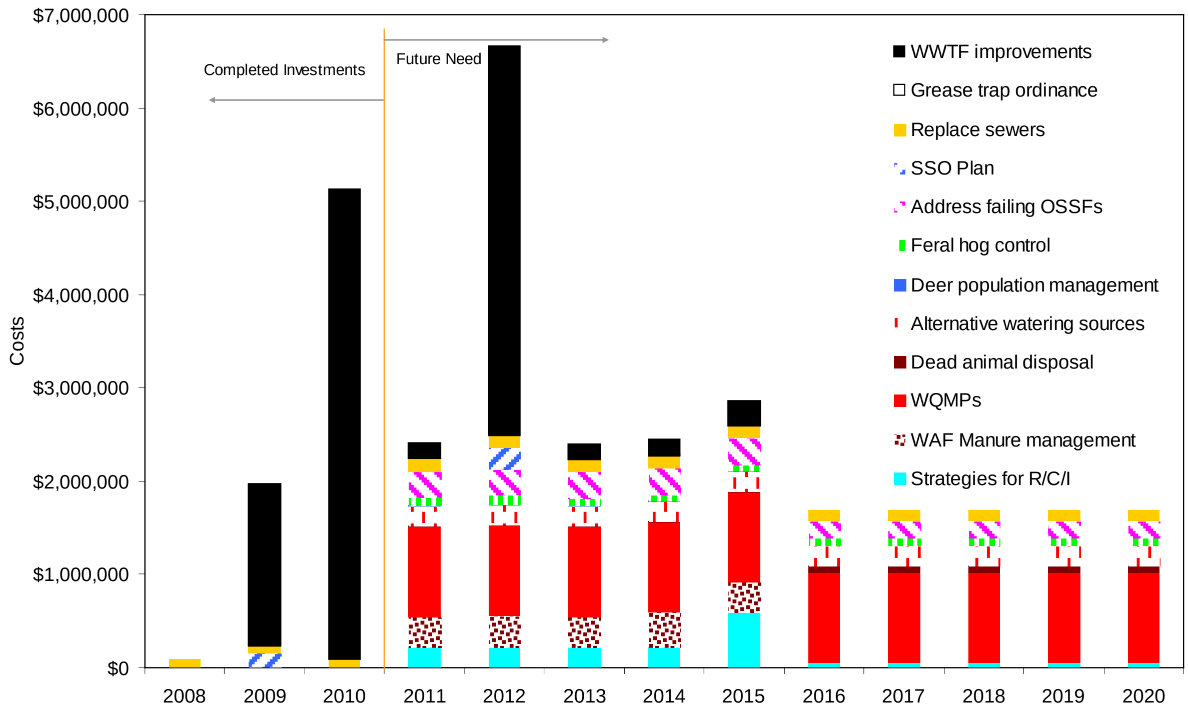
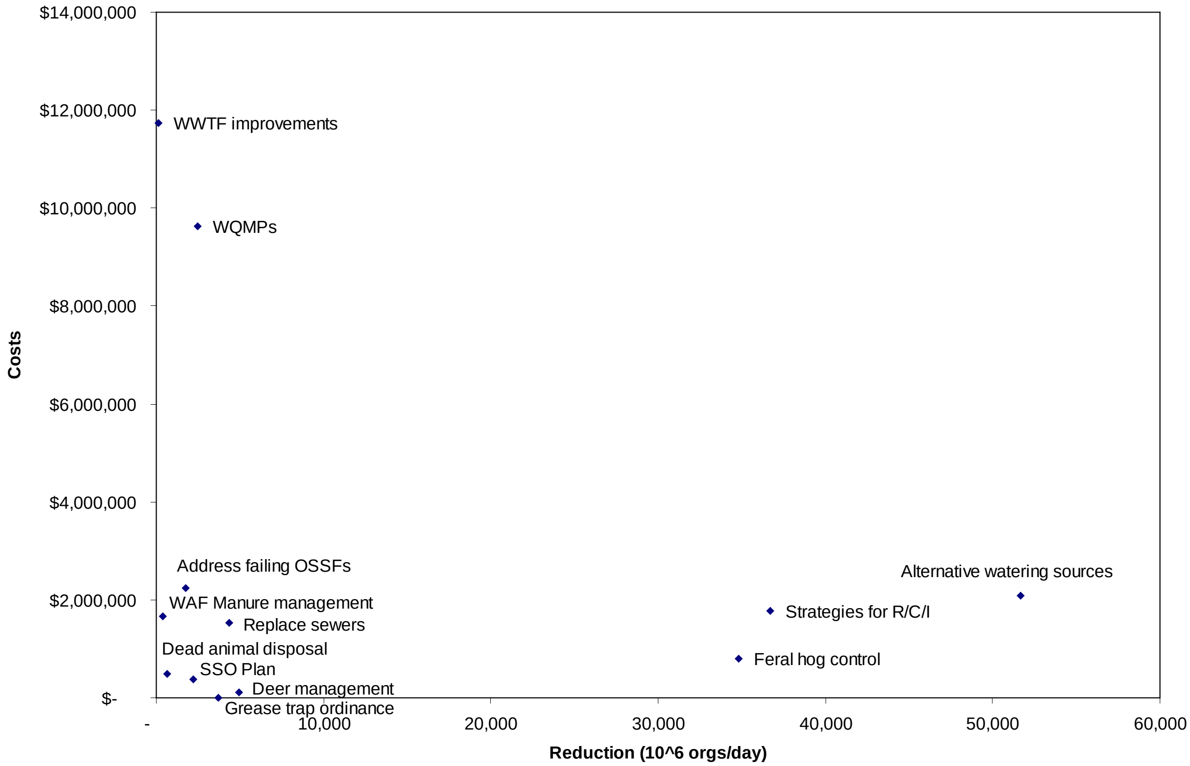


Figure 8.2 plots the relationship between the cost of a management strategy and the estimated reduction in *E. coli*. This graph provides additional information to aid stakeholders in prioritizing the implementation of the most effective management strategies and corresponding allocation of financial resources. This graph demonstrates the importance of investing in management strategies such as alternative watering sources, feral hog management and BMPs for residential, commercial and industrial developments.

Figure 8.2 Benefit Cost Analysis of Management Strategies



There are a variety of other costs associated with promoting and advancing stewardship and watershed management some of which can be estimated at this time others which cannot. The costs associated with these other strategies are summarized in Table 8.2. They were separated from the costs summarized in Table 8.1 because pollutant load reductions from implementing these strategies cannot be estimated. The costs provided do not incorporate increases expected from inflation and market changes.

Table 8.2 Summary of Financial Assistance Needed to Support Outreach and Education Strategies

Outreach and Education Strategy	Future Capital Costs (Dollars)										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Capital Cost
Watershed Steering Committee Operational Costs	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	**$50,000**
Watershed Coordinator	75,000	75,000	75,000	75,000	75,000	85,000	85,000	85,000	85,000	85,000	**$800,000**
Campaign to promote dead animal disposal services	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	**$80,000**
Feral hog management workshops and outreach	10,000	10,000	10,000	10,000	10,000						**$50,000**
OSSF training and outreach	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	**$150,000**
Wildlife management training and outreach	10,000		10,000		10,000						**$30,000**
Informational and outreach materials for absentee landowners and property owners who lease land for hunting		5,000	5,000	5,000	5,000						**$20,000**
DOPA training enhancement and outreach	80,000	80,000	80,000	80,000	80,000						**$400,000**
Municipal training workshops and outreach on streambank restoration	8,000		8,000		8,000		8,000		8,000		**$40,000**
Campaign to promote benefits of soil testing for proper nutrient management	5,000	5,000	5,000	5,000	5,000						**$25,000**
Farm/Ranch technical support and outreach for WQMPs	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	**$550,000**
Municipal training workshops and outreach on stormwater management strategies and setback ordinances	8,000		8,000		8,000		8,000		8,000		**$40,000**
Nonpoint source education workshops for municipalities	10,000		10,000								**$20,000**
Totals	**$289,000**	**$258,000**	**$294,000**	**$258,000**	**$284,000**	**$168,000**	**$184,000**	**$168,000**	**$184,000**	**$168,000**	**$2,255,000**

8.3 Sources of Financial Assistance

There are various federal and state programs available to provide funding for many of the management strategies identified in the Leon River WPP. There are a few NGOs that may also provide financial support to local governments or landowners to implement projects that promote land stewardship and improve water quality. Table 8.3 lists the primary federal and state programs and NGOs that can provide financial assistance for implementation of management strategies aimed at reducing bacteria and nutrient loads.

Table 8.3 List of Primary Sources for Financial Assistance to Support Implementation

$ Funding Sources $	Information Sources
Clean Water State Revolving Fund: Provides low-interest loans with flexible terms and significant funding for wastewater treatment infrastructure improvements and nonpoint source pollution controls. http://www.twdb.state.tx.us/financial/programs/cwsrf.asp	TWDB
USDA Rural Development Program (USDA-RD): Offers grants and supports low-interest loans to rural communities for water and wastewater development projects. http://www.rurdev.usda.gov/rd/nofas/index.html	USDA-Rural Development
Clean Water Act §319 Nonpoint Source Grant Program: Provides grant funding through TSSWCB and TCEQ from USEPA to implement specific projects that control and abate nonpoint source pollution. TSSWCB administers grants that are aimed at agricultural and silvicultural nonpoint source pollution and TCEQ administers grants that target all other nonpoint sources of pollution. http://www.tceq.texas.gov/waterquality/nonpoint-source/grants/grant-pgm.html http://www.tsswcb.texas.gov/managementprogram	USEPA, TSSWCB, TCEQ

$ Funding Sources $	**Information Sources**
Environmental Quality Incentives Program: The Environmental Quality Incentives Program (EQIP) was reauthorized in the 2008 federal Farm Bill continuing a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. EQIP offers contracts to provide financial assistance to implement conservation practices. Owners of land in agricultural production or persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. Program practices and activities are carried out according to an EQIP program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or measures needed to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions (NRCS 2010a). http://www.nrcs.usda.gov/PROGRAMS/EQIP/index.html#prog	USDA-NRCS
Farm Service Agency – Conservation Reserve Program: The Conservation Reserve Program is a voluntary program for agricultural landowners. Through Conservation Reserve Program, you can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland. The program provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. By reducing water runoff and sedimentation, Conservation Reserve Program protects groundwater and helps improve the condition of lakes, rivers, ponds, and streams. http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp	USDA
Wildlife Habitat Incentive Program: The Wildlife Habitat Incentive Program (WHIP) is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forestland, and Indian land. The Natural Resources Conservation Service administers WHIP to provide both technical assistance and up to 75% cost-share assistance to establish and improve fish and wildlife habitat. Key WHIP objectives include restoration of declining or important native fish and wildlife habitats; reduction of the impacts of invasive species on fish and wildlife habitats; and restore, develop or enhance declining or important aquatic wildlife species' habitats http://www.nrcs.usda.gov/Programs/whip/	USDA-NRCS

$ Funding Sources $	Information Sources
Agricultural Water Enhancement Program: The Agricultural Water Enhancement Program (AWEP) is a voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and groundwater and improving water quality. Grant funding is available to provide financial incentives for agricultural producers and other rural landowners to develop resource conservation plans and implement BMPs aimed at improving water quality (NRCS 2010b). Funding for 2009 through 2013 has been allocated through AWEP to the Water Quality Improvement Project for the Leon River. This project can provide funding for agricultural producers to develop natural resource conservation plans and implement best management practices that will assist in improving water quality. Counties included in the project area are: Bell, Comanche, Coryell, Eastland and Hamilton. http://www.tx.nrcs.usda.gov/programs/awep/index.html	USDA – NRCS Leon Bosque Resource Conservation and Development Council
Supplemental Environmental Project Program: Directing funds from fines, fees, and penalties for environmental violations toward environmental beneficial projects, such as Cleanup of Unauthorized Trash Dumps, Plugging Abandoned Water Wells, Repair/Replace Failing OSSFs. http://www.tceq.texas.gov/legal/sep/	TCEQ Leon Bosque Resource Conservation and Development Council
Texas Capital Fund: As part of the Community Development Block Grant, this program provides more than $10 million in competitive awards each year to small Texas cities and counties. The Texas Capital Fund provides funding for infrastructure projects that include water and sewer lines, and drainage improvements. http://www.agr.state.tx.us/agr/media/media_render/0,1460,1848_29179_24768_0,00.html	TDA
Water Quality Management Plan Program: A WQMP is a site-specific plan for land improvement measures developed through SWCDs for agricultural and silvicultural lands. WQMPs provide 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 the USDA-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. http://www.tsswcb.texas.gov/wqmp	TSSWCB, SWCD

$ Funding Sources $	Information Sources
Texas Clean Rivers Program: This statewide water quality monitoring, assessment, and public outreach program is funded by wastewater permit fees. Through this program, BRA can continue to utilize some of its Clean Rivers Program resources to monitor and assess water quality conditions in the Leon River watershed and document progress made toward reducing bacteria and nutrient loading. http://www.tceq.texas.gov/waterquality/clean-rivers/	TCEQ, BRA
Economically Distressed Area Program (EDAP): Funding in the form of a grant, or a combination grant/loan available for qualified communities for water and wastewater infrastructure improvements. The EDAP includes measures to prevent future substandard development. The county where the project is located must adopt rules for the regulation of subdivisions, prior to application for financial assistance. http://www.twdb.state.tx.us/assistance/assistance_main.asp .	TWDB
Agricultural Water Conservation Program: Provides grants and low-interest loans to political subdivision and private individuals for agricultural water conservation and/or improvement projects. The 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. http://www.twdb.state.tx.us/assistance/financial/fin_infrastructure/awcfund.asp	TWDB
Texas Farm & Ranch Lands Conservation Program: Established by Senate Bill 1273 in 2005. Provides grants to landowners for the sale of conservation easements that create a voluntary free-market alternative to selling land for development, which stems the fragmentation or loss of agricultural lands. http://www.glo.state.tx.us/res_mgmt/farmranch/apply.html	Texas General Land Office
Feral Hog Abatement Grant Program: TDA anticipates issuing a request for proposals in Fall 2010 to providing funding for practical, effective projects aimed at controlling the feral hog population across the state. http://texasagriculture.gov/	TDA

$ Funding Sources $	Information Sources
Outdoor Recreation Grants: This program provides 50% matching grant funds to municipalities, counties, municipal utility districts (MUD) and other local units of government with a population less than 500,000 to acquire and develop parkland or to renovate existing public recreation areas. There will be two funding cycles per year with a maximum award of $500,000. Eligible sponsors include cities, counties, MUDs, river authorities, and other special districts. http://www.tpwd.state.tx.us/business/grants/trpa/#outdoor	TPWD
Environmental Education Grants: The Grants Program sponsored by USEPA's Environmental Education Division, Office of Children's Health Protection and Environmental Education, supports environmental education projects that enhance the public's awareness, knowledge, and skills to help people make informed decisions that affect environmental quality. USEPA awards grants each year based on funding appropriated by Congress. Annual funding for the program ranges between $2 and $3 million. Most grants will be in the $15,000 to $25,000 range. http://www.epa.gov/education/grants.html	USEPA
Water Supply Enhancement Program: In Chapter 203 of the Texas Agriculture Code, the TSSWCB is designated as the agency responsible for administering the Texas Brush Control Program to enhance water supplies through the selective control of water-depleting brush. Chapter 203 created a cost share program for brush control, created the Brush Control Fund, limits the cost share rate to 80% of the total cost of a practice, and limits the cost share program to critical areas designated by the TSSWCB and to methods of brush control approved by the TSSWCB. It also establishes criteria for approving applications, setting priorities and contracting for cost sharing. http://www.tsswcb.texas.gov/brushcontrol	TSSWCB
Landowner Incentive Program: The TPWD Landowner Incentive Program (LIP) is designed to meet the needs of private landowners wishing to enact good conservation practices on their land. As a program, LIP efforts are focused on projects aimed at creating, restoring, protecting, and enhancing habitat for rare or at-risk-species throughout the State. The proposed conservation practices must contribute to the enhancement of at least one rare or at-risk species or its habitat as identified by the Texas State Wildlife Action Plan or the LIP Priority Plant Species List. http://www.tpwd.state.tx.us/landwater/land/private/lip/	TPWD

Chapter 9: Measuring Progress

Measuring progress is one of the fundamental components of adaptive management that can be used to guide decision-making throughout implementation. Stakeholders and water resource managers alike recognize that many aspects of bacteria and nutrient sources in the environment are not entirely understood. Scientific understanding of bacteria deposition rates, terrestrial and aquatic survival, source differentiation, overland and downstream transport, and cumulative inter-relationships between pollutants is limited. Despite the uncertainty created by the complexities of environmental systems and their impact on human and environmental health, implementation of the Leon River WPP can move forward by adhering to adaptive management principles. As management strategies are implemented, tracking progress through a multi-tiered evaluation framework can provide information necessary to make adjustments to the WPP. With this approach, bacteria load reduction and progress toward achieving water quality goals can be tracked to evaluate progress toward achieving pollutant reduction estimates and targets. The multi-tiered evaluation framework outlined in Chapter 9 provides the foundation for the Leon River WPP to meet the following three key elements of a WPP as recommended by USEPA guidance:

g. <u>Interim, measurable milestones</u> for determining whether management strategies are being implemented;

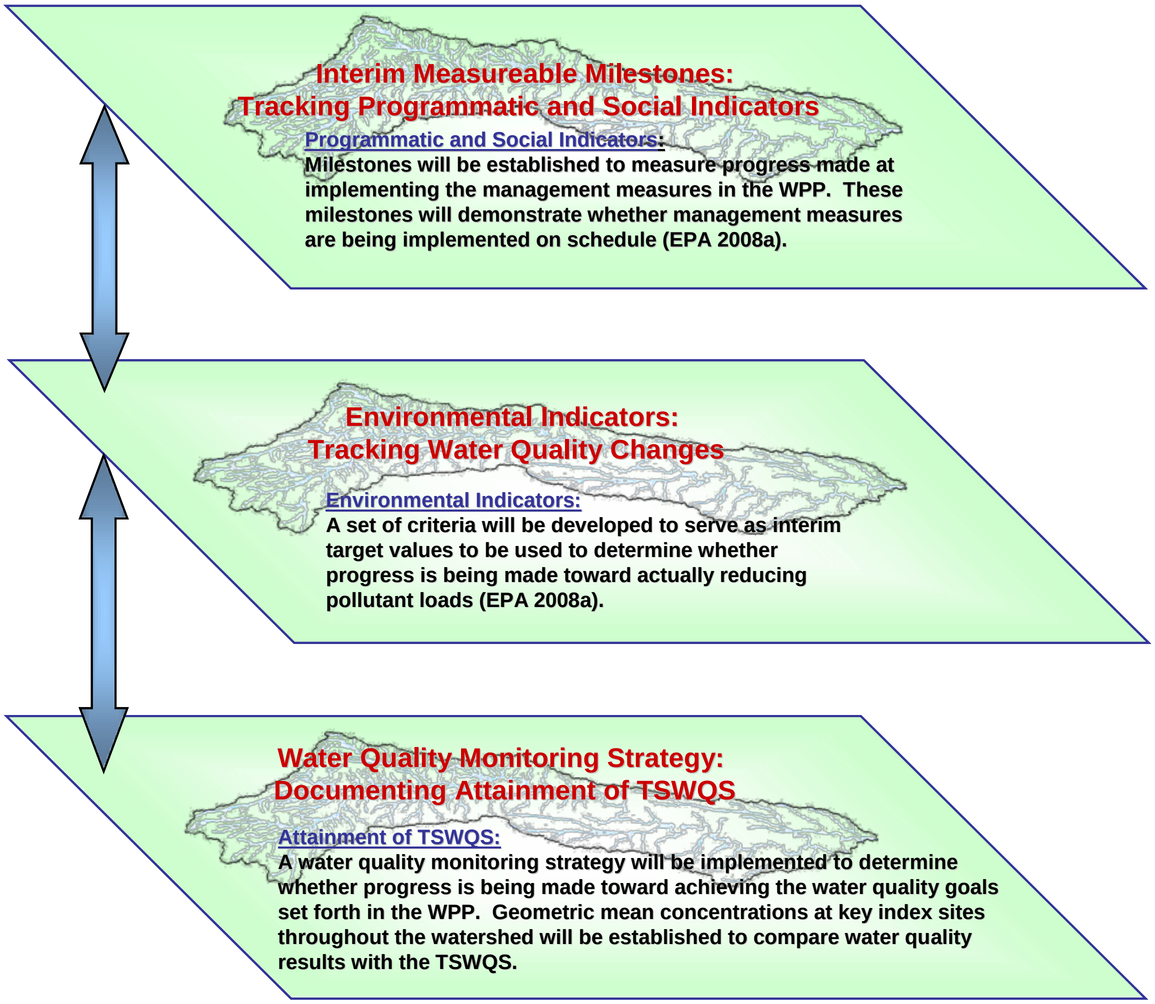
h. <u>Indicators</u> based on a set of criteria to be used to determine whether load reductions described in (b) are being achieved; and

i. <u>Monitoring component</u> to evaluate effectiveness of implementation measured against the established criteria described in (h).

9.1 Tracking the Water Quality Goal for the Leon River Watershed

As discussed in subsection 3.8, the primary goal of the Leon River WPP is to maintain an instream concentration of *E. coli* based on the long-term geometric mean of 206 cfu/100mL by lowering bacteria loads through voluntary management strategies and existing regulatory controls. Reduction goals have been estimated for each subwatershed, which range from 15 to 26 percent. Reaching these goals through implementation of management strategies outlined in Chapter 5 and the outreach and education activities summarized in Chapter 7 will also result in a corollary reduction of instream nutrient concentrations. A multi-tiered evaluation framework to track progress toward achieving these water quality goals in the Leon River watershed consists of the elements in Figure 9.1.

Figure 9.1 Measuring Progress Toward Achieving Water Quality Goals



Each tier of the evaluation framework is inter-related and co-dependent. Tracking progress and documenting results over the initial 10-year planning horizon (2011-2020) is critically important and will require technical and financial support to be achieved. Tracking individual programmatic and environmental indicators is the responsibility of a variety of different parties (e.g., TCEQ, BRA, TSSWCB, and Texas AgriLife Extension Service) depending on reporting cycles associated with various agencies. The WSC, with assistance from the watershed coordinator, has the primary responsibility for compiling data sources that can be used to report on specific progress in the Leon River watershed. The reporting cycle should be structured to release progress reports in June of even numbered years to follow the release of the Texas Integrated Report.

Milestones are defined as interim goals that can be tracked and quantified to demonstrate progress toward achieving the ultimate goal. Programmatic indicators measure the relative success achieved in implementing individual management strategies outlined in the WPP. Special attention will be given to tracking programmatic indicators at the subwatershed scale so that over time, adjustments can be made if necessary to ensure that the greatest level of effort possible is being targeted at key subwatersheds. Social indicators are measurements of the knowledge and changes in attitudes of the general public that result in positive action toward improving environmental conditions (Arroyo Colorado Watershed Partnership 2007). Environmental indicators are measurements of physical, chemical and/or biological attributes that can be used to gauge the health of the Leon River and its tributaries as the WPP is implemented (Arroyo Colorado Watershed Partnership 2007). Tracking and timely reporting of all three indicators will provide valuable information to stakeholders and water resource managers in making practical adjustments to implementing management strategies.

9.2 Interim Measurable Milestones

Table 9.1 provides a list of measurable milestones that can serve as programmatic and social indicators that will evolve out of the outreach and education strategies recommended in Table 7.3. Accomplishing these short-term milestones can also demonstrate the completion of organizational tasks and select management strategies that are critical to solidifying the functional responsibilities of the WSC and watershed coordinator.

Table 9.1 Short-term Targets for Programmatic and Social Indicators

Activity	Deliverable Responsibility	2011	2012	2013	2014	2015
Programmatic Indicators						
Workshops to promote participation in WQMP and AWEP programs	▪ TSSWCB, SWCDs, NRCS	3	3	3	3	3
Feral hog control workshops	▪ Texas AgriLife Extension Service ▪ Texas Wildlife Services	1	1	1	1	1
Presentation of RUAA report results to WSC and Leon River watershed stakeholders	▪ TCEQ	1				
Consider results of RUAA in establishing revised contact recreation water quality criterion for Leon River and tributaries	▪ TCEQ			1		
Reporting templates for communicating progress on Measureable Milestones, Environmental Indicators, and Monitoring Plan results	▪ Watershed Steering Committee ▪ Watershed Coordinator		1		1	
Training for landowners who lease land for hunting to strengthen contracts with hunters to include stewardship requirements	▪ Texas AgriLife Extension Service ▪ TPWD			1	1	1

Activity	Deliverable Responsibility	2011	2012	2013	2014	2015
Training and outreach meetings for OSSF owners in small communities and households located near creeks and rivers in the watershed	▪ TCEQ ▪ County ▪ Texas AgriLife Extension Service	3	3	3	3	3
Training and for inspectors, installers, and maintenance providers of septic systems	▪ TCEQ ▪ County ▪ Texas AgriLife Extension Service	2	2	2	2	2
TCEQ SSO training sessions provided to the municipalities in the Leon River watershed. Wastewater Treatment Operator and Wastewater Collection System Operator Training	▪ TCEQ ▪ City Mayors	1		1		
Absentee land owners mailing list for distribution of educational materials	▪ Watershed Coordinator ▪ Texas AgriLife Extension Service		1			
Landowner workshops to promote involvement in the preparation of wildlife management plans	▪ TPWD ▪ Texas AgriLife Extension Service			1		1
Informational materials to hunters and property owners who lease land for hunting	▪ County		1	1	1	1
DOPA training with new modules to fully incorporate bacteria sources and appropriate BMPs to reduce bacteria loading (i.e., Lone Star Healthy Streams Program – Dairy Cattle component)	▪ TCEQ ▪ Texas AgriLife Extension Service ▪ TSSWCB	1	1	1	1	1
Training workshops for municipal and county leadership on streambank and riparian protection and preparation of ordinances that can mitigate nonpoint source runoff and the Sports and Athletic Field Education program	▪ TCEQ ▪ Texas AgriLife Extension Service ▪ City Mayors	1		1		1
Annual workshop to provide technical support and recommendations to educate ranchers on proper grazing management BMPs (i.e., Lone Star Healthy Streams Program – Grazing Cattle component)	▪ Texas AgriLife Extension Service ▪ SWCDs ▪ NRCS ▪ TSSWCB		2	2	2	2

Activity	Deliverable Responsibility	2011	2012	2013	2014	2015
Campaign to promote the need and benefits of soil testing for proper nutrient management in agricultural areas	▪ Texas AgriLife Extension Service	1	1	1	1	1
Municipal training workshops for refining fats, oil grease ordinances; nutrient management; urban nonpoint source BMPs; stream corridor/riparian protection	▪ TCEQ ▪ Texas Municipal League ▪ City Mayors	1		1		
NEMO workshop	▪ Texas Sea Grant ▪ Texas AgriLife Extension Service	1		1		
Texas Watershed Steward Workshop	▪ Texas AgriLife Extension Service	1		1		1
Lone Star Healthy Steams for Dairy and Grazing Cattle Workshop	▪ Texas AgriLife Extension Service ▪ TSSWCB		1	1		
Placement of 20 watershed boundary signs; posting of 65 signs at bridges listing fines for illegal dumping or disposal of dead animals	▪ Watershed Coordinator ▪ County Judges				20	65
Social Indicators						
Hiring of an environmental officer in Hamilton and Comanche Counties modeled after the 2009 position filled by Coryell County	▪ County Judges		1	1		
Survey to estimate increase in number of watershed stakeholders participating in water quality restoration efforts	▪ Watershed Coordinator ▪ County Judges	1			1	
Series of surveys designed to estimate number of absentee landowners who implement some recommended form of stewardship activity	▪ Watershed Coordinator ▪ County Judges	1			1	
Survey to determine public support for stream setback ordinances in municipalities	▪ City Mayors					1

Table 9.2 provides a list of long-term programmatic indictors that are designed to demonstrate progress made in implementing management strategies over time. These milestones can be modified as the WPP adapts to the additional data and results of implementation.

Table 9.2 Long-term Measurable Milestones

Activity	Deliverable Responsibility	2011-2015	2016-2020
WSC meetings held 4 times per year to pursue funding and initiate implementation strategies	▪ Watershed Steering Committee ▪ Watershed Coordinator	15	15
Secure funding for Watershed Coordinator	▪ Watershed Steering Committee	2011	
E. coli permit limit and monitoring requirement for all WWTFs in Leon River watershed	▪ TCEQ ▪ City Mayors ▪ WWTF Operators	9	
Number of municipal ordinances approved to establish stream setbacks	▪ City Mayors	1	3
Number of compliance visits by each city per year to validate implementation of grease trap ordinance	▪ City Mayors	5	8
Number of WWTF upgrades	▪ City Mayors	2	1
Miles of sewer line replaced; number of lift stations repaired; Dollars spent on sewer collection system improvements	▪ City Mayors	40%	60%
Number of failing OSSFs geo-located, number of failing OSSFs repaired/replaced outside of municipalities	▪ County	20 per county	20 per county
Connection of OSSFs to municipal wastewater collection systems	▪ County	10 per city	5 per city
Dead animal disposal facilities feasibility report	▪ County		1
Number of farms with certified WQMPs	▪ SWCD ▪ TSSWCB	260	382
Annual increase in deer harvest tally by county	▪ Landowner ▪ TPWD (reporting only)	20 percent increase over 2008 harvest	10 percent increase over 2015 harvest
Continued support to landowners with Wildlife Management Plans and those participating in Wildlife Management Associations	▪ TPWD	NA	NA
Increase in county totals of hogs trapped or killed	▪ Texas AgriLife Extension Service ▪ TDA	15%	25%

9.2.1 Feral Hog Control Measurements

Feral hog control methods include trapping and hunting. The goal of each method is to reduce feral hog populations and limit the spread of these animals in order to decrease impacts to water quality and the surrounding environment. In order to determine the success of these control methods, stakeholders in Coryell, Comanche, and Hamilton Counties will need to coordinate their efforts through Texas Agrilife Extension Service's Texas Wildlife Damage Management Service (TWDMS). This agency protects the resources, property, and well-being of Texans from damages related to wildlife. TWDMS serves rural and urban areas with technical assistance, education, and direct control in wildlife damage management of both native wildlife and non-domestic animals. TWDMS resources include a variety of public education programs related to feral hog management that can be offered in each county. Texas AgriLife Extension Service has also developed an internet based reporting system that can provide stakeholders in the Leon River watershed the means to report reductions in local feral hog populations (Cathey, 2011).

9.3 Environmental Indicators to Measure Progress

The specific objective of establishing environmental indicators is to have a set of criteria that can be used over time to determine whether pollutant load reductions are actually being achieved. **In the case of the Leon River watershed, the primary environmental indicator that can be measured is the *E. coli* concentration at key monitoring stations.** Through the implementation of management strategies, instream *E. coli* concentrations are expected to decrease over time. By using interim targets defined by estimated *E. coli* concentrations, ongoing feedback can be provided to stakeholders allowing them to adjust implementation of management strategies both spatially and temporally. Table 9.3 provides a summary of recommended interim environmental indicators that stakeholders, the WSC and TCEQ can use as an index for tracking and reporting progress of changes in water quality over time. All the values presented in Table 9.3 represent *E. coli* concentrations as geometric means for each subwatershed. **It should be recognized that because there are so many variables (environmental, programmatic, social, and scientific) that influence the accuracy of measuring instream *E. coli* concentrations from year to year, all the geometric means shown in Table 9.3 should be used as benchmarks that may need adjustment in the future.** As demonstrations are made measuring instream *E. coli* concentrations from year to year, additional data collected will be used to demonstrate that nutrient and chlorophyll *a* levels are also diminishing over time. The WSC can couple these data analysis results with the documentation of the number of stream miles supporting their designated uses.

Table 9.3 demonstrates that by 2015 it is estimated that subwatershed 30 will not exceed the geometric mean *E. coli* concentration of 126 cfu/100mL and subwatershed 40 will not exceed a geometric mean concentration of 206 cfu/100mL. In 2020 subwatershed 60 will not exceed a geometric mean *E. coli* concentration of 206 cfu/100mL. After all the strategies are implemented, only subwatershed 20 will be slightly above the WPP goal of 206 cfu/100mL. The watershed coordinator should work with the WSC to set up a tracking and reporting method for calculating *E. coli* geometric means every two years using the previous seven years of ambient water quality data and comparing the results to the interim targets in Table 9.3. An interim milestone report to be submitted in April 2016 will represent the submittal of the 2016 Integrated Report which will coincide with results of the first five years of implementation in the Leon River watershed. The interim reduction targets in Table 9.3 show the estimated *E. coli* geometric mean concentration for each subwatershed that should be achieved by 2015 to report in the 2016 Texas Integrated Report results.

Table 9.3 Interim *E. coli* Targets for Evaluating Pollutant Load Reductions

	Proposed Evaluation Location	Relative Decrease in Concentration		*E. coli* Geometric Mean (Modeled Data)		
SW	**SWQM Station**	**2008-2015**	**2015-2020**	**2008**	**2015**	**2020**
10	11934	12	9	85	73	64
20	17379	35	17	301	266	248
30	11818	23	6	130	108	102
40	11817	26	15	229	203	188
50	18781	16	6	111	95	88
60	11808	43	19	253	210	191
70	11932	14	6	106	91	85
80	17547	14	5	93	79	73
90	11930	9	3	61	52	48
100	11929	9	4	62	53	49
110	18405	7	7	97	90	83
120	17501	14	5	93	79	74
130	11926	18	5	109	92	87
140	11925	16	5	99	83	79
150	11804	11	3	75	64	60

Note: Geometric mean at fecal coliform to *E. coli* ratio of 0.76
(red) not compliant at *E. coli* water quality goal of 206 org /100mL
(orange) not compliant at current *E. coli* water quality standard of 126 org/100mL

While specific interim targets have not been established for nutrients, sampling analysis results for nitrate nitrogen and orthophosphorus from ambient water quality monitoring will also be tracked and reported. The watershed coordinator should pay special attention to developing reporting tools that can effectively convey water quality changes to stakeholders. The environmental indicator for nutrient concerns such as nitrate nitrogen and orthophosphorus will be based on the TCEQ Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue, 2008 (RG-415) (TCEQ 2008d) for assessing streams using narrative criteria for nutrients, which is demonstrating that no more than 20 percent of the values in a seven-year monitoring period exceed the TCEQ screening level.

9.4 Long-term Water Quality Monitoring Strategy

The monitoring strategy outlined in this subsection will be implemented to verify that bacteria and nutrient reductions are occurring at the subwatershed scale and that the water quality goal set in this WPP is being achieved on schedule. The monitoring strategy will rely on the use of instream water quality data collected through routine sampling to ultimately demonstrate success at restoring the contact recreation use. Some aspects of the existing watershed-scale ambient water quality monitoring network will serve as the foundation of the long-term monitoring strategy. However, as currently implemented, the existing monitoring network cannot achieve all the objectives recommended to measure actual environmental progress. The main components of the long-term monitoring strategy that will provide the best data to measure progress of the environmental indicators outlined in subsection 9.3 are:

- Water quality monitoring stations located at an appropriate downstream site on each subwatershed;
- Flow monitoring;
- Effluent monitoring of *E. coli* for all WWTFs; and
- Special studies.

A partnership between the WSC, BRA, and TCEQ will be formalized to support the efficient acquisition, tracking and reporting of the Leon River watershed data to stakeholders and water resource managers. Developing reporting tools and a customized database to prepare results from TCEQ and BRA data sets will be another subtask for the watershed coordinator to take on.

9.4.1 Subwatershed Water Quality and Flow Monitoring

Table 9.4 summarizes the SWQM stations that will be used for evaluating short-term and long-term water quality conditions at the subwatershed scale to measure progress and provide critical data to guide decision-making through adaptive management. Figure 9.2 displays the locations of these SWQM stations. It is recommended that special attention be given to ensure that all future samples from SWQM stations be collected upstream of bridges to eliminate the influence that bird nesting under bridges may have on instream bacteria concentrations.

Table 9.4 BRA Monitoring Stations Selected for Measuring Progress in each Subwatershed

Subwatershed	Waterbody	2010 Assessment Unit ID	SWQM Station ID	USGS Gage Station	SWQM Station Description	County	Monitoring Frequency	
							Scheduled for 2011	Proposed in WPP[1]
10	Leon River	1221_07	11934	08099500	Leon River at US 67/ US 377 downstream Lake Proctor	Comanche	Monthly	Monthly
20	Walnut Creek	1221F_01	17379		Walnut Creek at FM 1476 south of Procter	Comanche	Quarterly	Monthly
30	Indian Creek	1221D_02	11818		Indian Creek at Comanche County Road 304 3.51 kilometers upstream of the confluence with the Leon River	Comanche	Quarterly	Monthly
30	Indian Creek	1221D_01	17542		Indian Creek at SH 36 east of Comanche	Comanche	Quarterly	Monthly
40	South Leon River	1221B_01	11817		South Leon River at SH 36 east of Gustine	Comanche	Quarterly	Monthly
50	Leon River	1221_05	18781		Leon River at Hamilton County Road 109	Hamilton	Monthly	Monthly
60	Resley Creek	1221A_01	11808		Resley Creek at Comanche County Road 394, 740 meters upstream of the confluence with the Leon River	Comanche	Quarterly	Monthly
70	Leon River	1221_05	11932	08100000	Leon River at US 281 north of Hamilton	Hamilton	Monthly	Monthly
80	Pecan Creek	1221C_01	17547		Pecan Creek at SH 22 east of Hamilton	Hamilton	Quarterly	Monthly
90	Leon River	1221_04	11930		Leon River at Hamilton County Road 431 southwest of Jonesboro	Hamilton	Monthly	Monthly
100	Leon River	1221_04	11929		Leon River at Coryell County Road 183 northeast of Levita	Coryell	Quarterly	Monthly
110	Plum Creek	Not Assessed	18405		Plum Creek at Coryell County Road 106 near Levita	Coryell	Monthly	Monthly

Subwatershed	Waterbody	2010 Assessment Unit ID	SWQM Station ID	USGS Gage Station	SWQM Station Description	County	Monitoring Frequency	
							Scheduled for 2011	Proposed in WPP[1]
120	Leon River	1221_03	17501		Leon River at Faunt Leroy Park immediately east of S 7th St, 452 meters south of College St upstream of US 84 in Gatesville	Coryell	Quarterly	Monthly
130	Leon River	1221_03	11926		Leon River at SH 36 southeast of Gatesville	Coryell	Quarterly	Monthly
140	Leon River	1221_03	11925		Leon River at FM 1829 southeast of North Fort Hood	Coryell	Quarterly	Monthly
150	Coryell Creek	Not assessed	11804		Coryell Creek at Coryell County Road 107	Coryell	Quarterly	Monthly

[1] Dependent on available funding

Figure 9.2 Proposed SWQM Stations for Tracking Status of Water Quality

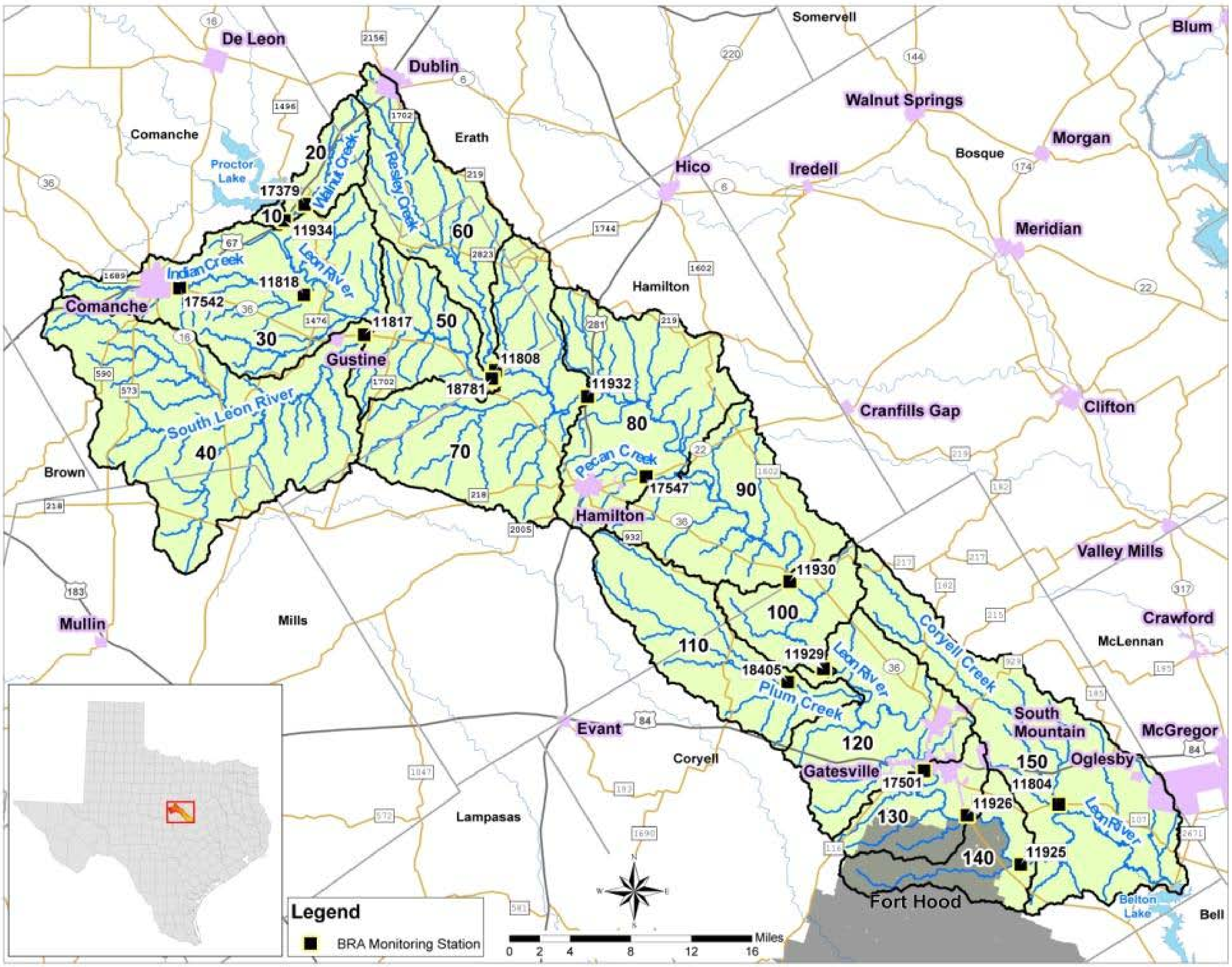


Table 9.5 provides a subset of key parameters collected through the routine monitoring program that will be utilized to demonstrate progress toward reducing *E. coli* and nutrient concentrations in subwatersheds over time.

Table 9.5 Water Quality Parameters Used for Measuring Progress

FIELD DATA
Dissolved Oxygen (mg/L)
Days Since Precipitation Event (days)
Specific Conductance
pH
Flow Severity
Instantaneous Stream Flow (cfs) (currently stream flow is only collected at existing USGS gage stations)
BACTERIA DATA
E. coli, mTec (#/100mL) (freshwater only)
CONVENTIONAL DATA (NUTRIENTS)
Nitrite + Nitrate-Nitrogen (mg/L as N)
Ammonia-Nitrogen Total (mg/L as N)
Orthophosphate Phosphorus (mg/L as P)
Total Phosphorus (mg/L as P)
Total Kjeldahl Nitrogen (mg/L as N)
Chlorophyll *a*, Spectrophotometric (µg/L)
Pheophytin-*a*, Spectrophotometric (µg/L)
DISSOLVED SOLIDS
Chlorides (mg/L)
Sulfates (mg/L)
Total Dissolved Solids

Source: TCEQ SWQM 2009 Data Management Reference Guide for Surface Water Quality. http://www.tceq.texas.gov/waterquality/data-management/dmrg_index.html

Monthly sampling will occur at all of the SWQM stations listed in Table 9.4. The availability of monthly bacteria and nutrient data along with daily precipitation and USGS flow data from the existing USGS gage stations will be valuable for estimating changes in pollutant loading over time.

This sampling commitment will occur throughout the implementation period. Every two years the WSC should present an analysis of the previous seven years of bacteria and nutrient data from each SWQM station for comparison to the interim targets provided in Table 9.3. Reporting bacteria and nutrient data analysis results every two years will also offer spatial and temporal trends that can aid in adjustments to targeting management strategies.

9.4.2 WWTF Effluent Monitoring

The WWTFs in the Leon River watershed will also contribute to the collection of data that can be used to measure progress. Until recently WWTFs in Texas were not required to monitor for bacteria, with the exception of facilities using an ultraviolet disinfection system. However, in July 2008, the TCEQ came to an agreement with the USEPA regarding bacterial monitoring requirements. As part of this agreement, a new rule was adopted on November 4, 2009, requiring that all TPDES domestic wastewater draft permits, for which Notice of Application and Preliminary Decision is published on or after January 1, 2010, be updated to include bacteria monitoring requirements at a frequency specified in the new regulation [30 Texas Administrative Code (TAC) §319.9(b)]. It is anticipated that by 2014, the nine TPDES-permitted WWTFs will receive a permit limit for *E. coli* and begin monitoring their effluent quality for *E. coli*. Currently, the cost to run an *E. coli* sample is estimated to be approximately $50. The total cost for a WWTF to monitor *E. coli* for a year represents only a small percentage of the annual cost of WWTF's monitoring requirements. The municipality focus group will coordinate with the WSC and watershed coordinator to develop a method that allows effluent monitoring results to be compiled in a manner that will assist in reporting annual progress of improvement in effluent quality from each WWTF over time.

9.4.3 Additional Recommendations for Monitoring to Measure Progress

In 2011 the BRA will be modifying their existing Clean Rivers Program monitoring stations in the Leon River watershed to more closely reflect the recommendations proposed in the WPP; however, funding for Clean Rivers Program is limited and the frequency of monitoring recommended cannot be achieved solely through the this program. The proposed monitoring stations listed in Table 9.4 would include two new SWQM stations added to the existing stations BRA currently collects water quality data from in the Leon River watershed. The combination of two additional SWQM stations and the conversion of sample collection from quarterly sampling to monthly sampling would require an estimated $60,000 in additional funding annually above the existing Clean Rivers Program funding BRA allocates to the Leon River watershed. The additional funding would be necessary to monitor all sites at the recommended frequency in Table 9.4 for the parameters indicated in table 9.5.

Throughout development of the Leon River WPP, stakeholders offered various recommendations for additional data collection efforts that could be beneficial to addressing uncertainty issues, targeting management strategies, and measuring progress. Some of the monitoring recommendations made have already been undertaken as part of special projects occurring in the Leon River watershed. Two recent TSSWCB monitoring projects conducted in the Leon River watershed could provide some additional data from which to measure progress or address uncertainty issues.

The main objectives of the first project, <u>Fate and Transport of *E. coli* in Rural Texas Landscapes and Streams</u>, are to identify, characterize, and quantify *E. coli* loads resulting from various sources in an impaired watershed, monitor survival, growth, re-growth, and die-off of *E. coli* under different environmental conditions, monitor re-suspension of *E. coli* in streams, and educate stakeholders by disseminating qualitative and quantitative information acquired in this monitoring and demonstration project. Information gleaned from this project will provide much needed knowledge relevant to modeling bacterial life cycles, their ability to survive and regenerate, and their impacts on water quality (TSSWCB 2009b).

This project is supported through a CWA §319(h) grant from TSSWCB and USEPA to AgriLife Research This project is scheduled for completion in July 2012 http://www.tsswcb.texas.gov/managementprogram/ftecoli.

The second project is titled Monitoring and Educational Programs Focused on Bacteria and Nutrient Runoff on Dairy Operations in the Leon Watershed: The overall objective of the project was to collect watershed-specific data in an effort to quantify the major sources of *E. coli* bacteria on dairy operations. Information and data collected during the monitoring phase were used in the development of an educational program focusing on BMPs to reduce the movement of *E. coli* bacteria and nutrients to surface waters. The educational program equips dairy producers with the knowledge and understanding needed to reduce the possibility that their operations contribute bacteria and nutrients to the Leon River. The monitoring and educational programs were designed to coordinate with the development of a TMDL I-Plan or a WPP, and provide information and assistance for future watershed planning needs. This project supports development of the Lone Star Healthy Streams Dairy Cattle component. This project is supported through a CWA §319(h) grant from TSSWCB and USEPA to Texas AgriLife Extension Service (TSSWCB 2009c). This project is scheduled for completion in August 2010 http://www.tsswcb.texas.gov/managementprogram/leonecoli.

Stakeholders recommended other data collection projects for consideration, most of which are aimed at reducing the uncertainty inherent in understanding the fate and transport of bacteria and providing information that will improve the targeting of management strategies to have the most beneficial effect. These data collection recommendations are summarized in Table 9.6.

Table 9.6 Stakeholder Recommended Data Collection Efforts to Support Adaptive Management

Monitoring Project	Objective	Duration	Project Initiation Lead	Estimated Cost
Bacterial Source Tracking (Initiated September 2010)	Utilize library dependent methods at a subwatershed scale to improve targeting of management strategies; Focus on evaluating human sources (OSSFs, collection systems), feral hogs, and cattle. https://www.tsswcb.texas.gov/managementprogram/lamleonbst	12 month sampling effort to include normal flow conditions and at least two wet weather events at 15 sites.	TSSWCB	$250,000
Illicit Discharge Inventory	Conduct a survey in each municipality to geo-locate and measure flow and concentration of illicit discharges within city limits.	Collect discharge samples to measure bacteria and nutrient concentrations and flow under normal or dry conditions; map all outfalls.	Municipality Focus Group	$350,000
Assessment of Leon River Segment Classification	Assess the biologic, hydrologic and geophysical features of the Leon River to determine if the 190 mile segment should be divided into two separate segments for assessment purposes.	24 month sampling and data collection effort.	TCEQ, BRA	$150,000

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Appendix A
Public Participation Process: Supporting Materials

TCEQ Leon River Bacteria TMDL Advisory Group

First Name	Last Name	Affiliation
Jay	Bragg	Brazos River Authority
Jennifer	Bronson	Texas Parks and Wildlife Department
Bruce	Butscher	City of Temple
David	Carrothers	City of Dublin
The Honorable Dickie	Clary	Hamilton County Commissioner
The Honorable Richard	Cortese	Bell County Commissioner
John	Cowan	Texas Association of Dairymen
Hall	DeBusk	Hamilton-Coryell Soil and Water Conservation District #506
David	DeJong	Texas Association of Dairymen
Richard	Eyster	Texas Department of Agriculture
Tom	Gerik	Texas AgriLife Research at Blackland Research and Extension Center
Daren	Harmel	USDA Agricultural Research Service
Rusty	Harris	Texas Farm Bureau
Ronnie	Harris	City of Hamilton
Royce	Lubke	Cattle Rancher
The Honorable Randy	Mills	Hamilton County Judge
Norman	Mullin	Enviro-Ag Engineering
Frank	Sprague	Hamilton County Farm Bureau
Genell	Stuteville	City of Gustine
Fred	Weaver	City of Gatesville
Aaron	Wendt	Texas State Soil and Water Conservation Board

LEON RIVER WPP FOCUS GROUP ROSTERS

Municipal Focus Group

Job Title	First Name	Last Name	City
Public Works Director	Darwin	Dickerson	City of Comanche
City Secretary	Bill	Flannery	City of Comanche
City Administrator	Bill	Funderburk	City of Hamilton
Public Works Director	Cory	James	City of Dublin
Director	Gary	Lacy	Upper Leon River Municipal Water District
Assistant City Manager	Luis	Lobo	City of Gatesville
City Manager	Roger	Mumby	City of Gatesville
City Consultant	Marvin	Reavis	City of Gustine
WWTF Operator	Clint	Splindor	City of Comanche
Water Program Manager	Rick	Young	Fort Hood

Designated Focus Group Spokesperson and Member of Working Committee

County Government Focus Group

Job Title	First Name	Last Name	County
Judge	James	Arthur	Comanche
Commissioner	Sherman	Sides	Comanche, Pct. 3
Commissioner	Kenneth	Feist	Comanche, Pct. 2
Commissioner	Jimmy	Johnson	Comanche, Pct. 4
Commissioner	Don	Jones	Coryell, Pct.3
Commissioner	Jack	Wall	Coryell, Pct. 1
Judge	John	Firth	Coryell
County Attorney	Brandon	Belt	Coryell
Representative	Sid	Miller	District 59, Texas House of Representatives
Judge	Randy	Mills	Hamilton
Commissioner	Dickie	Clary	Hamilton, Pct. 4
Judge	Tab	Thompson	Erath

Designated Focus Group Spokesperson and Member of Working Committee

Farm/Ranch Focus Group

First Name	Last Name	County
Larry	Adams	Comanche
Juanita	Anders	Hamilton
Donnie	Bramlett	Erath
Monte	Carmichael	Comanche
Mike	Coward	Coryell
Hall J.	DeBusk[1]	Coryell
Ginger	Dudley	Comanche
Tommy	Elliott	Comanche
Charles	Graham	Coryell
Rusty	Harris	Hamilton
Kenneth	Harris	Hamilton
JL	Harris	Hamilton
William	Hopper	Comanche
Mike	Horton	Coryell
Lloyd	Huggins	Hamilton
Doug	Ischy	Hamilton
Marti	Ischy	Hamilton
Steven	Jones	Comanche
Troy	Latham	Coryell
John	Lee	Coryell
Royce	Lubke	Comanche
Dennis	Luedtke	Coryell
Rick	Mathis	Erath
David	Mayfield	Erath
Eric	McCorkle	Coryell
Joe	Moore	Comanche
Robert	Scott	Erath
Jerry	Singleton	Erath
Frank	Sprague	Hamilton
Tim	Stallings	Comanche
Rodney	Stephens	Comanche
Neil	Walter	Coryell
Lillian	Wilhelm	Hamilton

Designated Focus Group Spokesperson and Member of Working Committee

[1] SWCD Member

Dairy Focus Group

First Name	Last Name	County
Glenda	DeGroot	Comanche
Rinke	DeGroot	Comanche
Wayne	Moerman	Comanche
Feije	Terpstra	Comanche
Damon	Chumney	Coryell
Frans	Beukeboom	Erath
Gerard	Hoekman	Erath
Hinke	Hoekman	Erath
Donna	Riley	Erath
Joe	Riley	Erath
Frank	Volleman	Comanche
Marcel	Volleman	Erath
John	Cowan	Texas Association of Dairymen
Darren	Turley	Texas Association of Dairymen

Designated Focus Group Spokesperson and Member of Working Committee

Large Lot Landowners Focus Group

First	Last	County
Gerald	Burns	Comanche
Robert	Chaison	Comanche
Ken	Harvick	Comanche
Gayle	Jones	Comanche
Larry	Kimmell	Comanche
James	Lester	Comanche
Charles	Levisay	Comanche
Glen	Levisay	Comanche
John	Luker	Comanche
Rex	Plumber	Comanche
Linda	Rippetoe	Comanche
C.D.	Seago	Comanche
Deloris	Seago	Comanche
Carolyn	Smith	Comanche
Carol	Teich	Comanche
Mitchell	Walker	Comanche
Jim	Kenton	Hamilton
Sheron	Kenton	Hamilton
Gene	Gilbreath	Erath
Wayne	Sears	Erath
Jeff	Stark	Erath
John	Davis	Hamilton
Jack	Dragoo	Hamilton
Roy	Newsom	Hamilton
Don	Strieber	Coryell

Designated Focus Group Spokesperson and Member of Working Committee

Leon River WPP Working Committee Members

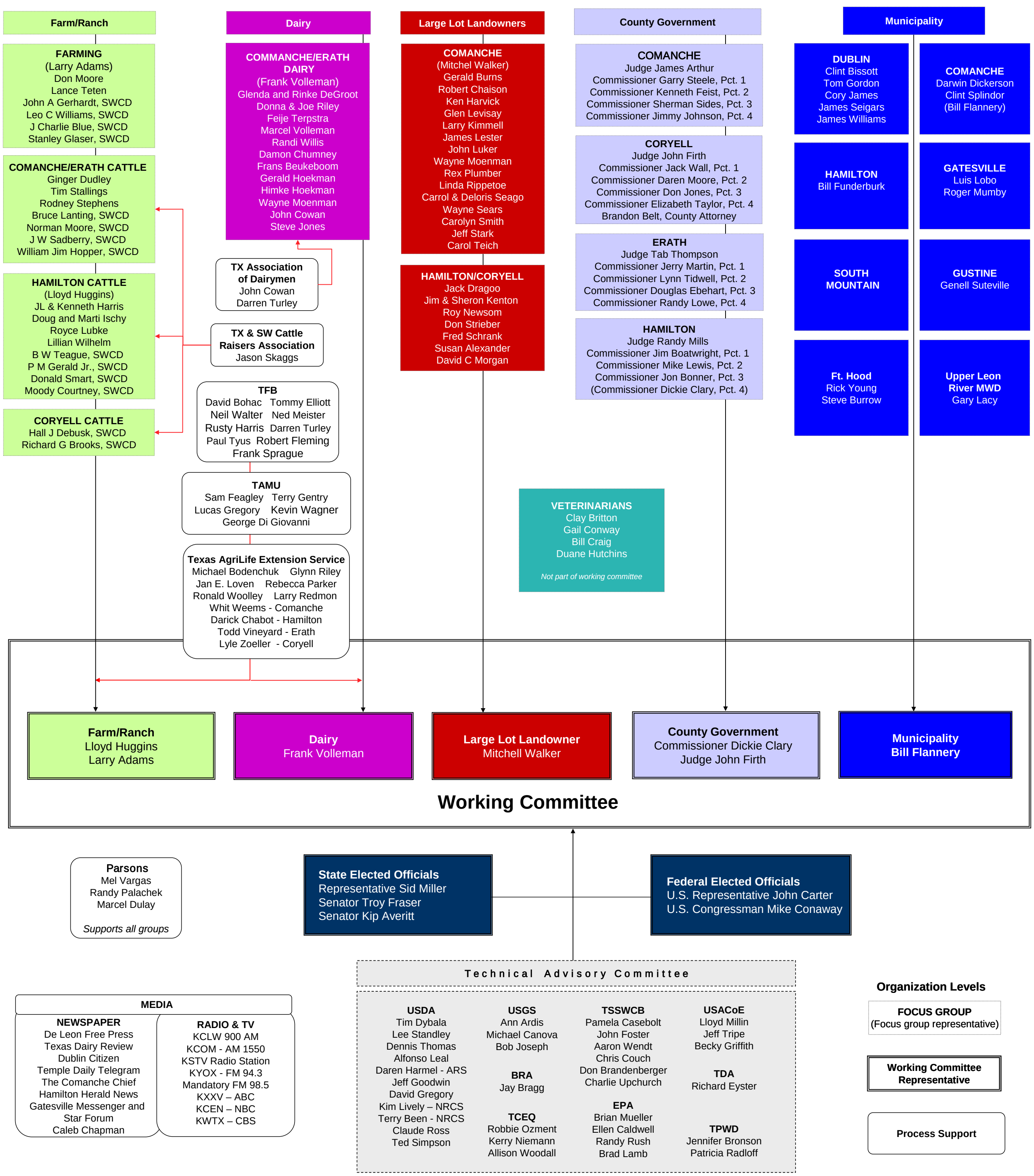
First	Last	County	Focus Group
Larry	Adams	Comanche	Farm/Ranch (alternate)
Lloyd	Huggins	Hamilton	Farm/Ranch
Bill	Flannery	City of Comanche	Municipality
Commissioner Dickie	Clary	Hamilton	County Government
Frank	Volleman	Comanche	Dairy
Judge John	Firth	Coryell	County Government
Mitchell	Walker	Comanche	Large Lot Landowners
Rodney	Stephens	Comanche	Farm/Ranch

Leon River WPP Technical Advisory Group

First	Last	Agency
Jay	Bragg	Brazos River Authority
Joe	McFarland	Leon Bosque RC&D
Susan	Baggett	NRCS – Temple HQ
Tim	Dybala	NRCS – Temple WRAT
Kim	Lively	NRCS
Terry	Been	NRCS – Brownwood Field Office
Cody	Bauman	NRCS – Comanche Field Office
Al	Leal	NRCS – Zone 5 Office – Weatherford Office
Lee	Standley	NRCS – Granbury
Jill	Csekitz	TCEQ Surface Water Quality Monitoring Team
Charles	Maguire	TCEQ
Allison	Woodall	TCEQ Clean Rivers Program
Kerry	Niemann	TCEQ - NPS
Robert	Ozment	TCEQ Field Operations Division - Waco
Clyde	Bohmfalk	TCEQ Water Quality Planning Division
Lori	Hamilton	TCEQ Water Quality Standards
Debbie	Miller	TCEQ Water Quality Standards
Terry	Gentry	Texas AgriLife Extension – College Station
Whit	Weems	Texas AgriLife Extension – Comanche County
Lyle	Zoeller	Texas AgriLife Extension – Coryell County
Todd	Vineyard	Texas AgriLife Extension – Erath County
Darick	Chabot	Texas AgriLife Extension – Hamilton County
Rebecca	Parker	Texas AgriLife Extension Service
Larry	Redmon	Texas AgriLife Extension Service
Ronald	Woolley	Texas AgriLife Extension Service
Dennis	Hoffman	Texas AgriLife Research
Richard	Eyster	Texas Department of Agriculture
Beth	Bendik	Texas Parks & Wildlife Department
Jennifer	Bronson	Texas Parks & Wildlife Department

First	Last	Agency
Ryan	McGillicuddy	Texas Parks & Wildlife Department
Patricia	Radloff	Texas Parks & Wildlife Department
Kevin	Wagner	Texas Water Resources Institute
Glynn	Riley	Texas Wildlife Services – Brownwood District
Jan	Loven	Texas Wildlife Services – Ft. Worth District
Pamela	Casebolt	TSSWCB
Aaron	Wendt	TSSWCB
Steven	Jones	TSSWCB – Dublin Regional Office
Glynn	Riley	USDA - APHIS Wildlife Service
Michael	Bodenchuk	USDA - APHIS Wildlife Services
Jan E.	Loven	USDA - APHIS Wildlife Services
Daren	Harmel	USDA-ARS
Henry	Brewer	USEPA Region 6
Brad	Lamb	USEPA Region 6
Randall	Rush	USEPA Region 6
Bob	Joseph	USGS
George	Ozuna	USGS

Leon River WPP Public Participation Organization Chart



Appendix B
Focus Group Perspectives

FOCUS GROUPS' PERSPECTIVES

The following narrative summaries were prepared to present the desires, concerns, issues, recommendations, challenges, and support stakeholders expressed during the development of this Watershed Protection Plan (WPP). It provides the reader with a synopsis of the key comments made during focus groups sessions, individual interviews, and working committee meetings as well as numerous informal communications organized according to each particular stakeholder group. Stakeholder groups are farm/ranch operators, dairies, municipal leaders, county leaders, and non-production land owners. The following categories convey the elements that stakeholders expressed as most important:

- Desires: the personal wishes or goals the group desires with regard to their lives, businesses, or employment.
- Problem: the concerns each group may have with regard to addressing water quality in the watershed. It discusses how water quality may or may not affect them and how possible action may hinder achievement of their desires.
- No action: the belief of what may occur to their livelihood if no action to improve water quality occurs as well as what may occur to their livelihood if actions not supported by stakeholders are implemented.
- Actions: a description of the actions stakeholders recommend to implement.
- Barriers: a description of challenges that will make implementation of any action to improve water quality difficult.
- Resources: a description of existing resources available to stakeholders to implement projects.

Each of these statements were conveyed by numerous individuals from each group and vetted through the working committee. They are general ideas that mostly capture the sentiments of many of those who participated in the development of this WPP. There may be items that are not captured or items that are not discussed to the degree some stakeholders may wish. Regardless, it is provided herein as background information for those reading the WPP to understand the context for which this WPP was prepared.

County Government Focus Group Perspectives

Some of the major responsibilities of county governments include building and maintaining roads; constructing and operating jails; operating the judicial system; law enforcement; conducting elections, and provide health and social services to many poor county residents. County governments also play an increasingly vital role in the economic development of their local areas. All these efforts work together to provide residents a high quality of life for the taxes and fees they pay. As a lofty, but valid partnership goal, county, state, and federal governments should seek to find appropriate solutions to local environmental issues that ultimately protect the social, financial, and environmental well being of all people. In such, the social and economic aspects of any environmental issue must be approached from the standpoint of a perceived good for all parties and balanced against cost.

County officials have come to understand two major concerns of having to reduce environmental contaminates in watersheds. First, county tax bases do not provide sufficient revenue to fund the ongoing costs of programs designed to improve bacteria concentrations in local streams. It is specifically noted by county officials that any water quality improvement initiatives are “destined for failure” without an appropriate funding source to pay for implementing and sustaining a program in subsequent years. Local taxpayers are opposed to increased taxation to fund programs that provide limited local benefits while serving political agendas or powerful special interests. The other major concern is that any unnecessary regulations will likely place financial hardships on citizens, infringe on the freedom that citizens feel they have to use their private property as they see fit, and essentially lose their ability to pursue life, liberty, and happiness on their private property. Increased costs and reduced freedoms are a hindrance to economic development, financial prosperity, and individual lifestyles.

County officials have come to understand many of the social and financial implications of not addressing an “impaired” water body within their boundaries. Officials understand that an “impaired” river can be perceived by citizens and visitors as being unsafe for use. This implication can potentially damage tourism, business, and commerce as well as reduce property values. These are outcomes that all officials seek to avoid. County citizens feel they are good stewards of natural resources. They have become resistant to government intervention in their lives, but will do the “right thing” when it comes to how they use their land in an attempt to keep government at arm’s length. If citizens do not accept responsibility for addressing bacteria in their local streams, to some reasonable level of protection, then history teaches us that the state and federal government will eventually impose its own prescription for the way people should work and live in the watershed.

Officials agree that high levels of bacteria in rivers and streams may pose a potential risk of water-borne diseases that could adversely affect people who come into contact with the water. Even though there is limited contact recreation activity in the Leon River and, therefore, unlikely that citizens can be exposed to contaminated water, county officials are open to supporting certain measures to control sources of bacteria pollution as long as they are: authorized by law; affordable; based on practical evidence; have a practical, tangible and beneficial outcome; considered reasonable and supported by citizens; and voluntary. Only when voluntary initiatives have been exhausted should government mandate actions.

County officials believe that significant progress has already been made in improving water quality in local rivers and streams in recent decades. Thirty years ago, there were few if any environmental regulations being imposed on county citizens. Today, municipal waste water treatment facilities, Concentrated Animal Feeding Operations (CAFO), and On-site Septic Facilities (OSSF) must all operate under strict environmental regulations to significantly reduce or eliminate bacteria and other environmental contaminates from being released into local watersheds. Counties currently serve as TCEQ's authorized agents in matters concerning the regulation and permitting of OSSFs. The regulation and permitting of OSSFs requires that all new septic systems and repairs to existing septic systems, meet certain minimum requirements and that these systems are inspected by a licensed inspector. These permitting regulations and inspections have undoubtedly improved water quality in recent years and will continue to improve water quality by ensuring that all new OSSFs and old upgraded OSSFs are properly installed and functioning effectively.

County officials believe that local citizens should be involved in all aspects of developing, deciding, and implementing any new bacteria reduction activities in the watershed. Key elements of a well-focused WPP should include ongoing education efforts on important water quality issues; informing citizens on the types of voluntary best management practices (BMP); educating people on the potential positive effects of BMPs, and the future negative ramifications if bacteria levels remain above state standards.

Asking for more than what is suggested above will be a challenge because of limited financial resources, questionable standards, and uncontrollable bacteria sources. Counties in the Leon River watershed have many citizens below the poverty rate, and businesses are sensitive to the regional economy, indicating that this area will be sensitive to how projects are funded. The Texas Water Development Board designated Coryell County as an Economically Distressed Area, with the other counties in the watershed facing similar economic conditions. Since the 1980s, many federal and state services have been mandated and delegated to county government, which lengthens the list of services counties must provide as they respond to the ever-changing needs of Texas residents. However, seldom has the funding been provided to pay for these mandated services.

There is concern among county officials about the evidence used to validate state water quality standards, which are adopted to safeguard the public from health risks. These perceived risks are not based on any local evidence that proves the water in the Leon River is actually a health risk to people, but are based on literature values gleaned from epidemiology studies conducted in areas with different circumstances and environmental conditions. The Leon River has been listed as “impaired” and has been documented to have elevated levels of bacteria since before the year 2000, but there is no local or state health evidence indicating that people have ever become ill from contact with the river water. It is doubtful that the medical community would be silent if they perceived the water quality in the Leon River to be a threat to human health. Therefore, county officials will find it difficult to implement any further water quality improvement initiatives without evidence that a real and present health risk actually exists.

Bacteria Source Tracking (BST) data have revealed that wild animals are the major contributor of bacteria in the Leon River by more than a 2:1 margin over any other source. Stakeholders believe the number of wild animals inhabiting Leon River watersheds continues to increase; therefore, since all point sources and OSSF installations and repairs are now strictly regulated, the bacteria source with the greatest potential to increase its bacteria contributions are wild animals. County citizens should not be required to bear the brunt of implementing any costly bacteria reduction measures to offset increasing bacteria contributions from wild animals. Counties recommend that the site-specific narrative provisions of the Texas State Water Quality Standards be applied to the Leon River based on the unavoidably high contribution of bacteria from wild animals as they are considered uncontrollable sources of bacteria. In particular, feral hogs, a large wild mammal that congregates near water bodies, have become a real nuisance in Texas and could be a significant source of bacteria. County officials and citizens agree that bacteria contributions in the Leon River will not be significantly reduced until feral hog populations are managed and controlled.

There are recent trends in rural counties that indicate a change in the way the land is used. Hamilton, Comanche, Erath, and Coryell Counties are primarily rural in geographic makeup. Their economy and citizenry have historically been heavily involved in agricultural production enterprises. Cattle and livestock operations were utilizing a large majority of land surfaces. Today, many farms and ranches have been passed down to younger generations who are often dividing their properties and selling off smaller tracts of land to people retiring from urban areas. Many new landowners are converting their land to wildlife use, which has potential to positively affect water quality in our rivers and streams. As a result, environmental concerns associated with agricultural operations in these counties have decreased in recent years. This trend will likely continue as more people retire to country living and more land is converted from agricultural use to wildlife use.

Furthermore, as land use continues to shift from production agricultural enterprises to wildlife uses, short grasses in cattle grazing pastures grow into lush habitats suitable to sustain increasing numbers of wild animals. These tall grasses tend to reduce water runoff and soil erosion and provide filtration to catch various types of water contaminates, including bacteria, before entering a stream. As livestock numbers continue to decline, so will the amount of manure that is deposited on land surfaces, resulting in significantly reduced bacteria loadings from cattle operations and other livestock production enterprises. The only sources of environmental contaminates that pose a continuing threat to water quality degradation are those related to the routine activities of mankind and the bacteria contributions from wild animals. Counties acknowledge that both of these sources are extremely difficult to effectively regulate or control.

County officials acknowledge that some degree of environmental regulation is necessary to protect people, property, and other natural resources from the negative impact of activities associated with unscrupulous people and businesses. As grass roots representatives of the people, county officials understand that there is a delicate balance between necessary regulatory actions and the unnecessary infringement of personal property rights. Finding that delicate balance is difficult, but not impossible.

The major perspectives of the County Government Focus Group are summarized below.

Watershed goals are:

- Pleasant living environment
- Economic growth

- Safe place for people to recreate

Imposing water quality rules may lead to the following:

- Loss of local control in watershed where the federal government will tell local citizens and governments what to do
- Excessive fines and litigation
- Loss of liberties
- Having to take action that is not justified

Potential causes of poor water quality could be:

- Failure of septic systems leading to overflows into creeks
- Direct waste discharges from feral hogs and other invasive species and dead animals
- Illegal dumping of waste (septic haulers)

If water quality is a problem and if nothing can be done, this may induce:

- Human health risks
- Property value loss
- Poor perception of the region leading to economic losses in tourism and business
- Animosity between citizens

Possible actions to improve water quality:

- Establish rules based on science appropriate to the region using data collected from the watershed
- Introduce incentives and voluntary programs to improve water quality
- Take local control of strategies
- Provide public education on pollution
- Enhance the activities of Texas AgriLife Extension Service agents (provide more funding)
- Find ways to better enforce ordinances that address pollution (haulers)
- Provide a dumpster service for dead animal pickup
- Increase trapper funding and address feral hogs
- Be responsive to citizen complaints of pollution discharges

Barriers to implementing projects are:

- Bounties to control feral hogs would be difficult to track
- Local landfill for waste disposal is costly and difficult to permit
- Wildlife is difficult to control
- Difficult to enforce rules on septic haulers

- Minimal staff to conduct septic tank inspections
- County funds are already stretched and staff is limited
- Tax base is minimal and citizens have limited ability to pay
- Regulatory constraints, jurisdiction, and justification

Existing resources to help improve water quality:

- County Extension Agents
- Existing county trapper to address feral hogs
- State dollars to support county activities
- Political will to improve the environment
- Local citizens
- Current trends in land use moving away from agricultural

Dairy Focus Group Perspectives

Dairy farming is a family business for many farmers in the region, but it is also a way of life that many wish to maintain and pass onto future generations. The dairy industry in Comanche, Erath, and Hamilton Counties were productive and growing prior to the economic recession and, although they are currently struggling through it, they have been and probably will continue to play an important role in the regional economy. Dairies in the region over the past two decades have made significant investments and sacrifices as they strive for sustained growth and a sense of permanence. Therefore, it is important for dairy farmers in the Leon River watershed that this WPP support their desire to have a business environment that does not hinder their growth, which ultimately affects the economy of the region as a whole. The desired action from the WPP process is to establish a fair program that would carefully consider what practices are put into place based on a better understanding of contributing sources and stewardship practices of dairy operations. Bacteria reduction strategies implemented by all stakeholders should be relatively equal in the Leon River watershed; however, this should be accomplished in a way that does not have unreasonable adverse effects on dairy businesses. It is believed that if it is necessary to expend additional funds, dairy operations should receive some kind of assistance.

The major concern is that the dairy industry, and consequently its way of life, is threatened from unfair legal repercussions, uncertainty in regulations, large financial risks, or other business obstructions. Fundamental parts of production in the dairy industry are land and water where unfair regulations threaten their reasonable sovereignty over them, which would have a negative impact to sustained growth. From their experience, a TMDL brings with it additional regulatory burdens that have already put other dairies in a neighboring watershed out of business because of legal battles over individual permits. There were no assurances during development of the TMDL that this would not occur in this watershed. Second, investigators identified livestock and livestock operations as contributors of bacteria that have negatively affected the public perception of dairy farmers when in actuality they are working hard to be good stewards of the land. Finally, there is concern that BST data identify many other contributing sources apart from cattle, which are not regulated, and by only going after regulated entities, it puts an unfair burden on dairies to shoulder the majority of the bacteria load reduction when a major percentage of bacteria sources are uncontrollable.

Dairy farmers know that a poor environment can have negative consequences to the long-term viability of the dairy industry and for the well-being of their community. Dairy farms operate with TCEQ-issued permits and, although one may think that dairies could be pollutant sources because of their high density of cows, the legally required environmental protections in place actually result in no waste leaving a dairy farm. If excessive bacteria are found in creeks downstream of dairy facilities or land application fields, those facilities could be unrightfully targeted as the major contributors, which would impose legal fines or other repercussions that would increase costs. In addition, without a high certainty of the true sources, dairies may continue to be isolated as the problem, leading to finger pointing and animosity among those in the community. The production of dairy products results in manure as a by-product that, if not properly managed, may contribute bacteria to the environment—this seldom occurs as manure is a valued resource for crop production. Dairy farmers realize that if they do not operate properly there is risk of unsafe products for human consumption and even unsafe working conditions for employees. All these scenarios are undesirable to dairy farmers. Finger pointing, litigation, fines, environmental contamination, unsafe products, and unsafe working conditions could put a dairy out of business.

Dairy operators understand that it is beneficial to keep creeks and rivers in the region as free of bacteria as much as possible for all these reasons above. As a result, dairy farmers follow all regulations imposed by TCEQ permits and implement various management practices to protect the environment, ensure proper stewardship of land and water resources, and minimize environmental effects of certain elements of production. Manure, which is associated with bacteria pollutants, is actually a resource that is used in agriculture as fertilizer. To those in this industry it is a precious resource and is carefully managed so it is not wasted. A positive public perception of dairy farmers and the dairy industry are also integral to continuing profitability as they are linked to many aspects of society and the economy. Dairy farmers throughout the region continue to work to reduce the negative perceptions that have evolved from the bacteria TMDL. The WPP is seen by dairy farmers as a way to ensure a rational, long-term approach to addressing bacteria problems regardless of the sources and an opportunity to avoid the counterproductive route of litigation, which was used in the Bosque River watershed and is having a spill over effect in the Leon River watershed.

Excluding extreme weather events, a properly functioning dairy operation would not contribute bacteria to a creek. The difficulty is that many dairy farmers are already doing what is required by law, and anything different beyond what is already required by their permit would be a challenge. Some have gone beyond their permits at their own cost; however, this was done to avoid future problems and was done during better economic times. From their perspective, given the uncertainty of the sources, having to do anything beyond what is required by permits would be a direct business expense affecting profitability and providing little perceivable environmental gain. The gain would be minimal as they do not experience any negative consequence from water quality conditions in the region, which in their view brings into question the validity of the bacteria standard for contact recreation and whether it is even appropriate in most creeks and rivers in the Leon River watershed. For this reason, deciding on whether it is productive to make dairy farmers go beyond what is already mandated as part of their general permit versus targeting other areas and sources in the region needs to be evaluated.

Dairy farming is an old industry and with it comes great knowledge and experience with sustainable practices, manure management, and well-established support groups (fellow dairy farmers, Texas Association of Dairymen, and various agencies). American dairy farmers also have access to financial aid and other forms of government support. The dairy farming community is well-established in the region, and many dairy farmers regularly meet to share ideas, knowledge, and other information. In response to the complex and stringent regulations that dairy operations must follow, dairymen work with TCEQ compliance officers and engineering consultants on a regular basis to continue improving their equipment, operations, maintenance, and management approaches. Finally, the Texas AgriLife Extension Service and Texas AgriLife Research also provide education and training, and assist producers by conducting research in bacteria and nutrient loadings, new technologies, and crop management.

The desire of dairy farmers is for their industry to prosper and be perceived as a wholesome family business where they contribute to protecting the land and water. The major concerns are unreasonable regulations that could impose unbearable costs that could put some dairies out of business and that the industry, because they are permitted and manage manure, is unrightfully targeted. Dairy farmers understand that if poor water quality remains, it is likely that animosity toward the dairy industry could result and that state and federal legal actions would be costly to dairy farmers, subsequently diminishing production with regional economic losses. Dairy farmers seek to provide input to the WPP suggesting ways they can demonstrate their compliance with regulations. They also want to promote practical ways to enhance manure management practices, cost effectively fund projects, and provide additional education. The challenge remains to reconcile the lack of evidence in human harm, current standards, and what is justifiable to implement. The dairy industry will continue to utilize the resources available to them to support any actions they pursue. The major perspectives of the Dairy Focus Group are summarized below.

Poor water quality may lead to:

- economic losses from litigation, implementing unreasonable measures, and uncertainty in regulations
- placing blame on the dairy industry as being principal contributors

Causes of water quality impacts resulting from dairy farming operations could be from:

- effluent from lagoons overflowing (only during extreme rainfall events)
- wash off from waste application fields during rain events where manure is not incorporated into the soil
- over application of manure on land application fields

Possible actions to enhance water quality:

- as part of the Dairy Outreach Program Area, enhance dairy farmer training modules to address bacteria issues
- help older farms improve their systems
- rapid integration of manure into soil
- wildlife management near creeks
- invasive species control (feral hogs)
- incentives and financial assistance to subsidize producing energy from manure
- continue vigilance on compliance
- work with TCEQ inspectors

Barriers to implementing projects are:

- limited ability to pay for projects
- if management and operational improvements are limited under a general permit, this hinders flexibility and industry responsiveness which will have negative impacts on the dairy industry
- under individual permits, operational costs are likely to increase

- unless there is new technology, there is little else that can be done to improve operations
- without perceivable benefits, it is difficult to justify additional efforts

Resources are needed to help improve water quality through:

- grants and other funds available to dairy farmers to improve land management practices
- existing knowledge in manure management
- strong support group of associations, government agencies, and other dairy farmers
- continued funding for research projects on new technologies and projects that promote better understanding of managing the bacteria life cycle

Farm-Ranch Focus Group Perspectives

Farming and ranching is not only a business, it is a way of life that spans generations. Farmers and ranchers rely on the land and must have access to water resources as part of their business. To stay in business, it is critical that these natural resources contribute to agricultural production. Farmers and ranchers seek to operate as efficiently as possible and hope for a good market and high yields. As in any other business enterprise, the ability to operate without the fear of legal repercussions, unforeseen financial risks, or other risks is desired. Protection of the environment is necessary for a sustainable, productive business and the good of the community. The reliance by farmers and ranchers on the land instills a strong connection to it giving a sense of the importance of its protection. In other words, farmers and ranchers feel they are stewards of the land and actively work to assure their operations are sustainable and do not harm the environment. The WPP is seen as a way to support and enhance these activities so that the implemented projects effectively use resources (existing and new) to reduce bacteria and also help support agricultural production.

Farms and ranches are mostly individually owned and operated with great pride. The cost of dealing with any problem directly affects farmers and ranchers socially, economically, and personally. TCEQ has deemed water quality in some creeks in the Leon River watershed as degraded because of high concentrations of bacteria and unacceptable for contact recreation. Three major concerns are expressed by farmers and ranchers:

1) The Farm-Ranch Focus Group has never known agricultural products to be contaminated in the Leon River watershed, workers have never been known to be sick in this area, and no one can recall a case when an individual in the Leon River watershed ever became ill from water-borne diseases. Little recreational use occurs on the Leon River by local residents other than fishing. Many farmer and ranchers commented that there are far more things in their daily ranching activities that would harm them than swimming in the creeks and streams.

2) New or additional regulations imposed on farming and ranching would impose additional costs on agricultural operations. Due to chronically low profit margins, increased costs could put some operators out of business, which would be devastating for those who do this type of work for the love of doing it. It is a life’s work for some with many farms and ranches going back generations. Being able to hand their ranches and farms to their children is vitally important to them and there is a risk of losing it all with heavy-handed regulations due to inappropriate standards and over-reaching regulations.

3) Farmers and ranchers consider themselves stewards of the land and being told that water quality is hazardous to citizens because of their farming and ranching is of great concern to their reputation. With minimal evidence that agricultural operations are the primary contributors to bacterial contamination, farmers and ranchers believe they are unfairly blamed in public.

The general concern is that designation of water bodies in the Leon River watershed as impaired can have significant consequences to farmers and ranchers, and remediation efforts may be costly causing some operators to lose their family business and land for possibly no environmental benefit in the final analysis. This prospect leaves them insulted and angered—in their view this is all an unjustified threat to private property rights brought on by government not understanding how it affects peoples' lives and not understanding the true nature of the problem.

Farmers and ranchers fully understand that it is possible for agricultural operations to contribute to bacterial pollution. Runoff from pastures or fields that are not managed properly can carry sediments containing bacteria. If pollutants such as bacteria create significant contamination, then there may be a real risk of human exposure to bacteria. Farmers and ranchers do not wish for such an exposure as it may cause harm to others and lead to a potential loss of business, costly litigation, problems with neighbors, and other undesired consequences.

Despite limited data on water quality conditions, farmers and ranchers understand that it is beneficial to maintain or improve water quality in the creeks and rivers of the Leon River watershed. Pollution may be a problem, but its true source must be identified and mitigation practices must be considered along with the many other issues farmers and ranchers must deal with. For this reason, expending additional funds must be balanced against business priorities and profit. Most, if not all, farmers and ranchers follow some level of sustainable farming and grazing practices. Many receive continuing education through various associations, agencies, and learning from fellow farmers and ranchers. Many ranchers have alternative watering sources to keep cattle away from creeks, rotate livestock grazing their pastures to maintain good turf, and use vegetative filter strips to filter sediment before it reaches creeks. Many even have fencing in place where it makes sense to restrict their cattle from creeks and rivers. Most importantly, ranchers and farmers are always willing to learn about better ways to manage their land that can offer synergies between improving their operations, improving water quality, and conserving natural resources. Setting environmental considerations aside, factors such as crop and cattle prices, cost of feed, fuel, and fertilizer, other input prices, agricultural yields, rural land markets, government intervention, and the weather all dictate profitability and how farmers run their businesses. As commodity producers, farmers and ranchers cannot dictate the prices they receive for their products; they have to take the prices offered by the market. Accordingly, agricultural producers cannot pass on the costs of higher production. Thus, to encourage farmers and ranchers to invest in water quality projects there has to be some kind of significant incentive or matching funds to make it affordable and help ensure a return on their investment or at least not result in an operating loss.

Ranching and farming in the Leon River watershed are major contributors to the regional economy and how farmers and ranchers invest in their businesses is directly related to economic conditions. Over the last several years agricultural economic conditions have largely been difficult in central Texas. Drought severely impacted the region in 2005-2006 and again in 2008. The extremes of rain in 2007 caused significant financial losses to local small grain farmers. The run-up in fuel, fertilizer, and feed prices in 2008, coupled with the drought and subsequent drop in cattle prices starting in the fall of 2008 severely affected the beef cattle industry. The ongoing recession dampened demand, worsening the price outlook for all local agricultural crops. Thus, despite all the best efforts by farmers and ranchers, there are many factors beyond their control that limit profitability in a business that has little room for frivolous investments.

Any new regulatory requirements will exact an additional cost from agricultural producers. Requirements for riparian fencing or construction of alternative watering sources will potentially cost the producers tens of thousands of dollars per project with no tangible return on this investment. Farmers and ranchers may not be in a position to be aware of and correctly interpret complex regulatory requirements. Affordable consultants are generally not available to agricultural producers, leaving them on their own to decipher regulatory requirements. Farmers and ranchers also understand that wildlife is likely a significant contributor to bacterial contamination of the river and creeks. Little can or should be done to manage this component of pollution other than the removal of invasive species such as feral hogs. Furthermore, farmers and ranchers question whether the acceptable threshold levels of bacterial contaminants are valid. On the whole, the major challenges in implementing any water quality improvement project will be to first show that it is justified followed by demonstrated ways to make it affordable, operable, and sustainable with the acknowledgement that there may be pollution sources about which nothing can be done.

Ranching and farming is as old as civilization itself and it would not have lasted if there were not proven methods to make it sustainable. Education is a key component of this because knowledge of how to best manage the land is handed down over time. Today is no different. Universities are very active in research and information dissemination as well as many other efforts that support farming and ranching (e.g., Texas AgriLife Extension Service). Many government agencies such as the Natural Resource Conservation Service and the Farm Service Agency of the U.S. Department of Agriculture also provide support through research funding and leadership. There are also many non-governmental organizations that have a long history of supporting this business (e.g., Texas Farm Bureau, Texas and Southwestern Cattle Raisers Association). Farmers and ranchers are very proud individuals who are always seeking ways to improve their operations, which includes ways of being better stewards of the land and water. As a result, they are eager listeners and learners. The combination of willingness to learn and availability of supporting agencies provides a positive environment for which strategies to improve water quality can be developed, implemented, and sustained.

The desired outcome of the WPP process is to establish specific management solutions that would improve water quality in the region, benefit the land, and continue to support the farming and ranching way of life. However, this should be accomplished with sound science leading to measures that do not have adverse effects on businesses. If it is necessary to have costly measures, financial assistance and cost sharing options must be identified and utilized. Farmers and ranchers understand that if poor water quality remains there may be state and federal action, potential economic losses, potential litigation, land values may decrease, and water quality may continue to degrade. Farmers and ranchers currently use many forms of land management practices where there is always room for enhancement. There are some areas where there may be little that can be done, but there also available resources that farmers and ranchers will continue to leverage. The major perspectives of the Farm-Ranch Focus Group are summarized below.

The desired WPP outcome is to:

- protect the way of life for farming and ranching
- support profitability as well as improve water quality
- respect property rights through voluntary adoption of implementation strategies identified in the WPP

Concerns with the impaired water bodies are that:

- there is no perception of human health concerns
- unfair regulation could harm businesses
- cattle ranchers are blamed as a reason water quality is bad
- other economic losses could occur due to an improper designation

Excessive bacteria in water may lead to:

- sick workers if they are in continuous contact
- consumers may become ill from water-borne pathogens on contaminated products
- loss of business because of the perception that the region grows contaminated food

Causes of poor water quality could be from:

- direct fecal matter deposit by feral hogs, deer, and wildlife near creeks
- poor grazing practices
- cattle and other livestock grazing near creeks
- untreated wastewater from hunters or other recreational users of the land

Possible actions to improve water quality are to:

- educate ranchers on sustainable stocking rates and other conservation measures
- provide farming and ranching education on how to reduce bacteria
- reduce waste discharge from hunters or other recreational users leasing the land
- install alternative water sources
- Encourage further use of buffer strips and protected areas along stream edges near cropland or grazing land
- control feral hogs as an exotic contributor to water-quality problems

Barriers to implementing projects are:

- limited ability to pay for projects and lack of a tangible return on investment
- some practices may change the way the land is utilized taking it out of production or significantly changing production practices
- lack of education/information about pollution contributions
- concerns that the projects are unjustified or unnecessary

Resources available to improve water quality are:

- grants and other cost-share funds available to farmers and ranchers to improve land use
- strong sense of land stewardship within the agricultural community
- strong support group of associations, government agencies, and other farmers and ranchers

- historic knowledge and culture in the region

Municipality Focus Group Perspectives

Officials of rural Texas cities wish to provide citizens who live and work in municipalities a healthy environment and a high quality of life through reliable services that provide high value for what they pay in taxes and utility bills. Tourism, recreation, sense of community and peaceful living make this part of Texas home to some of the best rural communities according to some surveys. The ability to offer reliable utility services is based on recovering revenue from customers at a higher level than delivering those services. City officials do their best to provide services not at a loss; and changes in state and federal government regulations have a direct impact on how they operate facilities, formulate ordinances, and enforce rules.

Although pollutants from urban foot prints have been identified as sources of bacteria pollution that could pose a risk to the region, municipal leaders have two concerns: 1) there is little evidence that the current state of water quality and access to swimmable water is detrimental to human health within urban areas, and 2) any actions imposed on cities may impose burdens on citizens. The general issue is simply that citizens ultimately bear the monetary burden of dealing with these problems through their taxes and utility bills and city expenditures have to be justified since increased fees for residents could be burdensome. For this reason, expending city funds to deal with issues must be balanced against other priorities, and if increases are justified, citizens must see them as reasonable. However, it should be noted that the likelihood of swimming in urban creeks within the Leon River watershed for the most part is not feasible because of the intermittent flow. City officials expressed that to their knowledge citizens have not been ill because of waterborne diseases obtained from creeks within city limits. Officials have expressed that protection of public health is a priority for them and, if high degrees of bacteria pollution exist where citizens were getting sick, action is necessary. At this time, they believe there is an inconsistency between the current TSWQS and the reality of health conditions in the watershed based on how creeks are used in the area. From a regulatory perspective, because cities are targeted through their TCEQ wastewater treatment plant permits, city leaders fear they may be unnecessarily targeted and forced to take on an unfair share of the pollutant reduction burden.

Most of the cities in the Leon River watershed have a creek within or near the city limits and, being close to households and businesses, these water features add to the aesthetic feel of each community. For example, parks that are open to the general population are enhanced by these water features. Municipal leaders acknowledge that any significant level of bacterial pollutants found in these waters may adversely affect citizens or children when swimming or playing in the water. If it is true that there are water-borne pathogens in local streams, it may give a negative perception of the region that may potentially make the area unattractive for recreation, residential retirement, or business. Cities realize that if water quality does not meet standards, federal and state regulators may impose stiffer operating guidelines and fines. Municipal leaders are also aware of the potential for their permits to become stricter if water quality does not improve. Not knowing future permit requirements brings much unrest because it makes it difficult to plan for future capital improvements and operations.

Cities in the watershed do have the ability to control point sources and to some degree nonpoint sources. City officials stated that they are and will continue to do their part implementing management measures to reduce bacteria pollution. After the initial 303(d) listing of the segments within the Leon River watershed, most cities began progressively acting to improve their infrastructure (e.g., expansion of wastewater treatment systems), which should improve water quality in impaired segments. The one city without advanced treatment is currently undergoing a renovation and is expected to have an advanced wastewater treatment plant that has no effluent discharge. The majority of cities have submitted plans to TCEQ for how they are going to address sanitary sewer system overflows. These plans contain costly infrastructure improvements that include inflow and infiltration studies, repairs of manholes, replacement of sewer lines, and even improvements to wastewater treatment facilities. Most cities have in place or are considering grease trap ordinance that reduce the potential for sewer system blockages from hardened grease in sewer lines. Some neighborhoods that were on septic systems have been annexed by the city and are now on central wastewater collection systems (there are no septic systems within city limits). Public restroom facilities that have been vandalized, such as those in parks, are being targeted for repairs. Cities also have in place rules that limit the number of pets and livestock within city limits. City leaders are open to learning how they can reduce pet and animal fecal matter within city limits. Thus, cities have and are continuing to make progress on reducing the risk of sewer system overflows, minimizing septic tanks, and decreasing pet and livestock waste within the urban footprint.

All of these efforts require funding and public acceptance, which will be a challenge. The area is known to have many families below the state's median household income and many citizens are on fixed incomes. For these two reasons citizens wish for utility rates and taxes to be low, minimizing the funding pool for infrastructure improvement projects. There also many competing services for limited city funds. Roads, fire protection, and security are always top priorities. Because citizens do not recreate in local creeks that flow through urban areas, there is little benefit of improving water quality above current conditions. The lack of benefit and high costs of projects makes it difficult to justify a shift in city priorities. Finally the rural country setting attracts individuals who wish for minimal government intervention in their lives. All of these factors make it difficult to fund infrastructure projects and to change human behavior.

Cities are eligible for various sources of grant funds for projects to address urban infrastructure. The U.S. Department of Agriculture has matching grants specifically for rural communities. For example, the City of Comanche has used these grants and loans to repair its wastewater treatment plant after it was damaged by a fire. Other grant funds are available through the state as well as federal agencies (e.g. Community Development Block Grants and Economically Distressed Areas Program Grants). The cities do have some resources available through the fees and taxes they collect. This allows them to hire professionals and have a capital improvement plan. Elected officials can gain access to other higher levels of government on behalf of the people as they seek to improve their cities.

Cities desire to have local control so citizens don't unfairly pay for projects that only provide marginal benefit for the money expended as compared to other funds spent in the region. City officials understand that if poor water quality is not addressed, quality of life and businesses could be adversely affected. City managers agree it is important to identify bacteria sources emanating from within city limits that can be reasonably removed, but it is a long-term process that needs constant attention. Members of the Municipality Focus Group described past, current and near future projects to improve wastewater services, outlined possible areas for ordinances, and identified ways people could be educated about reducing bacteria pollution.

However, even with all their efforts, there is only so much cities can do to fund projects, change behaviors, and educate the public. The major perspectives of the Municipality Focus Group are summarized below.

Cities goals are to:

- provide the needed city services as cheap as possible
- encourage economic growth and well being

Concerns are:

- having to implement projects that impose a burden on citizens
- unfairly having to make changes when other are doing their fair share

If urban creeks do have excessive pathogens then it may be possible for:

- public health to be at a greater risk
- the region to be perceived as an area with environmental problems
- property values to decrease
- economic losses in tourism and business

Causes of poor water quality could be:

- effluent discharges from lagoon wastewater treatment plants
- overflows from septic systems not connected to the city systems
- overflows from the sanitary sewer system during rain events
- livestock waste from residential areas carried into creeks during rain events
- pet waste from residential homes carried into creeks during rain events
- direct deposit from birds and wild animals (e.g., ducks and geese in parks with water)
- damaged restrooms in city parks

Possible actions to improve water quality:

- invest in wastewater treatment, remove failing septic system, and annex new areas
- reduce potential for sewer system overflows (I/I studies, rehabilitate lines, later connection repairs, and expand coverage)
- provide public education on pollution to those who have livestock and pets within the city
- evaluate potential benefits and impacts of new ordinances (grease trap, pet limits, livestock limits)

Barriers to implementing projects are:

- difficulty for some citizens to pay additional fees
- unwillingness of public to change habits

- lack of public education
- defined jurisdiction and ability to enforce rules

Existing resources to help improve water quality:

- current capital improvement projects aimed at improving city infrastructure, ordinances, and enforcement
- grants and other funds for investment in infrastructure (EDAP, CDBG, USDA)
- political will to make implement environmental management strategies

Large Lot Landowners Focus Group Perspectives

Residents who own land in Comanche, Hamilton, and Coryell Counties have an enjoyable lifestyle in their rural surroundings where they experience a clean environment, tranquility, open country, farming, and wildlife —a country way of life for their family. Many people do not want this way of life to change. Many in this group see their land as places where they can retire, locations for second or vacations homes, and areas for hunting or recreation. In addition to enjoying the land, the livelihood of some landowners is supplemented with cattle ranching, farming, and commercial recreation to make additional money or save on taxes. Typically, this group of landowners is not interested in major agricultural production from the land as a business, but if they do it is more a hobby or a way to connect to the land. Landowners of this type are responsible for large portions of the Leon River watershed, and the right to choose how they mange the land without any unreasonable constraints from regulators is a shared goal. For the most part, landowners are content with the current conditions of the region; however, some improvement could be made in reducing trash, invasive species, and poaching.

If water quality in local creeks truly puts human health at risk, then landowners recognize their role in improving water quality. However, until this is proven, landowners are concerned about being forced to make environmental improvements without any definitive human health benefits. The notion that water quality is poor is an issue to landowners because they do not recall being sick from having full contact with the water on their property. The intermittent nature and low flow of some streams in the area make it difficult to support the presumption that full body contact recreation is viable in most creeks. Even if there were a problem, another concern is that some suggested changes to land use practices may impose unfair costs, hamper the ability to enjoy their land, and that property rights may be violated. Those landowners who manage livestock or wild game, or who farm the land recognize that such activities may contribute pollution, but landowners believe it is no different than what has existed in the past and there has never been a problem. Landowners are willing to act if needed, but at this time they are troubled from having to change how they use their land with no reason.

Most do agree that when creeks are truly polluted it may decrease land value and prohibit enjoyment of the land. Perception of poor water quality may also reduce the attractiveness of a region to hunters, campers, and other recreational users. Landowners agree that when sound management practices are not used there is the potential for creeks to become polluted. No landowner wants their land to have a polluted creek where they can no longer enjoy water-related recreation. Because landowners in the Leon River watershed perceive no threats to their health from current water quality in the region, they would prefer for conditions not to change. However, they do recognize that if water quality does not meet state regulations there is a chance for them to lose local control to state and federal authorities who might establish additional land management requirements.

Landowners are concerned with water quality impairments and, as such, are supportive of implementing a reasonable level of management measures. Should water quality continue to degrade they want additional scientific information to determine if the implementation of more costly measures would actually make a difference. Landowners have and continue to implement various measures to mitigate potential impacts to the environment. Landowners have long been committed to these conservation measures, not only as a good farm practices, but because landowners do not wish to pollute their own land because it may harm their family and environment. For example, some landowners have ponds or other alternative watering sources to keep cattle away from creeks, which also provide added aesthetic features, opportunities for water recreation, and enhanced conditions for wildlife and hunting. Some landowners are willing to enhance or expand their existing conservation measures to improve the environment. Many landowners do seek to enhance wildlife on their property and some are part of wildlife management associations that implement environmental restoration measures. Landowners also practice land management similar to large scale operations such as using agronomic stocking rates, participate in continued education, and follow water quality management plans. Some have received grants to fund brush control. All these activities are plausible, but have to be attractive to the land owner and appear reasonable based on the certainty of perceived benefits to humans and the environment. Before decisions are made, efforts in the WPP should try to understand the effects from wildlife and other uncontrollable sources (although they recognize this may be difficult). The best option is to work with existing rules, make additional actions voluntary, and provide grant opportunities for projects. Landowners and regional experts will have to share their knowledge with new landowners to assure environmental conservation in the region as it is seeing recent sales of land to absentee landowners.

Cost, enforceability, and justification are among some of the greatest challenges for landowners. Many landowners, such as some retirees, may be on fixed incomes and would find it difficult to pay for expensive measures. Landowners who have even modest livestock operations are currently facing higher cost of production with prices staying relatively the same, which makes them sensitive to any additional costs. Absentee landowners are not likely to implement any change, and some landowners may be reluctant to do anything that would change the nature and use of the land. It will be a challenge to convince landowners to make expenditures given the level of uncertainty in the science and the basis for the regulations given, that is, does not match with what is being observed in the watershed (i.e., landowners have been swimming in these creeks and have not been ill). Because of the sensitivity of the costs, landowners suggest more work be done to identify sources, understand management strategy effectiveness, and evaluate where best to implement strategies before they can consider significantly investing in costly measures given their other priorities. Finally, their bacteria sources must be addressed by other efforts far beyond the ability of most landowners (e.g., eradicating all feral hogs) and some bacteria sources will have to be accepted (e.g., wildlife).

Many landowners are permanent residents and have long histories in the region, which is why there is a strong incentive for maintaining a high quality environment. Landowners have many of the same resources available to them as farmers and ranchers. In particular, grant funds are available to help landowners develop wildlife management plans through Texas Parks and Wildlife Department and water quality management plans through Texas State Soil and Water Conservation Board. There are numerous opportunities for attending training and courses to learn how to better manage the land offered by Texas AgriLife Extension Service. Local county extension agents are also willing to visit land owners and provide assistance. There is also a strong sense of community in the region and many neighbors help each other.

Landowners would like the desired outcome of the WPP process to establish a program that offers options that consider the practical application of management measures to improve the environment that are attractive to the landowner. Being forced to act without some basis is seen as an injustice and there is much work to do (scientific, legal, and economic) before landowners can fully support any actions. Landowners understand that if poor water quality remains, it is likely to reduce land value and diminish the appeal of the region. Landowners are open to implementation of strategies, but there are limitations to what they can afford and accomplish. The measures proposed in the WPP must make sense, be reasonable, be a benefit to the landowner, and have financial assistance. Hopefully, there should be sufficient data in the future to better target problem areas, and an influx of funding would allow water quality improvement to occur faster. Many landowners have stated that water quality on their land is good and they are hopeful it will remain that way. The major perspectives of the Large Lot Landowner Focus Group are summarized below.

Landowners desire to:

- maintain a peaceful, pleasant, and aesthetic way of life
- maintain/increase the value of their land
- keep a balanced wildlife population
- support environmental conservation
- respect property rights through voluntary adoption of implementation strategies identified in the WPP

Their major concerns are:

- threats to their way of life from unfair regulations based on limited scientific understanding
- a hardship may be imposed by having to unjustly spend money that may not have environmental benefits
- there are no perceived human health problems based on how they have used their land and how the land has been historically used in the area

Causes of poor water quality from private property could be from:

- direct deposit of fecal matter from feral hogs, deer, birds, and wildlife near creeks
- direct deposit from livestock grazing near creeks
- dumping of dead animals, garbage, and untreated waste in creeks or desolate roads
- discharge of human waste in rural areas (e.g., from camping and hunting)
- sediment wash off from overgrazed plots of land
- new landowners require some time to be education on local environmental conditions and effective conservation measures for the area
- diminishing annual average creek flow

Poor water quality may lead to

- risk of water-borne diseases from contact with polluted water
- land value reduction or depreciation of assets

- loss of recreation and tourism revenue
- landowner liability if people get sick on land

Possible actions to improve water quality

- conduct outreach and education to landowners on how to enhance their land use management practices
- develop and implement water quality management plans
- county trapper to contain feral hogs
- implement practices such as buffer strips and alternative water supplies
- bounty on invasive species
- better understanding of science to efficiently allocate program dollars
- work with game warden on dealing with deer population
- other activities that support existing current conservation strategies
- educate new landowners on conservation measures
- more data to understand where to optimize limited resources and funding
- encourage more activity among landowners
- enhance native species
- understand how this region compares to other regions so that people can understand the sense of urgency of the situation

Barriers to implementing projects are:

- limited ability to pay for projects
- land with absentee owners will not change
- difficult to control invasive species
- hard to change habits of people
- some projects are not attractive as it they may be hard to maintain and could change how land is used

Resources available to help improve water quality:

- grants and other funds available to improve land use
- existing Wildlife Management Associations have valuable information
- government assistance to establish wildlife management plans for deer population control, prescribed burning for rangeland management, and landowner incentives to enact good conservation measures
- strong support group of associations, government agencies, and other landowners; and
- great knowledge of how to protect the environment

Appendix C
1992 Land Use/Land Cover Acreage and Percentage Summary

1992 Land Use/Land Cover Acreage and Percentage Summary

Subwatershed	Land Use Categories								Total Area
	Forest	Crop/Pasture	Rangeland	Rural Residential	Rural Commercial /Industrial	WAF[1]	Urban Residential	Urban Commercial /Industrial	
Acres of Land									
10	784	976	2,420	93	66	-	16	44	4,400
20	1,383	1,999	8,660	11	51	1,667	2	34	13,808
30	11,919	20,796	59,927	888	411	2,888	157	274	97,261
40	13,676	11,841	111,846	0	138	698	0	92	138,290
50	2,960	4,365	22,024	-	66	1,112	-	44	30,571
60	5,680	5,890	36,940	550	331	4,473	97	221	54,182
70	9,403	6,357	72,592	61	105	1,044	11	70	89,644
80	13,612	4,978	66,346	873	327	940	154	218	87,447
90	9,107	4,034	39,958	-	109	-	-	73	53,280
100	5,344	3,244	19,478	-	50	-	-	34	28,151
110	8,527	5,214	45,446	-	4	-	-	3	59,193
120	12,383	3,489	42,014	764	396	-	135	264	59,443
130	8,091	710	19,528	449	406	-	79	270	29,535
140	13,147	449	17,351	11	121	-	2	81	31,162
150	28,012	13,471	63,375	186	148	681	33	99	106,005
Total Acres	**144,029**	**87,813**	**627,906**	**3,886**	**2,731**	**13,503**	**686**	**1,821**	**882,374**
Land Use Percentage in Watershed									**% Total Area**
10	17.8%	22.2%	55.0%	2.1%	1.5%	0.0%	0.4%	1.0%	0.5%
20	10.0%	14.5%	62.7%	0.1%	0.4%	12.1%	0.0%	0.2%	1.6%
30	12.3%	21.4%	61.6%	0.9%	0.4%	3.0%	0.2%	0.3%	11.0%
40	9.9%	8.6%	80.9%	0.0%	0.1%	0.5%	0.0%	0.1%	15.7%
50	9.7%	14.3%	72.0%	0.0%	0.2%	3.6%	0.0%	0.1%	3.5%
60	10.5%	10.9%	68.2%	1.0%	0.6%	8.3%	0.2%	0.4%	6.1%
70	10.5%	7.1%	81.0%	0.1%	0.1%	1.2%	0.0%	0.1%	10.2%
80	15.6%	5.7%	75.9%	1.0%	0.4%	1.1%	0.2%	0.2%	9.9%
90	17.1%	7.6%	75.0%	0.0%	0.2%	0.0%	0.0%	0.1%	6.0%
100	19.0%	11.5%	69.2%	0.0%	0.2%	0.0%	0.0%	0.1%	3.2%

Subwatershed	Land Use Categories								Total Area
	Forest	Crop/Pasture	Rangeland	Rural Residential	Rural Commercial /Industrial	WAF[1]	Urban Residential	Urban Commercial /Industrial	
110	14.4%	8.8%	76.8%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%
120	20.8%	5.9%	70.7%	1.3%	0.7%	0.0%	0.2%	0.4%	6.7%
130	27.4%	2.4%	66.1%	1.5%	1.4%	0.0%	0.3%	0.9%	3.3%
140	42.2%	1.4%	55.7%	0.0%	0.4%	0.0%	0.0%	0.3%	3.5%
150	26.4%	12.7%	59.8%	0.2%	0.1%	0.6%	0.0%	0.1%	12.0%
% of Watershed	**16.3%**	**10.0%**	**71.2%**	**0.4%**	**0.3%**	**1.5%**	**0.1%**	**0.2%**	**100.0%**

Data Source: USGS 1992 National Land Cover Data, http://www.mrlc.gov/

[1] Waste Application Field is not a NLCD land cover category. Acreage was derived from TCEQ and was disaggregated from rangeland acreage.

Appendix D
Model Calibration and Sensitivity Analysis Summary

Three exercises were performed to address uncertainty: 1) a calibration review comparing existing fecal coliform data to calibrated simulations to understand the overall performance of the model, 2) a conversion factor of fecal coliform to E. coli, and 3) a comparison of model input data and the factors used to make adjustment for calibration to indicate how changes in these input data can change the priority of strategies. These exercises are summarized in the following pages.

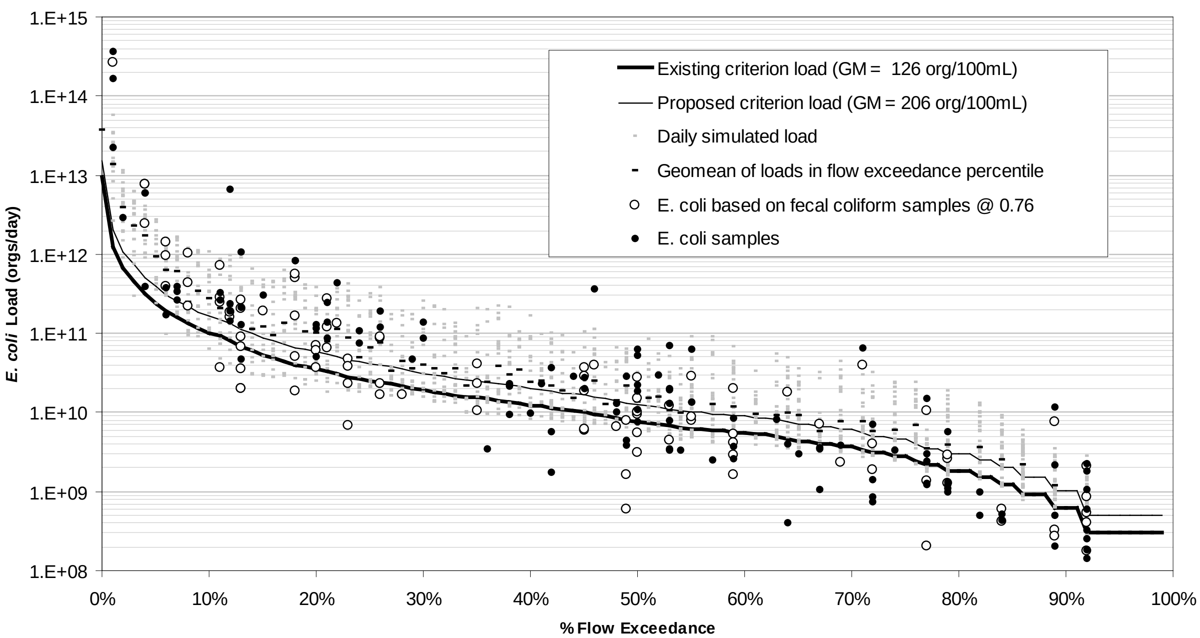
Calibration Review

This WPP established a list of management strategies that are summarized in Chapter 5 for which bacteria reduction estimates have been developed using the existing calibrated watershed loading model – [Hydrologic Simulation Program – FORTRAM (HSPF)] – used by TCEQ to support the draft bacteria TMDL. The existing calibrated form of the model is well-suited for estimating bacteria reductions in the Leon River watershed and, based on the relative difference in performance, prioritizing the list of management strategies. Model calibration is the process by which a computer model that represents elements of the real world is reconciled with real data as best as possible to demonstrate the accuracy of its representation of existing conditions. As many assumptions are made during model development given the range of various input parameters, it is necessary to vary the range of these parameters so model runs of existing conditions match up with collected field data. This is a challenge because many times there are insufficient data for the period of record, literature values may only be available for input coefficients, and wide ranges of values exist for input parameters, all of which may have significant impact to model outputs. The responsibility of the modeler is to select values for these inputs based on their best judgment so the model performs as best as possible. The setting of the inputs is typically done iteratively where permutations of input parameters are compared until there is little to no improvement in how the model matches with existing data with additional variations in inputs. The model is considered calibrated when some predetermined threshold of acceptability on a variety of outputs is reached. Although it is not possible to perfectly simulate the real world, it is reasonable to have a model relatively well-calibrated to use in evaluating possible management scenarios.

For the Leon River HSPF watershed loading model, the hydraulic calibration result “generally demonstrates compliance with desired criteria” and for water quality the results indicate that “correspondence between simulated and observed values is similar to standards of performance exhibited in other TMDL determinations for bacteria.” (Miertschin 2006). The model is considered acceptable for the purpose of identifying bacteria reductions in each subwatershed based on implemented strategies and the need to prioritize these lists of projects. A Decision Support System (DSS) was developed to allow manipulation, repetitive analysis, and access by stakeholders. Therefore, the following discussion is based on results from the DSS using the base case developed by the TCEQ in the 2008 draft bacteria TMDL Report.

The calibration, although reasonable, still has an impact on the relative inter-relationships between pollutant sources. Thus, it is appropriate to discuss the fit of the calibration in greater detail than what was offered in the TMDL modeling report. This is important as it helps provide additional understanding of the uncertainty of using simulation models in deciding how strategies should be prioritized. The example used to demonstrate how well the model was calibrated is for subwatershed 60 at the downstream SWQM station 11808 in Resley Creek. This subwatershed had the largest data set and had high concentrations above the current *E. coli* criterion of 126 cfu/100mL. Figure D.1 presents a load duration curve for Resley Creek and demonstrates on a single graph the estimated load of bacteria (org/day) for a given flow exceedance percentile.

Figure D.1 Calibrated Run - Subwatershed 60 Load Duration Curve (2001-2004) Station 11808 - Resley Creek



Six loads are displayed on the figure: the current water quality standard (thick continuous line), proposed criterion load (thin line), *E. coli* sample data (solid circles), converted fecal coliform data (hollow circles), and model simulations (gray and black dashes). The abscissa (x-axis) represents a normalized continuum of flow regimes where the percentile indicates the fraction of measured flows that exceeded that flow percentile. The values to the left are high flows and the values to the right indicate low flows (e.g., the 100 percentile indicates the lowest flow as all flow measurements exceeded it). The ordinate (y-axis) represents the number of actual org/day of *E. coli* flowing past a given point per day. The existing criterion load and the proposed criterion load are plotted by multiplying the flow at a given percentile multiplied by the concentration of the standard. These two lines represent the allowable load according to the standard and the water quality goal preferred by the stakeholders. Flows and bacteria concentrations are simulated in the model for each day. The light gray dashes represent the product of these two values, which are plotted according to the flow exceedances percentile. The gray band of dashes represents all daily loads for the period of 2001 to 2004 as simulated by the calibrated model. The dark dash is the geometric mean of all the model-simulated daily loads at a given flow exceedance percentile. *E. coli* and fecal coliform sample data are shown on the figure. The solid circles represent samples taken at station 11808 where the load is calculated by multiplying the *E. coli* concentration by the simulated flow (actual flow data were not available at that station). The hollow circles represent fecal coliform data that were converted to *E. coli* (see below for an explanation on this conversion) and plotted.

The figure demonstrates that, for the most part, the daily model-simulated loads roughly coincide with the measured loads, indicating agreement. The best agreement is between the middle and high flow ranges. The model does underestimate bacteria loads at the highest flows and appears to overestimate loads at the lowest flows. These extremes are hard to calibrate as the model does not have sufficient resolution at the watershed level to accurately represent the countless direct discharges that would dominate low flow conditions nor incorporate areas that may account for spikes in load during extreme rainfall events. The model is most capable of simulating average conditions, and less capable at simulating extreme conditions. These observations discussed herein are consistent with the conclusion reached by Miertschin (2006) in that the model is relatively well-calibrated and for this WPP, it is well-suited for understanding the impact of strategies in each subwatershed.

To further demonstrate the calibration of the model, additional load duration curves follow in Figures D.2 through D.4 for subwatersheds 20, 30, and 40. For these watersheds, similar conclusions were reached. The model underestimates the highest flow conditions and overestimates the lowest flow conditions. However, under most conditions, the levels were fairly well-simulated.

Figure D.2 Calibrated Run - Subwatershed 20 Load Duration Curve (2001-2004) Station 17379 - Walnut Creek

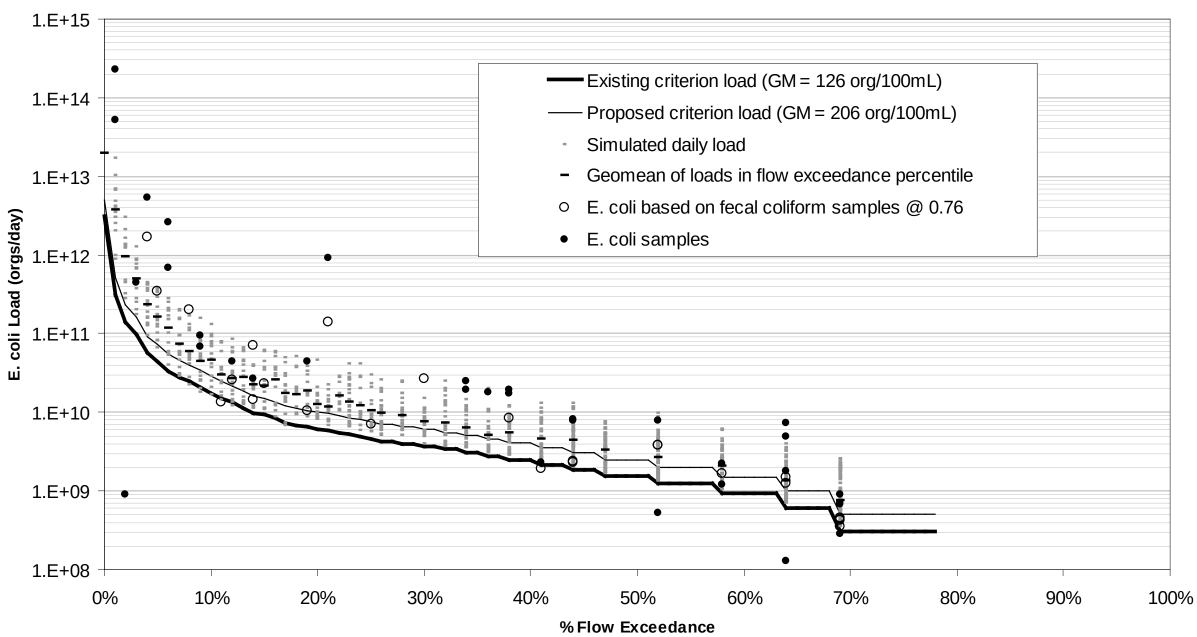


Figure D.3 Calibrated Run - Subwatershed 30 Load Duration Curve (2001-2004) Station 17591 – Leon River

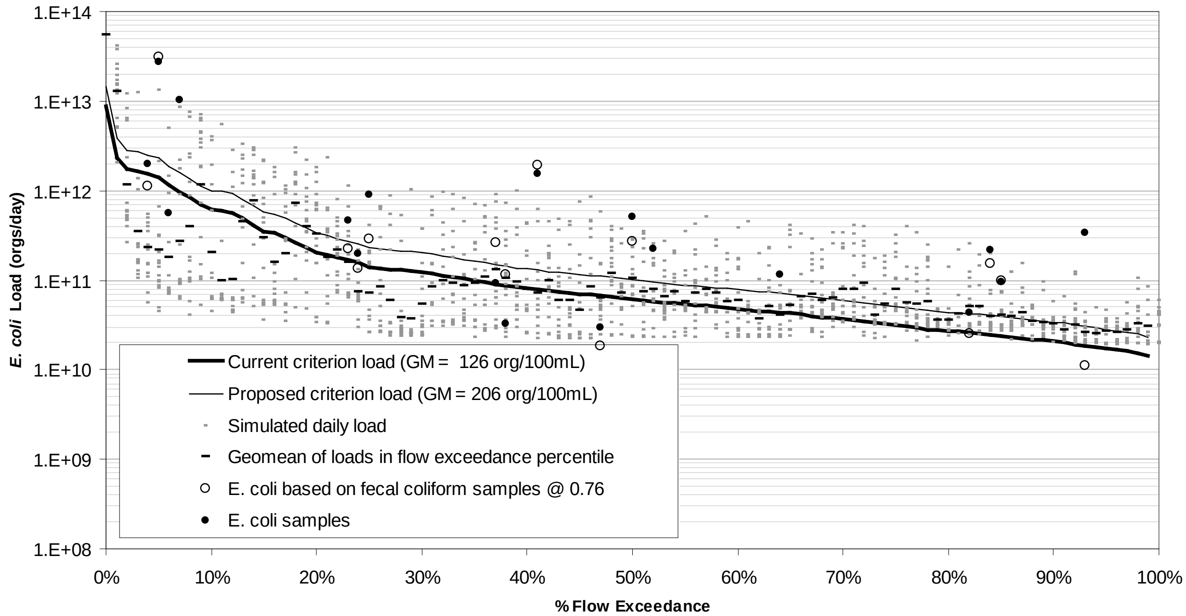
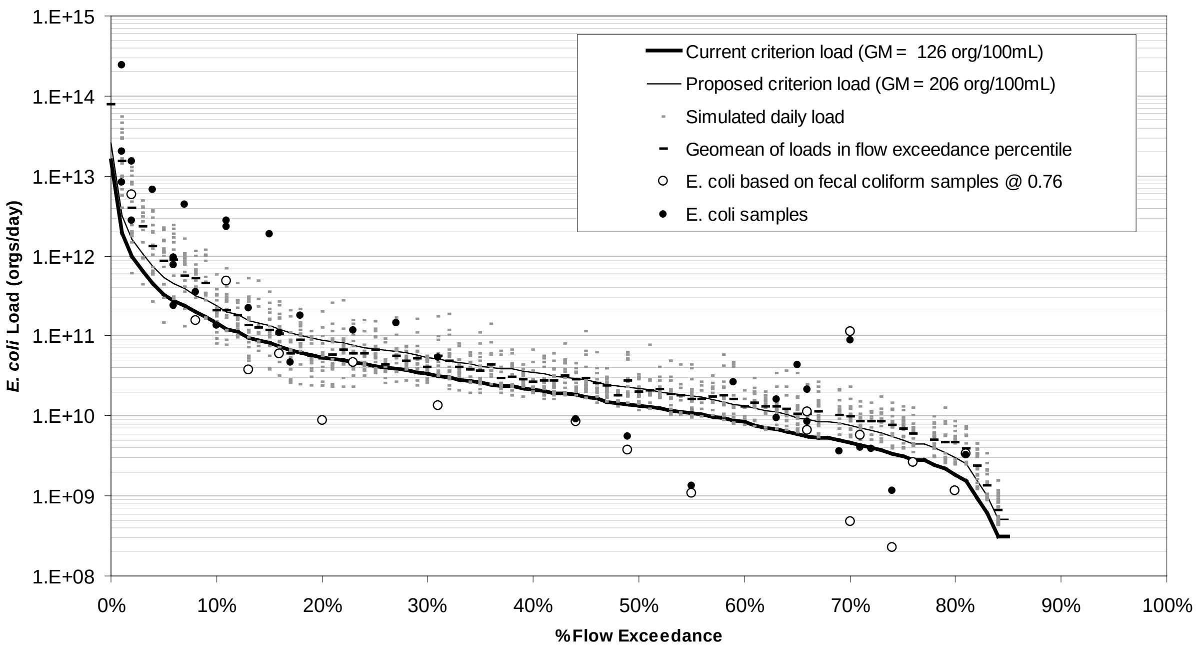


Figure D.4 Calibrated Run - Subwatershed 40 Load Duration Curve (2001-2004) Station 11817 – South Leon River



Fecal Coliform to *E. coli* Conversion

The determination of support for contact recreation in freshwater is based on whether the concentration of fecal bacteria exceeds limits that are believed to be safe. In 2000, the indicator bacterium for freshwater evaluations was changed from fecal coliform to *E. coli* as a result of the approved changed to the SWQS. *E. coli* represent a major specific subset of fecal coliform bacteria that are more strongly indicative of contamination by feces of warm-blooded animals. Prior to 2001, most fecal indicator bacteria measurements were of fecal coliform. After 2004, most measurements were of *E. coli*. The water quality model developed for the TMDL is based on fecal coliform. However, the water quality goal for the Leon River WPP is based on an *E. coli* criterion. Therefore, to utilize and compare older data, and to present modeling analysis results of implementation strategies, a conversion between the two indicator bacteria classes is necessary. A conversion carries with it some level of uncertainty because there is not a one-to-one correlation between the two indicator organisms.

Figure D.5 below presents the relationship between paired samples of fecal coliform to *E. coli* for the period of 2001 to 2004 for Segment 1221. These data exclude any sample results that had a greater-than or less-than value. Results show that for the Leon River watershed, measured *E. coli* values are higher than measured fecal coliform values from paired samples. These ratios are higher than expected since *E. coli* is a sub-class of fecal coliform. While this result cannot be explained at this time (see Table D.1), it is likely that it results from laboratory issues between two very different analytical methods. For this reason, results of the model output, when converted, need to consider the uncertainty in the conversion factor. The model results of the fecal coliform-based model were converted to *E. coli* using an average of the values found in the literature (0.76) (see Table D.1).

Figure D.5 Fecal Coliform to *E. coli* Comparison (2001 to 2004)

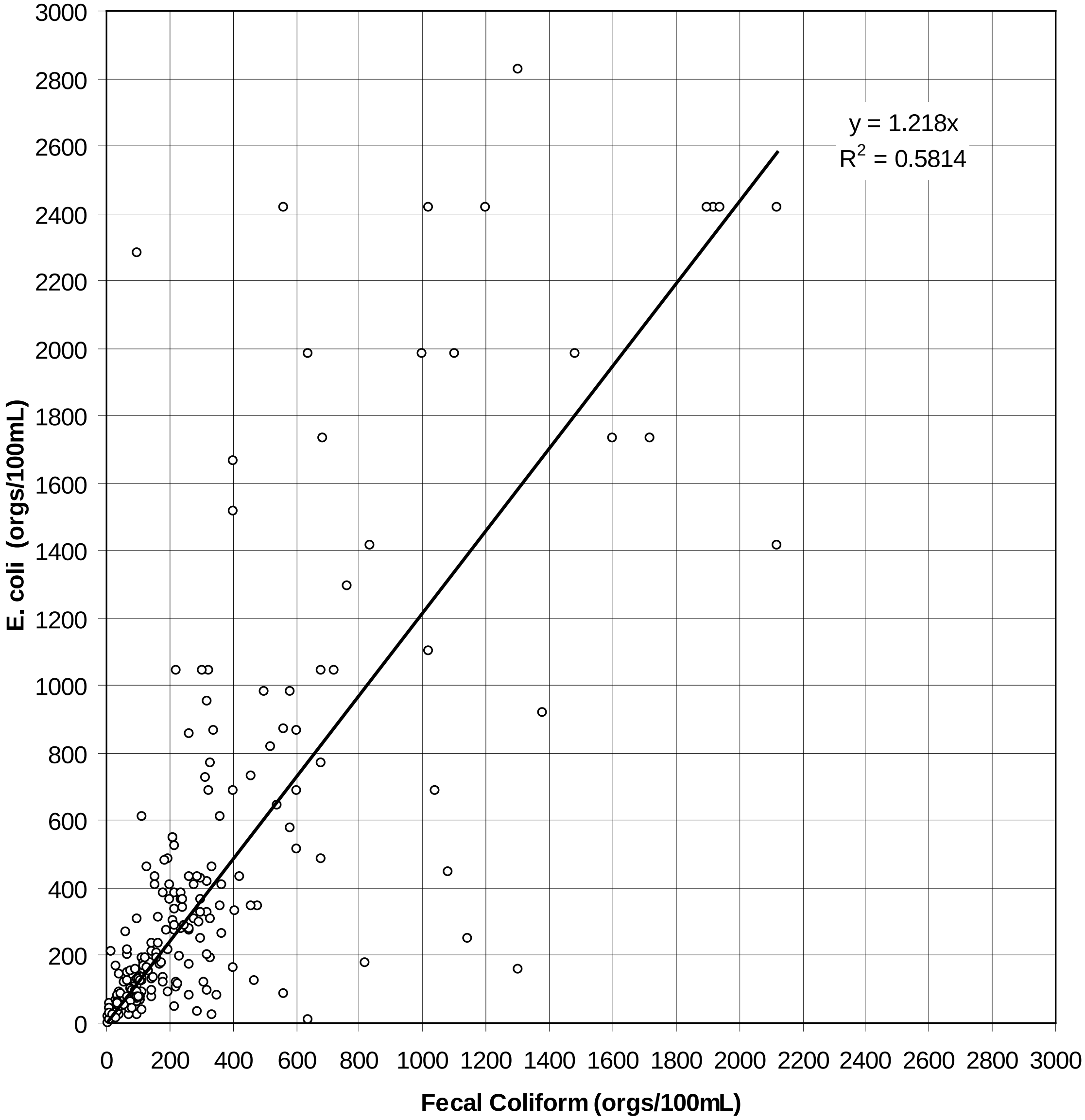


Table D.1 *E. coli* to Fecal Coliform Ratios Found in Published Work

Literature Source	*E. coli*/FC
Madison WI – Nine Springs WWTF	0.42
Denver CO – South WWTF	0.45
Metropolitan Water Reclamation District of Greater Chicago - John Eagan WWTF	0.61
E. coli geometric mean to fecal coliform geometric mean ratio (SWQS)	0.63
MWRDGC's - Hanover Park WWTF	0.70
Green Bay WI WWTF	0.7
Elmund paper (1966 to 1997)	0.74
U.S. Geological Survey	0.77
Gannon, John J. and Busse, Michael K.	0.82-1.34
Parkersburg WV WWTF	0.89
MWRDGC's - James Kirie WWTF	1.09

Note: Average ratio for published work is equal to 0.76

Sensitivity Analysis

The existing HSPF model developed as part of the TCEQ draft bacteria TMDL has three areas where bacteria loading can be reduced: direct discharges, land use loadings, and wash off. For each of these areas there were several categories. As described above, direct discharges included direct deposition from warm-blooded species, wastewater treatment facilities, near-stream OSSFs, and SSOs. Wash off is a function of two elements: the loading of bacteria on the land and the process by which it is washed off into creeks. The loading of different land uses were: subdivided based on land use type (rural commercial/industrial, urban commercial/industrial, cropland, forestland, rangeland, WAFs, urban residential, and rural residential). Wash off is a factor of the type of vegetative cover on the land and its imperviousness where the thicker the vegetative growth (e.g., a forest) the higher the protection. The potential for bacteria pollutants to reach nearby creeks is reduced by higher levels of vegetation on the land.

It was possible to use the HSPF model to estimate how much each source category contributes to the total bacteria load in each subwatershed. This was accomplished by running the model iteratively decreasing the loading in each subwatershed by 100 percent and holding constant all other sources in the subwatershed. Results of this exercise for all subwatersheds are presented in Table 4.10 and 4.11 of the WPP for the period of 2001 to 2004. This sensitivity analysis performed at the 100 percent reduction level was used to determine the contribution of each source.

The percent reduction is based on the geometric mean of the calibrated model for the base condition. The percent reduction calculation was conducted using the following standard formula:

$$R = \frac{C_0 - C_s}{C_0} \cdot 100$$

Where R = Reduction, percent

C_0 = Base condition geometric mean, orgs/100mL

C_S = Management strategy geometric mean, orgs/100mL

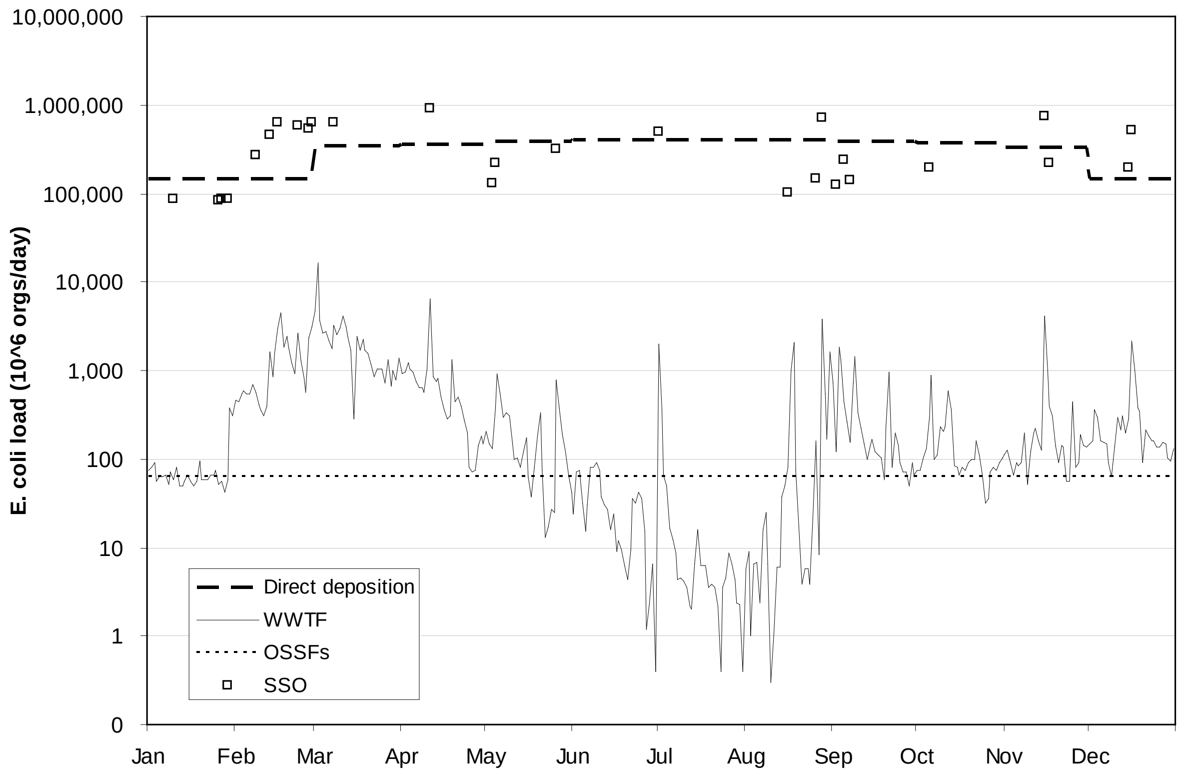
The major finding of the sensitivity analysis indicates that a significant reduction in direct deposition will be needed to reduce bacteria levels that would attain current *E. coli* standard of 126 cfu/100mL. For example, 100 percent reduction of all other sources combined in subwatershed 60 is only capable of reducing the bacteria concentration to 181 cfu/100mL, which is not sufficient to attain current standard. A reduction level of 100 percent of direct deposition alone is capable of reducing bacteria concentration to attain water quality standards with no other strategies implemented.

Source Assumptions

Stakeholders sought to obtain a better understanding of which management strategies and which sources should be targeted to achieve bacteria reductions that would result in achieving water quality goals. The sensitivity analysis indicates direct deposition is the major bacteria source contribution, but the model cannot distinguish which specific type of direct deposition (domestic or wildlife) is the major contributor in each subwatershed. The reconnaissance surveys identified all the known sources, but were not designed to specifically identify the degree to which each species contributed loads. Although there are three kinds of direct deposition associated with warm-blooded animals - wildlife, feral hogs, and livestock – deciding which of these three contributes the most bacteria loading has major implications. Reducing the level of direct deposition will be a challenge. Despite this challenge, it is necessary to move forward with implementation in the short-term knowing there is uncertainty. It is possible to set interim milestones to conduct further review of data and other knowledge as it becomes available to make mid-course corrections on projects, outreach, and education. To assist stakeholders in making decisions on management strategies aimed at dealing with feral hog contributions and cattle an additional sensitivity analysis was prepared to compare removal of direct deposition from hogs vs. cattle which is presented below in Appendix D.

The sensitivity analysis does present some insight as to what may be the major source of bacteria; however, because it is based on certain assumptions <u>it may not be appropriate to exclude sources that may appear in the sensitivity analysis to have little effect in reducing bacteria loads</u>. A reordering of priority projects is possible if some new information is made available; but it would be very costly to verify all these assumptions. However, it is appropriate to discuss these assumptions, at least for direct discharges, to help understand the uncertainty in the assumptions. The principal concern is that existing data, assumptions, and other information used to develop the model produced a relatively well calibrated model, but it is conceivable that another distribution of sources could have reached a similar level of calibration. Watershed 60 is a good example of four sources of direct discharges of pollutants to a waterbody. Figure D.6 presents the time series data of the direct discharge inputs to the model.

Figure D.6 Subwatershed 60 Direct Discharges (2001)



The ordinate displays the *E. coli* load measured in millions of organisms per day or 10^6 orgs/day. As was shown in the sensitivity analyses, animal direct discharge was the dominant source with continuous values above 100,000 x 10^6 orgs/day. This number was arrived at by estimating the number of warm-blooded animals in the watershed, calculating the amount of bacteria each produced, and factoring the amount of time they spend near water. The population was estimated based on county-wide census data and literature values. Wildlife was distributed evenly across the watershed and livestock was distributed onto forestland and rangeland areas (feral hogs were not taken into account). It is possible there are higher densities in different parts of the watershed based on more suitable habitat for wildlife, sustained water sources for invasive species (particularly hogs), and historic ranching practices. An assumption was made that only a small fraction of livestock spend time in direct contact with water (e.g., less than 2% of the time during spring to fall months and none during the winter). This seasonal fluctuation is the reason why there is an increase in estimated loading starting in March that ends in November. Livestock loading could be different, especially if ranchers are using alternative watering sources and other BMPs to draw livestock away from the creek.

Despite the limited data available on the size of the feral hog population in the Leon River watershed bacteria loading contributions from this invasive species are critical to understand. Although an adult cow produces more bacteria than an adult feral hog, most studies indicate that feral hogs prefer bottomlands such as rivers, creeks, and drainages when available (Taylor 2003), which would substantially increase the percentage of feral hog contribution to direct deposition loading. There are limited data on feral hogs in the watershed, but several studies suggest that feral hogs are a significant source of bacteria and that they are found predominately near water. Jay, et Al. (2007) identified feral hogs near spinach fields on four ranches on the central California coast as one of the sources of *E. coli* O157 contamination in the September 2006 outbreak from consumption of fresh, bagged, baby spinach in 26 states and Canada reporting 205 cases of illness and three deaths. Coblentz and Baber (1987) found that feral hogs are mostly found near succulent green forage and water and that they reproduce rapidly. To protect particular species, they recommended total eradication of pigs in sensitive habitat zones. Hone (1995) reports on the damage to crops from feral hogs, that there is positive correlation with the their abundance and rainfall, they are mostly located in wet locations, and only intense eradication efforts will succeed in reducing pig numbers.

Sanitary sewer overflows had high loading values, but because they were not continuous the total load over the year was low. TCEQ compliance reports indicate that overflows occur at treatment facilities, lift stations, and throughout the collection system, but there is limited data as to their frequency, magnitude, and duration. To include them in the model, SSOs were assumed to occur with 0.5 inch rainfall events or more, flows were three times the WWTF plant flow, events had durations of six hours, and bacteria concentrations were set at 30,000 cfu/100mL. Obviously, all these parameters have the potential to be substantially different. A collapsed sewer can occur without rainfall, which would make the flow equal to the WWTF flow, but the concentration of bacteria could be higher. A leaking sewer may not be reported for days or go unnoticed before it can be repaired, which itself may take more than six hours. Spikes in influent flow to a WWTF during rainfall events may last much less than six hours, and holding tanks in most WWTFs are capable of absorbing most flow spikes without losing treatment efficiency. It is difficult to predict where and when sewer system failures will occur. It is possible that the overflows during 2004 were not well-estimated, but without better data, it is unlikely that this can be improved. Future work to estimate the bacteria concentration of overflows probably would not provide much benefit. Efforts would be better focused on improving the overall integrity of collections systems, reducing inflow and infiltration, and making improvement to WWTFs with a focus on infrastructure that is aging, damaged, or likely to fail so that the likelihood of any overflow is minimized.

Input parameters for subwatershed 60 indicate that the Comanche WWTF contribution is low compared to the animal direct discharges. This is due to only six days in 2001 the effluent concentrations exceeded the 126 orgs/100mL standard. The geometric mean for the year was 22 orgs/100mL with many single digit values. This evaluation was possible because data for both flow and bacteria concentrations were available (the other WWTFs only have flow data). With the other WWTFs it is assumed that effluent concentrations were lower because of their advanced treatment capacity, typically 1 org/100mL. It is possible to have higher concentrations, but it is not unreasonable to maintain very low concentrations with an advanced WWTF that is well maintained and operated. Even if the Comanche WWTF effluent concentration were higher than the other facilities, it is still a substantially low contributor and the others even less with regard to other sources. This is the reason the WWTFs do not have an effect in the sensitivity analyses. However, because there is no monitoring of the other treatment facilities, there is a potential for the other facilities to have higher concentrations. While the magnitude of bacteria loads from WWTFs may be small relative to land-based washoff bacteria loads, their contribution is important, particularly under base-flow conditions in the impaired reach of the Leon River because the likelihood that wastewater effluent contains human-based pathogens is high compared to non-human nonpoint source loads.

The lowest values were for OSSFs, which were assumed to be constant. To calculate near stream OSSF failures, the density of septic tanks from the census was taken, which was homogeneously distributed along creeks and a failure rate coefficient was applied. This was the best that could be done given that: 1) it would be very time consuming to research all the records, with no guarantee of actually accounting for all the OSSF; 2) there was limited information available to distribute the OSSFs in the watershed; and 3) there are limited data identifying which OSSF is failing. Therefore, if there are substantially more OSSFs in the watershed than the 1990 census provided, it would be very possible that OSSFs as a source of bacteria could be higher. It is also likely that these flows would vary over the year.

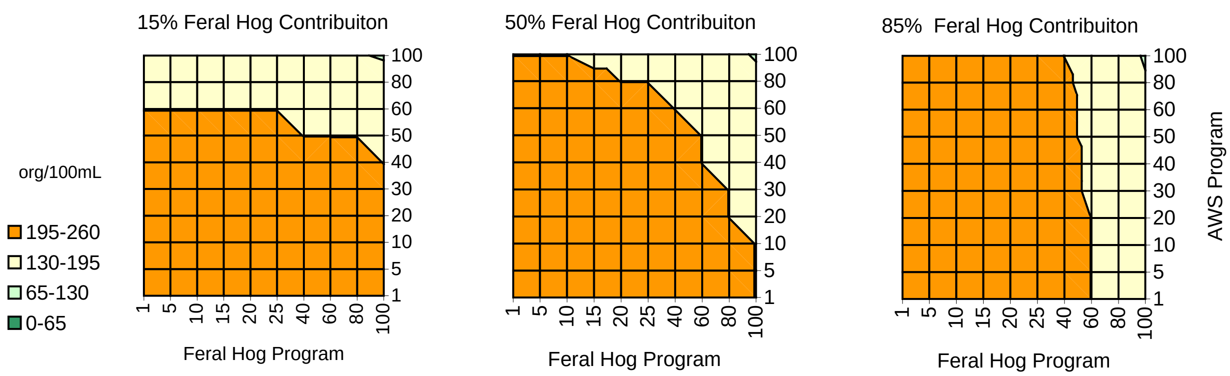
Evaluating the Relationships between Different Direct Discharges

The above discussion shows that a direct discharge can be relatively flat and carry some degree of uncertainty. The flatness of these values is important because it is possible to achieve calibration by setting one parameter to match field data, ignoring the others, and as a result absorb any errors caused by ignoring the others. It is actually possible to adjust any one of the others and achieve the same level of calibration. For this reason it may not be possible to exclude any one input parameter, such as OSSF. As information becomes available, those projects that are effective and address significant bacteria sources can be enhanced and those that are not so effective can be curtailed. Gaining knowledge over time with an adaptive management approach will allow efficient use of limited resources in the watershed.

The combined reduction of direct deposition from the three largest roaming animals, feral hogs, deer, and cattle, has the potential for the greatest level of bacteria reduction of all the strategies. The amount of direct deposition is dependent on the type of animals that congregate near creeks and the amount of time they spend near the water. To accomplish this assessment county livestock census data and an estimate of the feral hog population in the three-county area were used. This was coupled with research estimates of the amount of time livestock and feral hogs spend near creeks. The bacteria deposition load is heavily dependent on the amount of manure produce and time each of the two largest animals spend in creeks.

TPWD has reported that feral hogs prefer creeks and rivers, wallow in wet areas, and roam in dense vegetation associated with water. The riparian corridor of the Leon River matches this habitat description and thus has a high probability for hogs (Taylor 2003). Cattle spend a small portion of their time near water (Miertschin 2006). It is important to know how much each animal contributed to direct deposition because which source has the greatest impact will influence which mitigation strategy is most effective. A comparison was conducted to demonstrate which effort – alternative watering source program or feral hog program – would have a greater beneficial effect at reducing loads from these two species into creeks based on the load contribution by each animal. A sensitivity analysis was prepared using the bacteria loading estimates in manure from a beef cow and hog and adjusting the amount of time feral hogs spend in the riparian corridor while holding cattle times constant. Figure D.7 presents the results for subwatershed 60 for three different contribution percentages.

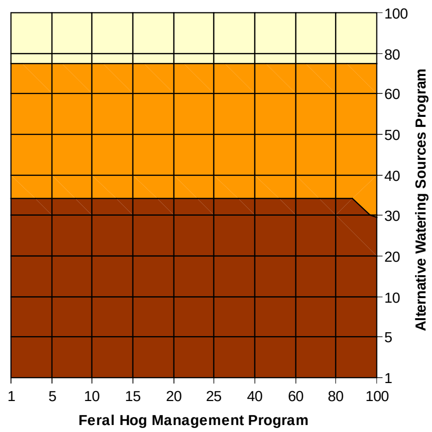
Figure D.7 Feral Hog vs. Cattle Bacteria Reductions



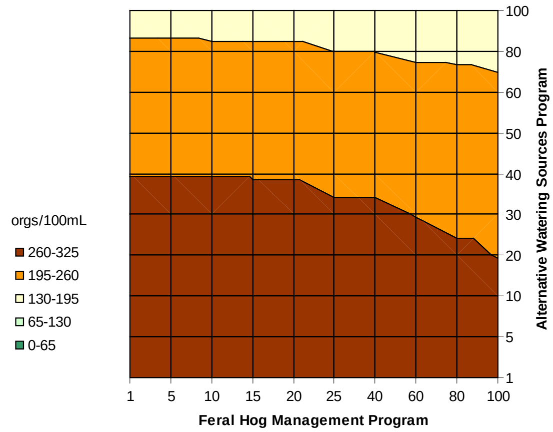
The three graphs are for a feral hog load contribution of 15, 50, and 85 percent. The x-axis represents an estimate of the percent effectiveness at reducing loads by implementing feral hog management strategies. The y-axis represents the percent load reduction for the alternative watering source program (AWS). The colors indicate the expected water quality in Resley Creek. This assumes that all other strategies suggested by stakeholders are in place at levels they recommend. The colored graph for subwatershed 60 at the 50 percent contributed between from cattle and hogs, indicates that to achieve instream *E. coli* concentrations below 190 cfu/100mL would require a program that could eliminate 100 percent of the hogs and minimize access to the riparian corridor to only 10 percent of the cattle. The program effectiveness required for alternative watering sources would increase non-linearly along the curve up to 100 percent if the feral hog program decreases to 10 percent. In contrast, if feral hogs were responsible for 85 percent of the load contributed from cattle and hogs, to achieve instream *E. coli* concentrations below 190 cfu/100mL would require a program that could eliminate 60 percent of the hogs where minimizing access to the riparian corridor for cattle would have a negligible effect. The reverse is true if feral hogs only contribute 15 percent to the load. These analyses demonstrate that the more effective each program is at limiting access by feral hogs and cattle to creeks, the lower the estimated instream concentration of *E. coli* will be. Both programs are heavily dependent on which source is the major contributor. Additional sensitivity analyses for subwatersheds 20, 40, and 60 where the contribution of feral hogs was adjusted from 2.5, 15, 30, 50, 70, and 85 percent are provided in below in figures D.8 through D.10. The figures show the effectiveness of the pair of mitigation strategy at different levels under the different feral hog contribution percentages. These ranges of options can aide ranchers, landowners, and water resource managers in deciding which species to target for long-term management once more information is available about the population and contribution of feral hogs.

D.8 Sensitivity Analysis of Animal Direct Discharges on Composite Run for Subwatershed 20

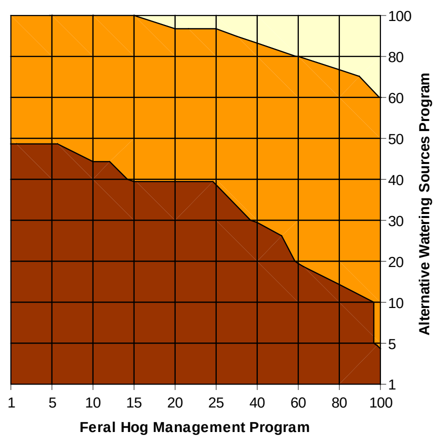
Watershed Geometric Mean
2.5% Feral Hog Contribuiton



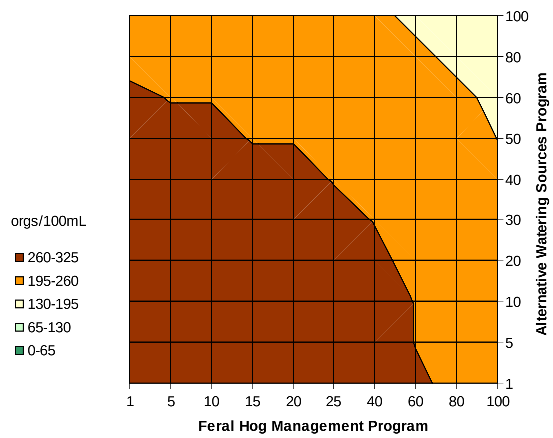
Watershed Geometric Mean
15% Feral Hog Contribuiton



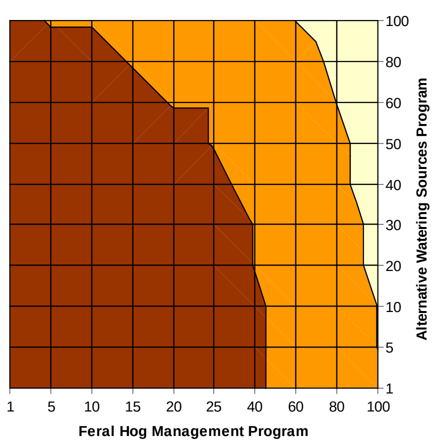
Watershed Geometric Mean
30% Feral Hog Contribuiton



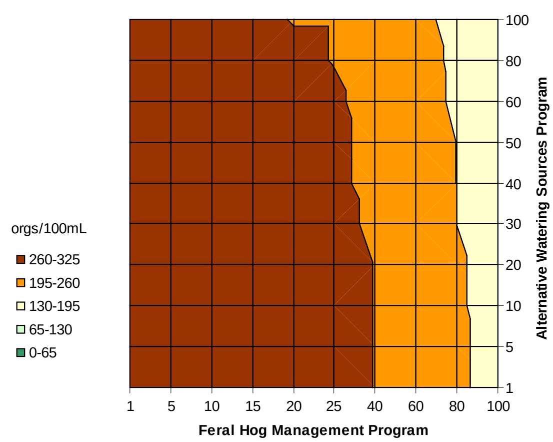
Watershed Geometric Mean
50% Feral Hog Contribuiton



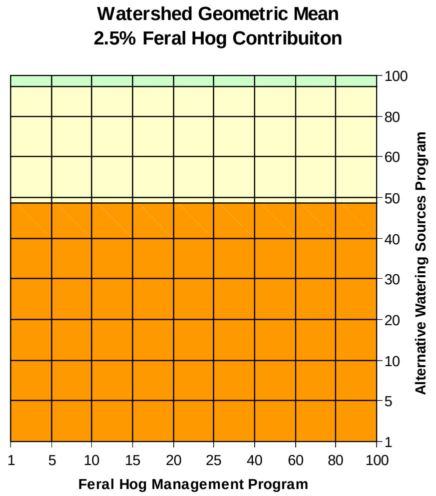
Watershed Geometric Mean
70% Feral Hog Contribuiton

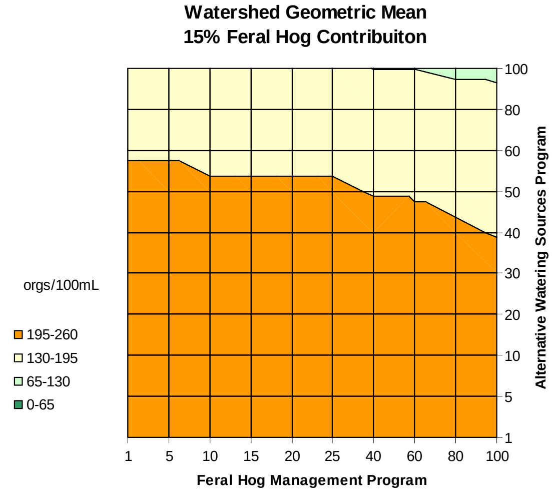


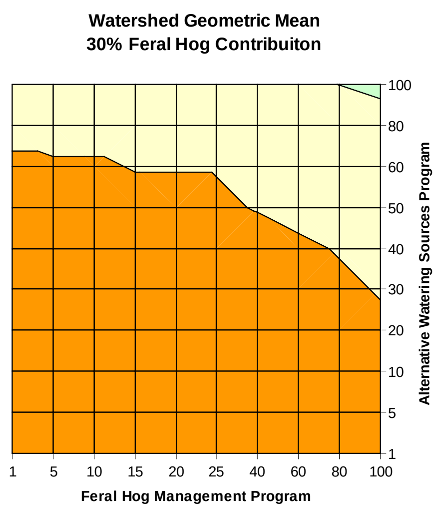
Watershed Geometric Mean
85% Feral Hog Contribuiton

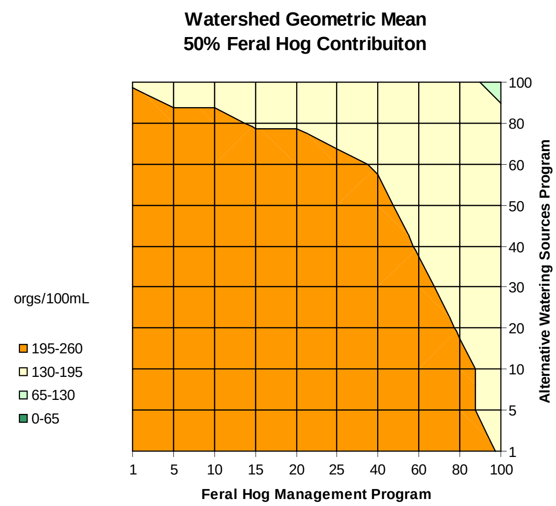


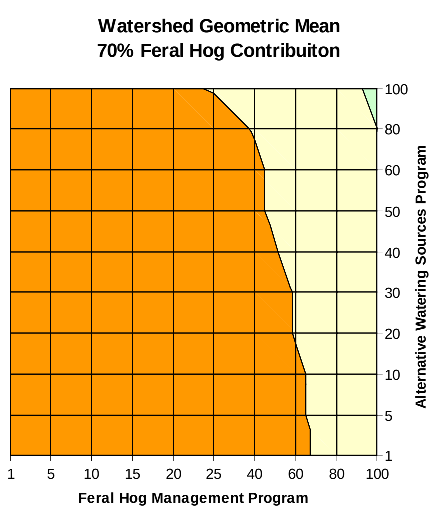
D.9 Sensitivity Analysis of Animal Direct Discharges on Composite Run for Subwatershed 40

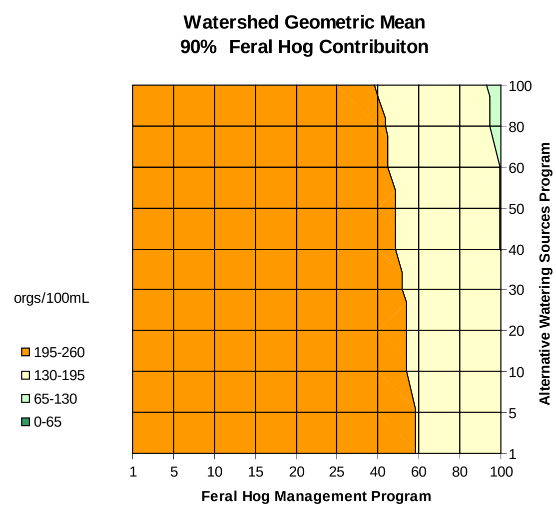












D.10 Sensitivity Analysis of Animal Direct Discharges on Composite Run for Subwatershed 60