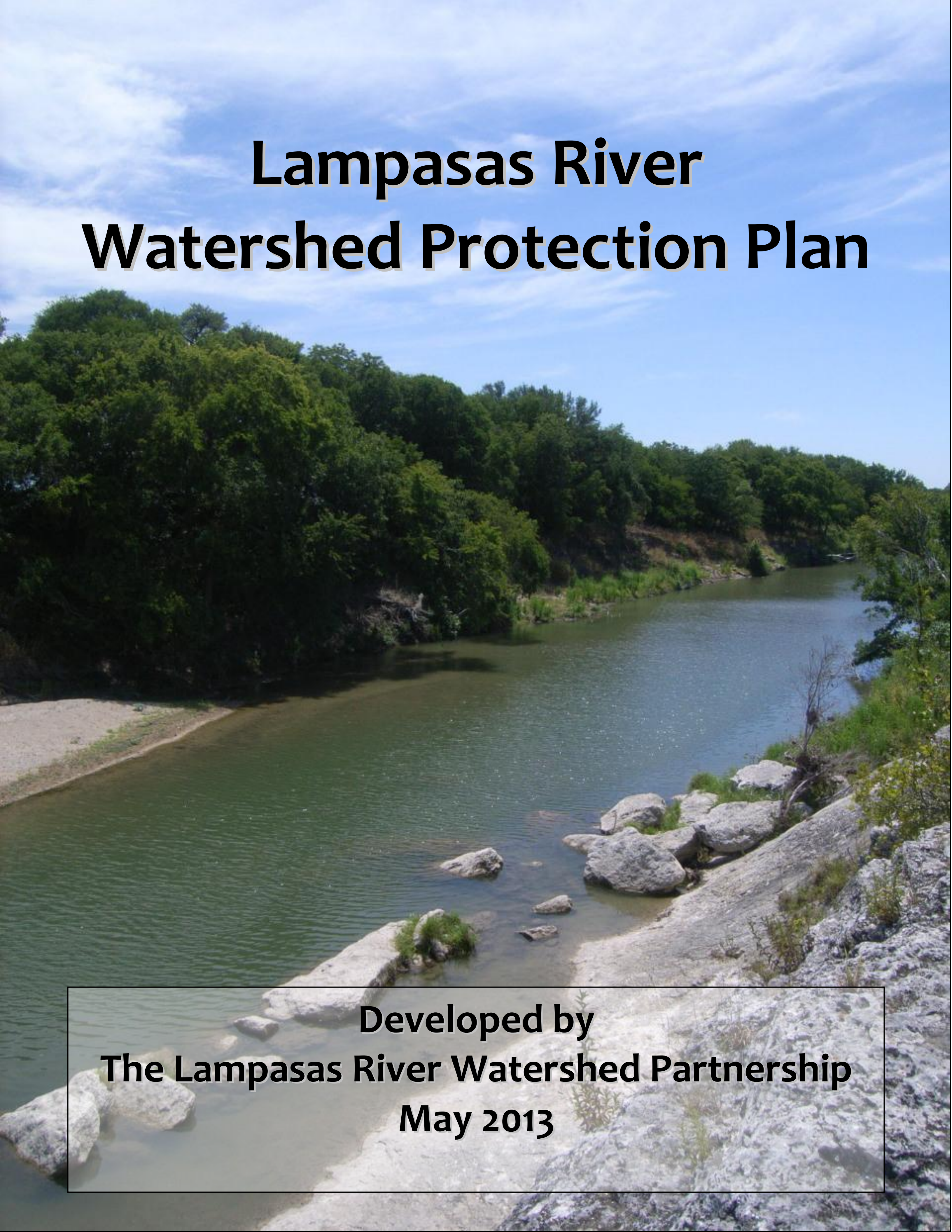
Lampasas River Watershed Protection Plan



Developed by
The Lampasas River Watershed Partnership
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THE LAMPASAS RIVER WATERSHED PROTECTION PLAN

Prepared for the
Lampasas River Watershed Partnership
by

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LIST OF ACRONYMS

AUE	Animal Unit Equivalent
AgriLife Research	Texas A&M AgriLife Research
AgriLife Extension	Texas A&M AgriLife Extension Service
BMP	Best Management Practice
BRA	Brazos River Authority
BST	Bacterial Source Tracking
CAFO	Concentrated Animal Feeding Operation
CCN	Certificate of Convenience and Necessity
CFU	Colony Forming Unit
CRP	Clean Rivers Program
CRP	Conservation Reserve Program
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FDC	Flow Duration Curve
GBRA	Guadalupe-Blanco River Authority
GIS	Geographic Information System
LDC	Load Duration Curve
LU/LC	Land Use/Land Cover
mL	Milliliters
MS4	Municipal Separate Storm Sewer System
NAIP	National Agriculture Imagery Program Digital Ortho Imagery
NLCD	National Land Cover Dataset
NASS	National Agricultural Statistics Service
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
OSSF	On-site Sewage Facility
RMU	Resource Management Use
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSO	Sanitary Sewer Overflow Plan
STEP	Septic Tank Elimination Program
SWCD	Soil and Water Conservation District
SWMP	Stormwater Management Plan
SWQM	Surface Water Quality Monitoring Program
SWQS	Surface Water Quality Standards
TAG	Technical Advisory Group
TCEQ	Texas Commission on Environmental Quality
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board

TWDB	Texas Water Development Board
TWS	Texas A&M Wildlife Services
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTSPH-EP	University of Texas Health Science Center at Houston School of Public Health, El Paso Regional Campus
WHIP	Wildlife Habitat Incentive Program
WMA	Wildlife Management Association
WMP	Wildlife Management Plan
WQMP	Water Quality Management Plan
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility

EXECUTIVE SUMMARY

The Lampasas River watershed lies within the Brazos River Basin in Central Texas which drains to the Gulf of Mexico. The Lampasas River's headwaters are in eastern Mills County and flows southeast for 75 miles, passing through Hamilton , Lampasas, Burnet and Bell counties. In Bell County the river turns northeast and is dammed five miles southwest of Belton to form Stillhouse Hollow Lake. Stillhouse Hollow Lake is the primary drinking water supply for much of the surrounding area. The watershed encompasses 798,375 acres across Mills, Hamilton, Coryell, Lampasas, Burnet, Bell and Williamson Counties. The Lampasas River is primarily a rural watershed with few urban centers. The cities of Lampasas and Kempner are wholly within the watershed boundaries, while the cities of Copperas Cove and Killeen are only partially in the watershed.

The Lampasas River was originally listed as not meeting state water quality standards for human contact recreation uses on the 2002 Texas Water Quality Inventory and 303(d) List based upon bacteria levels, and carried forward to subsequent lists in 2004, 2006 and 2008. Elevated bacteria levels are an indicator of fecal contamination from warm blooded animals and poses a human health hazard.

Texas A&M AgriLife Research and the Texas State Soil and Water Conservation Board selected the watershed for the development of a watershed protection plan (WPP) based upon the level of interest from watershed stakeholders and the river's placement on the Texas Water Quality Inventory and 303(d) List. The WPP process uitilizes a series of cooperative, iterative steps to: 1) characterize existing conditions; 2) identify and prioritize problems; 3) define management objectives; 4) develop protection or remediation strategies; and 5) implement and adapt selected actions as necessary.

Public meetings were held in Killeen and Lampasas in May 2009 and the Lampasas River Watershed Partnership was formed in November 2009 to guide development and implementation of the WPP. The Partnership is led by a Steering Committee comprised of stakeholders that were either nominated or demonstrated interest in the planning process. A stakeholder is an individual or organization that has a vested interest (i.e. stake) in the welfare of a particular natural resource or that is affected in a significant way by the implementation of recommendations designed to protect and restore the resource. The goal of the Partnership is to develop and implement a WPP to improve, protect and meet water quality goals set by the Partnership and that supports statewide efforts to meet designated uses for contact recreation and a healthy aquatic ecosystem for the Lampasas River.

The Partnership utilized a variety of scientific approaches to update existing land use classification, analyze water quality data and identify potential pollutant sources to assist stakeholders in identifying and prioritizing management measures within the watershed.

Load duration curves (LDC) were developed to characterize the historical water quality data that had been collected within the watershed. This approach was developed for the assessment of nutrient loading within streams and has become a popular method of analysis in the development of WPPs to differentiate between point and nonpoint sources that contribute to bacterial contamination within a stream system. These analyses were performed for *E. coli* at 6 monitoring sites within the Lampasas River watershed.

Although the LDCs do not indicate a necessary reduction in bacteria loading to achieve state standards, the Partnership has determined that a 10% overall reduction in bacteria loading should be implemented to allow for changes in future land use. By voluntarily reducing bacteria loadings by 10%, the Partnership hopes to keep the Lampasas River in its current state or to even improve it.

While LDCs are useful in narrowing down the causes of potential exceedances to either point or nonpoint sources, they do not include a spatial reference to potential sources. The Spatially Explicit Load Enrichment Calculation Tool (SELECT) model was used to identify potential pollutant sources and estimate daily potential *E. coli* loads from each source based upon populations and *E. coli* production rates of various sources and their distribution across the watershed. SELECT was utilized to determine potential daily *E. coli* contributions from livestock (including cattle, sheep, goats and horses), confined animal feeding operations, on-site sewage facilities (OSSF), wastewater treatment facilities (WWTF) and domestic dogs. The SELECT model was also used to estimate potential contributions from whitetail deer and feral hogs.

SELECT results, along with personal knowledge about the area, were utilized by topical work groups to develop recommendations of management practices to reduce bacteria levels. Key recommendations were then adopted by the Steering Committee.

The Agriculture Nonpoint Source Work Group focused their efforts on contributions from livestock, whitetail deer and feral hogs. They recommended implementation of voluntary Water Quality Management Plans (WQMP) for individual agriculture operations. WQMPs are voluntary, site-specific management plans that are developed and approved by local Soil and Water Conservation Districts for agricultural lands. To facilitate development and implementation of these WQMPs, the Partnership will persue funds to support a financial incentive program as well as create a new position at the local level to provide technical support to landowners and producers.

The Agricuture Nonpoint Source Work Group also recommended encouraging more landowners to take advantage of existing Texas Parks and Wildlife Department habitat management programs, such as Wildlife Management Plans and Managed Land Deer permits to mitagate the bacteria contribution from whitetail deer. The Work Group felt that feral hogs also needed to be addressed and recommended the creation of a watershed specific feral hog specialist to provide technical assistance to landowners. This person would be responsible for working with landowners to develop trapping plans and recommended management measures specific to their needs. The Partnership will also seek funds to purchase several hog traps and develop a free or low-cost trap rental program for landowners within the watershed.

The Urban Nonpoint Source Work Group addressed concerns about wastewater, stormwater and domestic dogs. The Work Group recommended a detailed database and inventory of all OSSFs within the watershed be developed along with repair or replacement of aging systems in particular subwatersheds. The cities of Copperas Cove and Killeen both operate under a Municipal Separate Storm Sewer System permit and will continue to manage stormwater in accordance to their permit. Domestic dog waste was also addressed, and in conjuction with the city of Lampasas, identified several areas that would benefit from the installation of pet waste stations. These areas are local parks that have walking trails and higher levels of dog traffic.

The Partnership also outlined a recommended water quality monitoring regime to measure changes within water quality. Routine, monthly sampling at 10 sites throughout the watershed has been requested for at least the first 3 years of implementation. The Partnership will then review the data collected and make further recommendations for water quality sampling sites.

While water quality changes may be slow, the Partnership has identified interim milestones and goals to measure the effectiveness of implementation. Implementation activities have been outlined for a 10-year period. Achievement of these milestones will be assessed biennially and changes will be made as deemed necessary by the Partnership.

The Partnerhip will continue to meet quarterly to receive updates on the progress of implementation efforts and to guide the program through adaptive implementation.

1. WATERSHED MANAGEMENT

WATERSHED DEFINITION

A watershed is an area of land that water flows across, through or under on its way to a stream, river, lake or ocean. Not only does it encompass the actual waterway, but it also includes all of the land that contributes to a water body. Watersheds come in all shapes and sizes and all are connected across the landscape and nested within each other. Smaller watersheds nested within larger watersheds are called sub-basins or subwatersheds.

Watersheds are not defined by political boundaries and can cross county, state and national borders. Watersheds are defined by geographical boundaries called divides, which are the elevational highpoints that surround a given drainage system or network of drainage systems. All of the land between those highpoints drain to a common point and are considered to be the same watershed. Any water that falls outside of a watershed divide will enter another watershed and will flow to another point.

WATERSHEDS AND WATER QUALITY

Watersheds supply drinking water, provide recreation and respite, and sustain life. Therefore, it is important to have a measure of suitability for specific uses of water, or water quality. Water quality describes the chemical, physical and biological characteristics of water typically with respect to its suitability for a particular purpose or designated use.

There are many human activities and natural processes that affect water quality within a watershed. It is also important to examine all the potential activities within a watershed that may affect water quality. Pollutants can come from many different sources and affect both surface water, such as lakes and rivers, and groundwater. Although surface water and groundwater are typically managed as two separate resources, they are interconnected. Surface water can seep through the soil to become groundwater while groundwater can feed surface water sources in the form of seeps and springs (Figure 1.1).

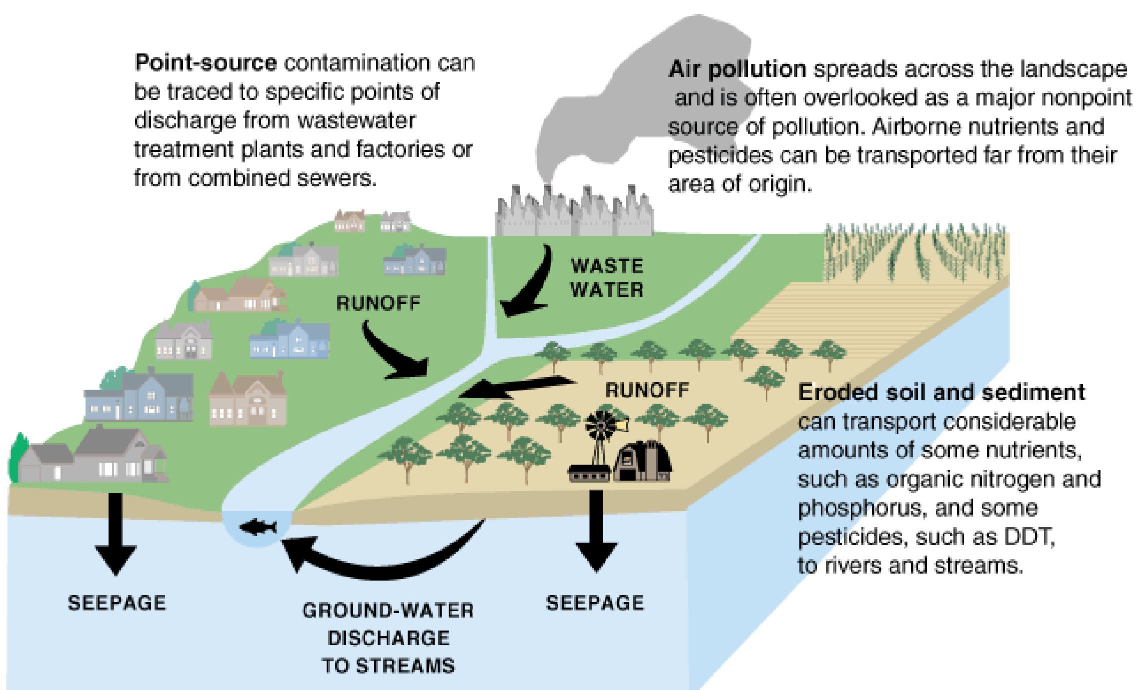

Figure 1.1 A diagram depicting the interaction of surface water and groundwater and contributing pollutant sources for each. (Courtesy of United States Geological Survey.)

Pollutants such as pesticides, nutrients and pathogens can come from rural, industrial or urban sources. In order to be better able to manage the pollutant source, potential pollutants are classified based upon their point of orgin as point source and nonpoint source (NPS) pollution.

Point source pollution refers to contaminants that enter the the waterway from a single defined source or identifiable location such as a pipe or a ditch (Figure 1.2). Examples of point sources in the urban setting includes discharges from a sewage treatment plant, known as a wastewater treatment facility (WWTF), a factory or city storm drain. Large permitted animal feeding operations or concentrated animal feeding operations (CAFO) are also considered point sources. Because point source pollution is typically discharged directly into a waterway, it contributes to pollution in both drought and flood conditions. Dischargers in Texas that hold a Texas Pollutant Discharge Elimination System (TPDES) permit are considered point sources. As such, their discharge or effluent is permitted with specific limitations on levels of pollutants to reduce their impact on the receiving stream. Wastewater treatment facilities and CAFOs both operate under TPDES permits.

Figure 1.2 Water flows out of a pipe carrying pollutants to nearby waterways. (Photo courtesy of Natural Resources Conservation Service).

NPS pollution comes from a source that does not have a defined point of orgin (Figure 1.3). Pollutants are generally carried over the landscape during storm events. As stormwater runoff runs over the land, it picks up contaminants and deposits them into the streams and subsequently the rivers. Nonpoint source pollution is typically the cumulative effect of small amounts of contaminants picked up from large areas. Because of the function of NPS, the types of pollutants transported depend largely on the types of land use in the watershed, whether it is agricultural, residential, industrial or undeveloped areas. Each land use type has varying sources of contaminants. Fertilizer leaching from the soil and carried in sheet runoff during storm events is an example of NPS from an agriculture source, while contaminated stormwater from parking lots, roads and yards is considered an urban source.

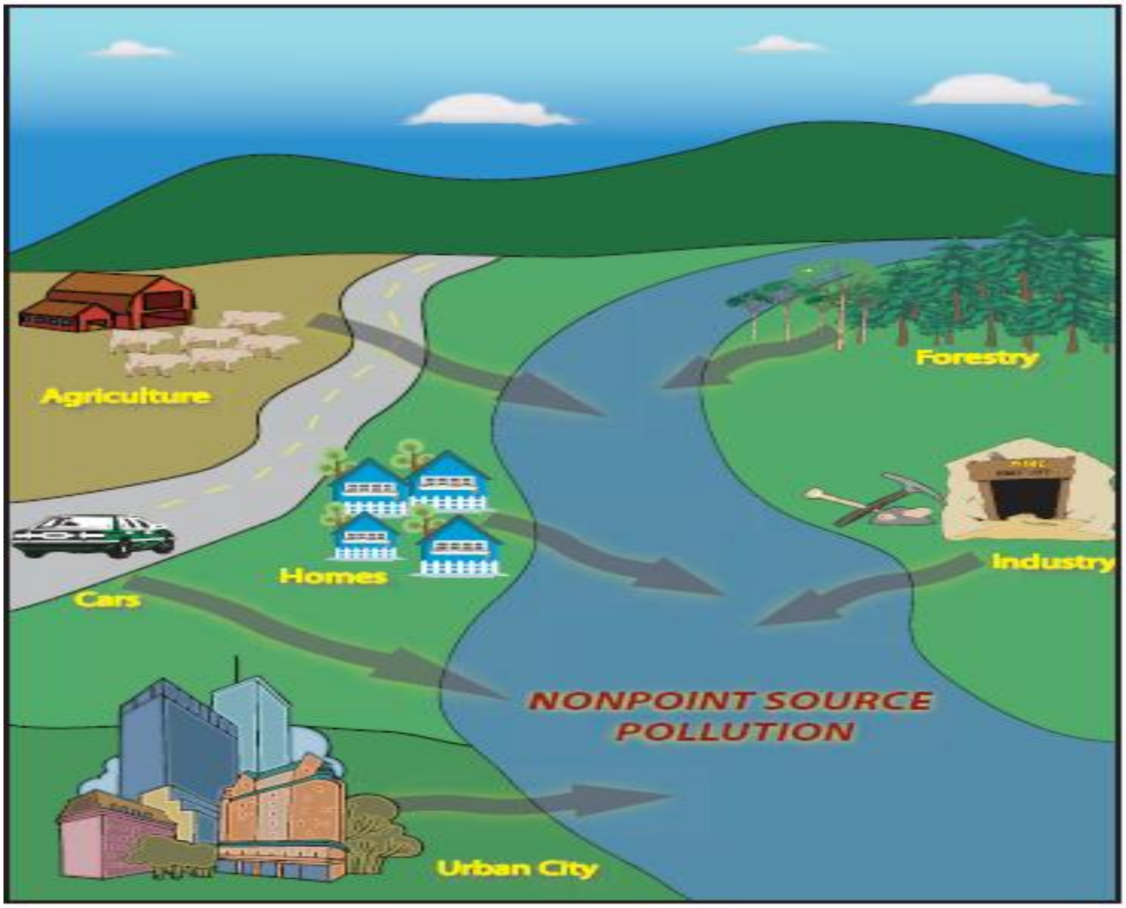

Figure 1.3 Nonpoint source pollutants originate from many different places and are carried to waterbodies by runoff. (Diagram courtesy of Texas Watershed Stewards Handbook).

A WATERSHED APPROACH

A watershed approach is a coordinated framework for environmental management that focuses the efforts of both public and private entities and landowners to address prioritized problems within a watershed, rather than multiple individual efforts based on political boundaries.

A watershed approach should include a partnership, comprised of those people who would be most affected by management decisions throughout the process to help shape key decisions. This ensures that the environmental objectives are appropriate and that those people who are dependent upon natural resources within the watershed are informed of and participate in both planning and implementation activities.

This approach also relies upon watershed stakeholders to use sound scientific data, tools and techniques in the decision making process to develop best management practices (BMPs).

WATERSHED PROTECTION PLANNING

The watershed planning process uses a series of cooperative, iterative steps to: 1) characterize existing conditions; 2) identify and prioritize problems; 3) define management objectives; 4) develop protection or remediation strategies; and 5) implement and adapt selected actions as necessary. The outcomes of this process are documented in a watershed protection plan (WPP). WPPs are typically developed according to the Environmental Protection Agency's (EPA) Elements of Successful Watershed Plans (Figure 1.4). These elements are intended to help communities, watershed organizations and state, local, tribal and federal agencies to develop and implement WPPs to meet water quality standards and protect water resources.

A. Identify the causes that need to be controlled to achieve load reductions
B. Estimate the load reductions from management measures
C. Management measures that need to be implemented to achieve load reductions
D. Technical and financial assistance needed to implement the WPP
E. Information and education that will be used to encourage public understanding and involvement in WPP
F. Timeline for implementing management measures
G. Measurable interim milestones to determine whether management measures are being implemented
H. Criteria that can be used to determine if load reductions are occurring
I. Water quality monitoring to measure effectiveness of implementation against above criteria

Figure 1.4 EPA's nine elements of a successful watershed plan.

2. THE LAMPASAS RIVER WATERSHED

The Lampasas River watershed lies within the Brazos River Basin in Central Texas which drains to the Gulf of Mexico. The Lampasas River (segment 1217) rises in eastern Mills County, 16 miles west of the city of Hamilton and flows southeast for 75 miles, passing through Hamilton, Lampasas, Burnet and Bell counties. In Bell County the river turns northeast and is dammed five miles southwest of Belton to form Stillhouse Hollow Lake (segment 1216). Below Stillhouse Hollow Lake, the Lampasas River flows to its confluence with Salado Creek and the Leon River to form the Little River. While the WPP only directly addresses the Lampasas River and its tributaries above Stillhouse Hollow Lake proper, water quality in the lake and the river downstream of the dam should reap the cumulative benefits of the WPP.

The watershed encompasses 798,375 acres across Mills, Hamilton, Coryell, Lampasas, Burnet, Bell and Williamson Counties (Figure 2.1). Lampasas County comprises 44% of the watershed while Burnet and Mills Counties comprise 22% and 17%, respectively. Bell and Hamilton Counties represent 9% and 6%, respectively, while Coryell and Williamson only occupy approximately 1% of the watershed.

The Lampasas River is primarily a rural watershed with few urban centers. The cities of Lampasas and Kempner are wholly within the watershed boundaries, while the cities of Copperas Cove and Killeen are only partially in the watershed. The communities of Goldthwaite, Evant, Lometa and Florence are all just outside of the watershed boundaries.

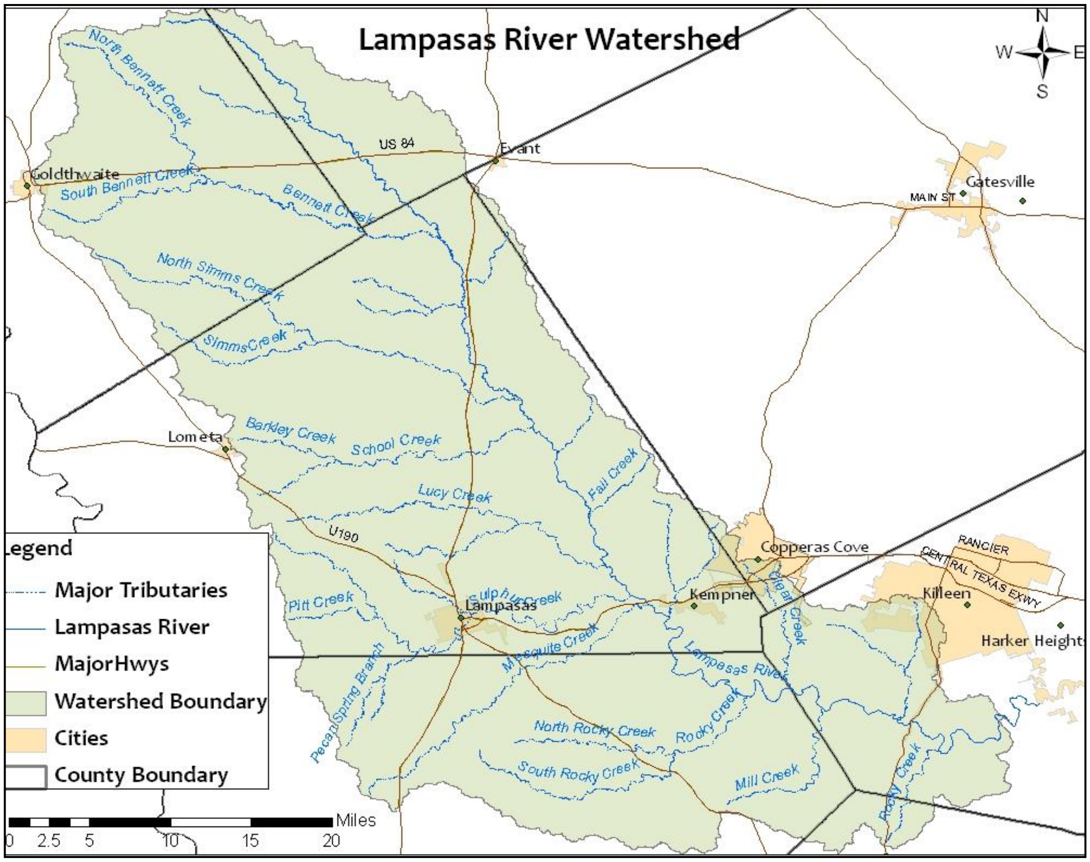

Figure 2.1 The Lampasas River watershed.

WATERSHED CHARACTERISTICS

ECOREGIONS

The Lampasas River watershed is located primarily in the Limestone Cut Plain Ecoregion, a part of the larger Cross Timbers Ecoregion (Figure 2.2). The Lampasas Cut Plain is underlain by Lower Cretaceous limestones, including the Glen Rose Formation and Walnut Clay, which are older than the limestone of the Edwards Plateau. The Glen Rose Formation has alternating layers of limestone, chert, and marl that erode differentially and generally more easily than the Edwards Limestone. The effects of increased precipitation and runoff are also apparent in the increased erosion and dissolution of the limestone layer. The Limestone Cut Plain has flatter topography, lower drainage density, and a more open woodland character than the Edwards Plateau. The vegetation is comprised primarily of post oak, white shin oak, cedar elm, Texas ash, plateau live oak, and bur oak. Although the grasslands of the Limestone Cut Plain are a mix of tall, mid, and short grasses, some consider it a westernmost extension of the tallgrass prairie, which distinguishes this ecoregion from the Edwards Plateau Woodland. Grasses include big bluestem, little bluestem, yellow Indiangrass, silver bluestem, Texas wintergrass, tall dropseed, sideoats grama, and common curly mesquite.

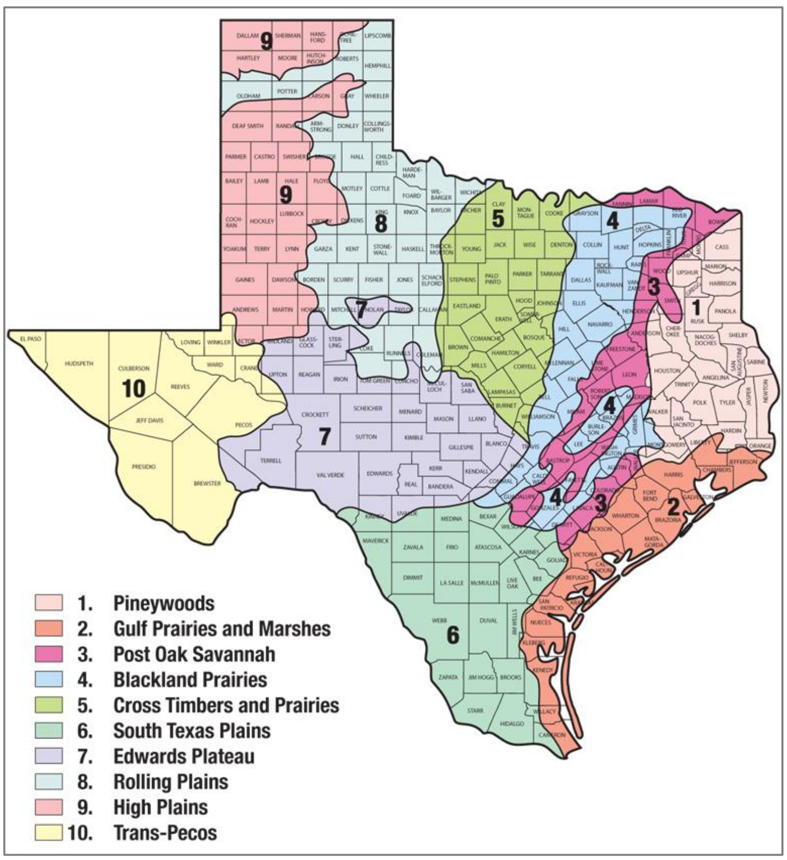

Figure 2.2 Level III Ecoregions of Texas.

WATER RESOURCES

The Lampasas River is primarily an intermitent stream in the northern reaches of the river, as well as most of the associated tributaries. Flow typically only occurs during and immediately after rainfall events. Bennett, Simms, School and Lucy Creeks are all major tributaries that empty in to the Lampasas River in the mid to upper watershed. About midway through the watershed, as the drainage size increases, the river is characterized by relatively low water levels most of the time and is heavily driven by spring flow. Sulphur Creek, in particular, provides a significant inflow of water from springs. Sulphur Creek drains through the city of Lampasas. Mesquite, Rocky, and Clear Creeks all empty into the Lampasas River in the lower watershed before it reaches Stillhouse Hollow Lake.

CLIMATE

The climate in the Lampasas River watershed is hot in the summer and cool in the winter with an occasional surge of cold air caused by a sharp drop in otherwise mild temperatures. In the summer, the average temperture is 81ºF and the average daily maximum temperature is 93ºF. The average temperature in the winter is 46ºF, with an average minimum temperature of 32ºF. Total annual precipitation is about 29 inches. Most of the yearly rainfall, 17 inches or 59%, occurs between April and September.

HISTORY

The area in and around the Lamapsas River watershed was home and hunting grounds to Indians for many centuries, prior to the arrival of the Spanish and the Anglos. Numerous campsites, kitchen middens and burial mounds and rock shelters for burials from the late prehistoric era have been found within the watershed. The Tonkawas, Lipan Apaches, Wacos, Anadarkos, Kiowas, and Comanches frequented the area.

Although several Spanish expeditions and missionaries supposedly passed through some of the present day counties of the watershed in the early 18th century, there were no known settlements until the mid 1800s. Settlers were drawn to the area after Moses Hughes and his invalid wife, Hannah, moved near the site of what is now Lampasas in November 1853, seeking to take advantage of the medicinal properties of local springs (Figure 2.3). Each summer people were drawn to Lampasas to bathe in the mineral springs, and it became a tented city with hundreds of people camped nearby.

Figure 2.3 The crumbling remains of the Hancock Springs Bathhouse, along the banks of Sulphur Creek in Lampasas. Many tourists visited the springs in the late 1800s to partake in the spring's medicinal properties.

During the 1850s and 1860s settlers in the area suffered from Comanche raids and outlawry. Several local militias were formed in the various counties to ward off Indian attacks, but aside from this there was little law and order until well after the Civil War. As white hunters began to kill off the buffalo for profit and sport, the Indians began to resent encroachment on their hunting grounds and increased their raids on the settlements. Although buffalo herds were plentiful through the 1860s, they had largely disappeared by 1875.

As the frontier became less subject to Indian attacks, agriculture became the most important industry within the Lampasas River watershed. Agriculture census numbers vary by county, but cattle numbered to nearly 44,000 head in the late 1800s to early 1900s. Sheep, pig and poultry raising were also significant ranching operations. Cropland production was secondary to livestock operations, and was concentrated on cereals, small grains, grain sorghums, cotton, pecans, and some potatoes and fruits, particularly peaches and melons.

LAND USE

There are few urban areas within the Lamapsas River watershed and they are all concentrated in the mid to lower portion of the watershed. The northern and western portions of the watershed are primarily rural and utilized for agricultural production. The City of Lampasas is located in the middle of the watershed, while Copperas Cove and Killeen are located near the southeastern tip of the watershed. All three urban areas are connected by US Highway 190 that serves as a major thoroughfaire through each community. The US Army's Fort Hood Military Installation is also partially located within the watershed, between Copperas Cove and Killeen.

Land use in the lower portion of the watershed has changed significantly over the recent decades. Fort Hood was established in 1942 to serve the US Army. Although the reservation encompasses nearly 215,000 acres of land with over 135,000 acres dedicated to vehicular maneuver training, it is primarily located in the Leon River watershed. However, a significant portion dedicated to manuever training is located in the Lampasas River watershed. In addition to the military training, rangelands are leased out to area ranchers for cattle production and those areas remain relatively untouched by urbanization.

Fort Hood's presence has had a bigger impact on the land use of the surrounding communities. Killeen, Copperas Cove and even Lampasas have experienced population growth from the placement of soldiers and their families throughout the years. Areas south of Killeen, in particular, have recently seen conversion from agricultural production to urban areas, in an effort to provide housing for military personnel. Killeen experienced a 32% growth in population between 2000 and 2010, while Copperas Cove showed a modest 8% growth. Lampasas actually showed a slight 2% decrease in population between 2000 and 2010.

LAND USE CLASSIFICATION

Identification of geophysical watershed features was necessary to determine potential pollutant sources within the watershed. As part of the development of the WPP, an up-to-date Land Use/Land Cover (LU/LC) dataset for the Lampasas Watershed was created. Various datasets were used to spatially define current land cover types within the watershed. Urban land, open water, barren land, forest, rangeland, managed pasture, unmanaged pasture and cultivated cropland were considered major land use classes (Table 2.1). Parcels were assigned classes based on natural features such as vegetation and hydrology and the degree of development by humans (Figure 2.4). Because of the close similarity of land management between both rangeland and unmanaged pasture, stakeholders made the decision to group the two into one class and call it rangeland. A more thorough discussion of the land use classification process can be found in Appendix B.

Table 2.1 Land use classes and corresponding total acreage and proportion of the Lampasas River watershed.

Land Use Class	Total Acres	Proportion of Watershed (%)
Forest	168,074	21
Barren	26,214	3
Cultivated Crop	19,003	2
Managed Pasture	49,931	6
Rangeland/Pasture	515,210	65
Water	1,666	<1
Urban	18,127	2
Total	798,225	100

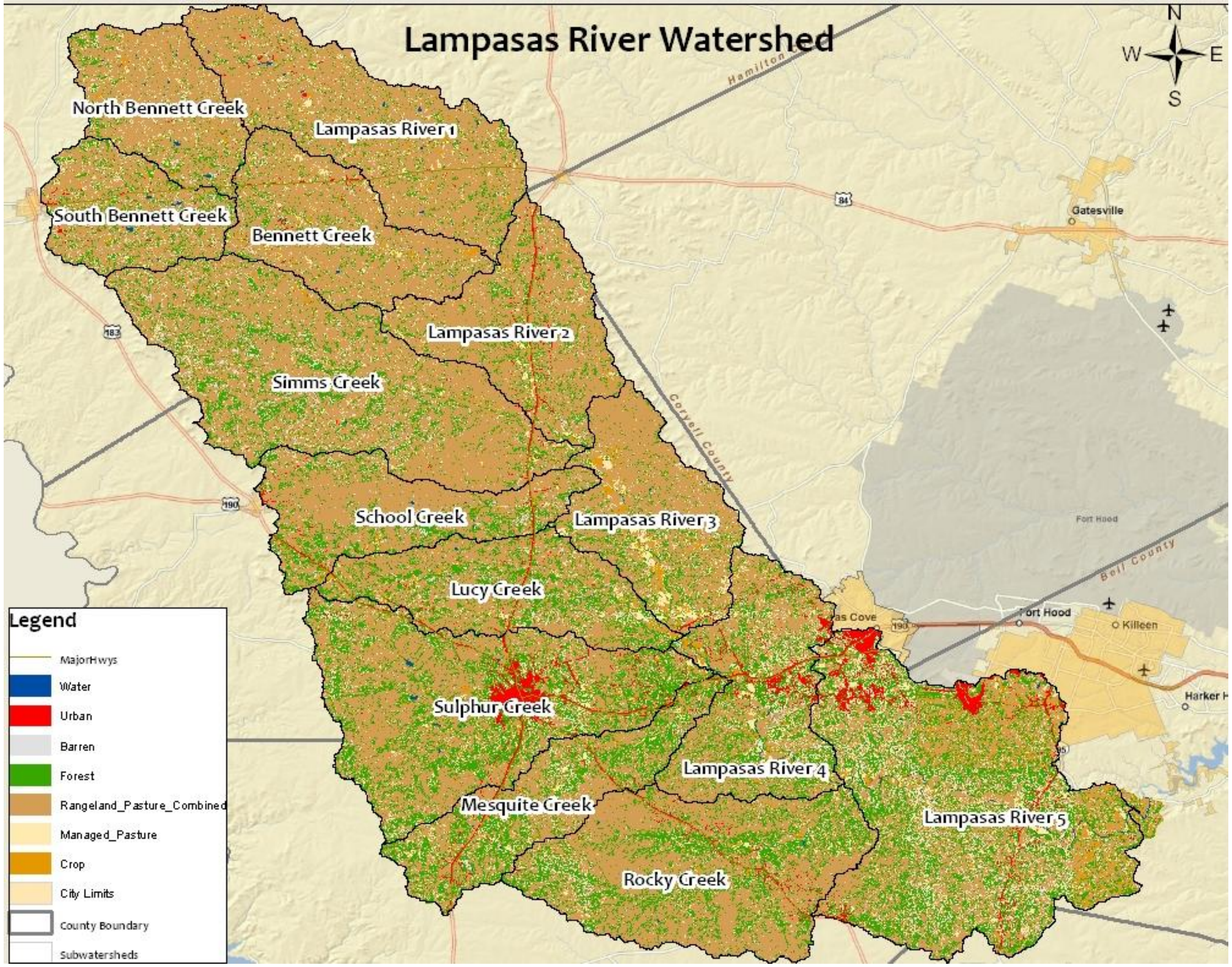

Figure 2.4 Land use classification map of the Lampasas River watershed.

SUBWATERSHED DELINEATION

The Lampasas River watershed was divided into 14 subwatersheds based upon elevation and hydrological characteristics during the LU/LC analysis (Figure 2.5). This allowed stakeholders to more closely examine potential pollutant sources and also acted as a tool in focusing implementation efforts.

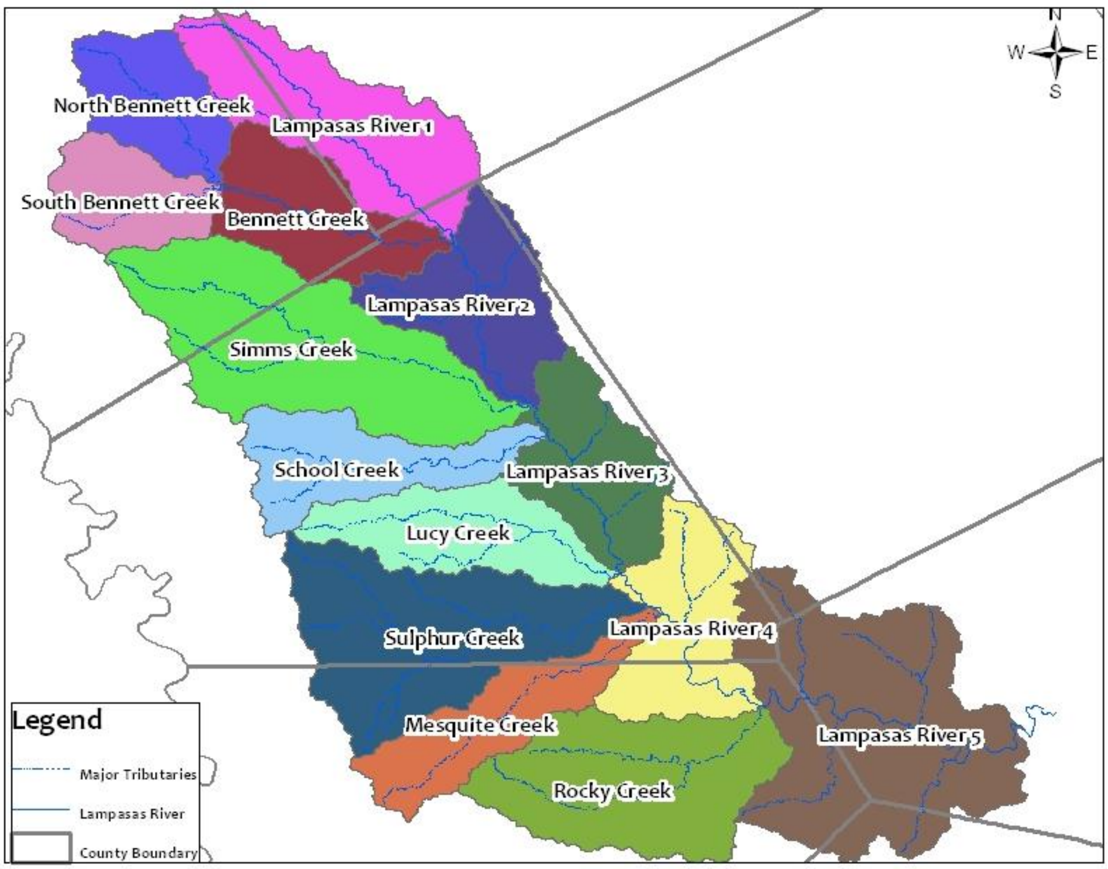

Figure 2.5 Subwatersheds of the Lampasas River watershed.

WATER QUALITY

TEXAS SURFACE WATER QUALITY STANDARDS

The 1972 Federal Clean Water Act, Section 303 required states to establish water quality standards to achieve objectives and goals. The Texas Surface Water Quality Standards (SWQS) establish explicit goals for the water quality of streams, rivers, lakes and bays. The SWQS were developed to maintain the water quality in surface waters so that it supports public health and enjoyment and protects aquatic life.

The SWQS also defines water bodies as either classified or unclassified; classified segments are individually defined in the SWQS. Applicable water quality standards for unclassified water bodies are defined according to flow type exhibited by the given stream.

ASSESSMENT UNITS

After designation as either classified or unclassified, water bodies are given a written description of the segment and further divided into assessment units (AU). AUs are the smallest geographic area of use support reported in the water body assessment. The Lampasas River above Stillhouse Hollow Lake is designated as 'classified' and broken into five AUs (Figure 2.6). There are also six 'unclassified' tributaries defined and broken into various AUs. Rocky Creek, Sulphur Creek, Simms Creek, North Rocky Creek, South Rocky Creek and Reese Creek are all broken into either one or two AUs depending on the stream.

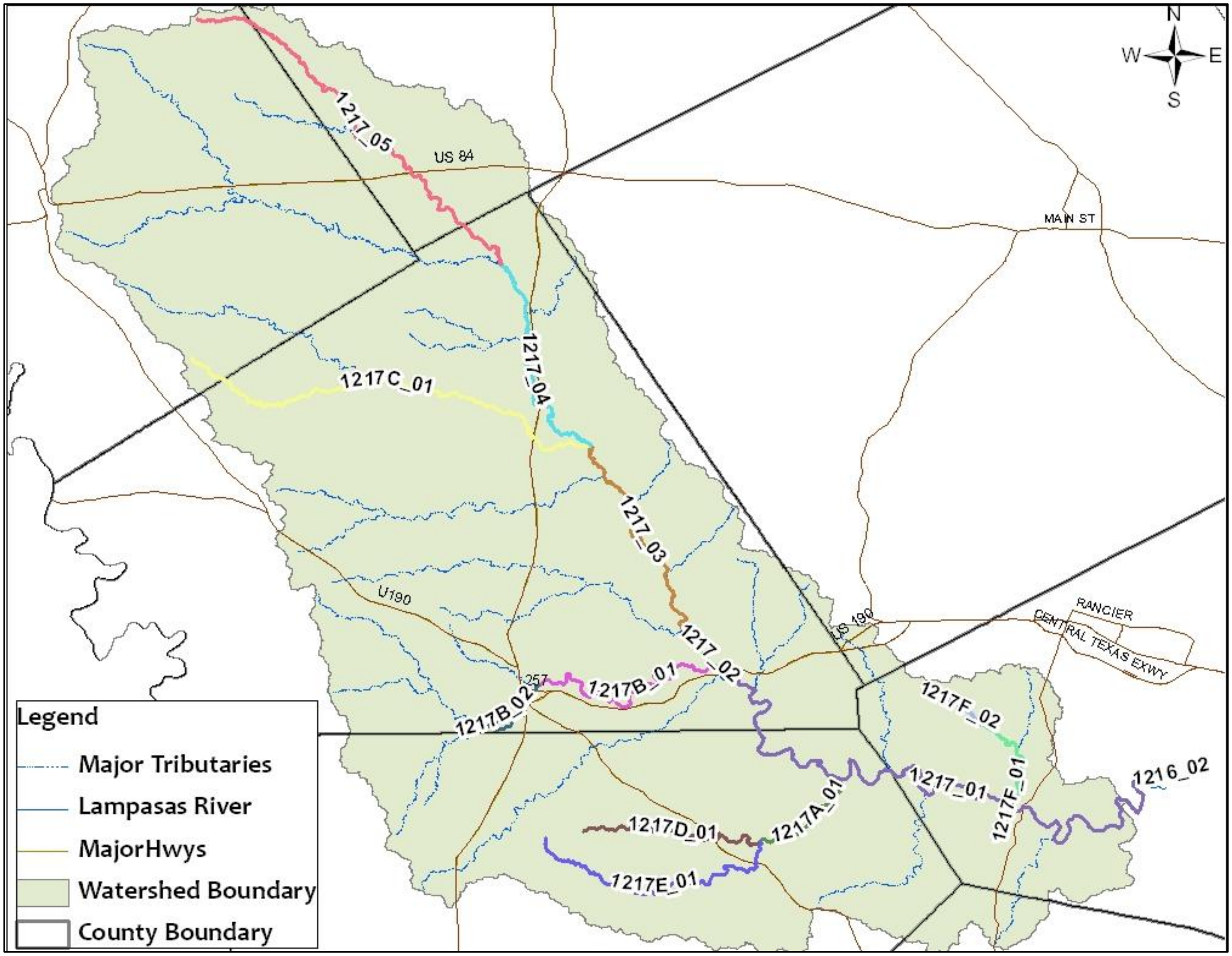

Figure 2.6 The assessment units of the Lampasas River and its tributaries as defined by TCEQ's SWQS.

DESIGNATED USES OF THE LAMPASAS RIVER

Designated uses of water bodies are defined by the SWQS for all classified and unclassified streams within the state. The Texas Commission on Environmental Quality (TCEQ) requires that the water quality in the Lampasas River and its unclassified tributaries be suitable for aquatic life use, contact recreation use and general use. Aquatic life use is defined by a water body's ability to sustain a healthy aquatic habitat and ecosystem and is measured by dissolved oxygen (DO) levels and indicies for habitat, benthic, macroinvertabrates and fish communities. Contact recreation is defined by the water body's ability to support designated levels of recreation. It is evaluated by measuring the concentration of indicator bacteria organisms or colony forming units (CFU) in 100 milliliters (mL) of water. *Escherichia coli* (*E. coli*) is the indicator organism used in the Lampasas River and its tributaries. An indicator organism is used rather than a direct measurement of individual pathogens because it is generally indicative of potential contamination of fecal matter from warm blooded animals. General use refers to a general assessment of the water quality and includes criteria that measures water temperature, pH, chloride, sulfate, and total dissolved solids. Water quality standards used to evaluate the Lampasas River and its tributaries are found in Table 2.2. Standards may be revised on a site-specific basis when sufficient information is available.

Table 2.2 2010 Surface Water Quality Standards as set by TCEQ.

Parameter	Criteria
Water Temperature	32.8° C
Dissolved Oxygen	absolute minimum - 3.0mg/L 24hr minimum - 5.0mg/L
pH	6.5 - 9.0
E. coli	geometric mean ≥ 126 cfu/100 mL
Chloride	500 mg/L
Sulfate	100 mg/L
Total Dissolved Solids	1200 mg/L

WATER QUALITY INVENTORIES

TCEQ conducts the actual water body assessments every two years. This asssessment utilizes data collected of the most recent 7 years, collected by various partners and entities across the state. The most recent assessment was conducted in 2010, utilizing data collected between December 1, 2003 and November 30, 2010 (Table 2.3). This assessment was previously called the "Texas Water Quality Inventory and 303(d) List" (referred to as the 303(d) List) but is now called the "Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)" (referred to as the Integrated Report). During these assessments, a water body is deemed to be either Fully Supporting (FS), Non Supporting (NS) or Not Assessed (NA) of its individual designated use.

Table 2.3 Assessment units of the Lampasas River and their corresponding status of support for aquatic life, contact recreation and general use, based upon the 2010 Integrated Report.

Assessment Unit ID	Stream Segment Name	Assessment Unit Description	Aquatic Life	Contact Recreation	General Use
1217_01	Lampasas River Above Stillhouse Hollow Lake	Portion of Lampasas River from confluence with Rock Creek in Bell County, upstream to confluence with Mesquite Creek, west of Kempner in Lampasas County.	FS	FS	FS
1217_02	Lampasas River Above Stillhouse Hollow Lake	Portion of Lampasas River from confluence with Mesquite Creek upstream to confluence with Lucy Creek in Lampasas County.	FS	FS	FS
1217_03	Lampasas River Above Stillhouse Hollow Lake	Portion of Lampasas River from confluence with Lucy Creek upstream to confluence with Simms Creek in Lampasas County.	NA	NA	FS
1217_04	Lampasas River Above Stillhouse Hollow Lake	Portion of Lampasas River from confluence with Simms Creek upstream to confluence with Bennett Creek in Lampasas County.	NA	NA	FS
1217_05	Lampasas River Above Stillhouse Hollow Lake	Portion of Lampasas River from confluence with Bennett Creek upstream to its headwaters in Mills County.	NA	NA	FS
1217A_01	Rocky Creek (unclassified water body)	Entire water body.	FS	FS	NA
1217B_01	Sulphur Creek (unclassified water body)	Portion of Sulphur Creek from the confluence with the Lampasas River upstream to confluence with Burleson Creek in the City of Lampasas, Lampasas County.	FS	FS	NA
1217B_02	Sulphur Creek (unclassified water body)	Portion of Sulphur Creek from the confluence with Burleson Creek upstream to the confluences with Donalson Creek and Espy Branch west of Lampasas in Lampasas County.	NS	FS	NA

Assessment Unit ID	Stream Segment Name	Assessment Unit Description	Aquatic Life	Contact Recreation	General Use
1217C_01	Simms Creek (unclassified water body)	Entire water body.	NA	NA	NA
1217D_01	North Rocky Creek (unclassified water body)	Entire water body.	NS	NA	NA
1217E_01	South Rocky Creek (unclassified water body)	Entire water body.	FS	NA	NA
1217F_01	Reese Creek (unclassified water body)	From confluence with Lampasas River above Stillhouse Hollow Lake upstream to confluence with un-named tributary (NHD reach code 12070203002555).	FS	NA	NA
1217F_02	Reese Creek (unclassified water body)	From confluence with un-named tributary (NHD reach code 12070203002555) upstream to headwaters in Bell County.	NA	NA	NA

WATER QUALITY MONITORING SITES

Water quality data collection has been ongoing in the Lampasas River and its tributaries since 1972 (Table 2.4); various parameters have been measured throughout the years. Site locations have been changed and moved over time at the discretion of monitoring agencies, stakeholder input and available funding. It is important to note that sampling sites may have long time periods of time between monitoring. These data gaps are discussed more in Chapter 4.

Table 2.4 Water quality data collected at 29 individual sampling sites for various time periods beginning in 1972.

Station ID	Description	Start	End
11724	Rocky Creek at FM 963	1988	2009
11725	South Fork Rocky Creek at FM 963	1981	1997
11895	Lampasas River at FM 2484	1973	2009
11896	Lampasas River at SH 195	1972	2002
11897	Lampasas River at US 190	1981	2009
15250	Sulphur Creek at Lampasas CR 8 (FM 1715)	1996	2009
15762	Lampasas River at US 84	1998	1999
15763	Simms Creek at US 281	1998	1999
15766	Sulphur Creek at Lampasas Park	2004	2006
15770	Lampasas River at CR 105	1998	2009
15780	Sulphur Creek at SH Loop 257	2005	2006
15781	Sulphur Creek at Lampasas CR 7	1999	2006
15782	Sulphur Creek near Santa Fe Rd	2005	2005
16358	Sulphur Creek at Deadman's Cut	2005	2006
16404	Lampasas River at FM 2313	1998	1999
18330	Rocky Creek, 1.6 KM Upstream FM 963	2002	2004
18331	Rocky Creek 6.6 KM Upstream 963	2002	2004
18332	Rocky Creek 8.9 KM Upstream 963	2002	2004
18333	South Fork Rocky Creek at S US 183	2002	2007
18334	North Fork Rocky Creek at S US 183	2002	2004
18657	South Rocky Creek at US 183	2005	2005
18759	Reese Creek near FM 2670/ Burnet CR 985	2006	2006

Station ID	Description	Start	End
18760	Sulphur Creek at Burnet CR 988	2006	2009
18761	Lampasas River at FM 2484/ Burnet CR 986	2006	2006
18782	Sulphur Creek at Naruna Rd	2006	2006
18783	Sulphur Creek 105 M DS US 183	2006	2009
18784	Hannah Springs near Burleson Creek	2006	2006
18787	Sulphur Creek at Hancock Springs	2006	2006
18850	Reese Creek Downstream Maxdale Rd	2006	2007

Contact Recreation Impairments

The Lampasas River first appeared on the 2002 303(d) List based up data collected in 1998 and 1999 (Table 2.3). Segments 1217_04 (Lampasas River from confluence with Simms Creek upstream to confluence with Bennett Creek) and 1217_05 (Lampasas River from confluence with Bennett Creek upstream to its headwaters in Mills County) were both listed as 'Non Supporting' for contact recreation uses. Twelve bacteria samples collected from July 1998 through June 1999 at each site exceeded the fecal coliform standards. Although no additional data had been collected in these segments, these impairments have been carried forward to subsequent lists in the following years.

Typically data from the past 7 years is used to determine attainability of standards but in cases such as this, data from the past 10 years may be used. However, at least half of the samples must come from the most recent 7 years. There is no data for the sites in question within the 7 years prior to the 2010 assessment, so TCEQ removed the Lampasas River from the 2010 303(d) List.

All other segments of the Lampasas River and its tributaries have always met water quality standards for contact recreation.

Aquatic Life Use Impairments

Data collected prior to 2002 also indicated that Rocky Creek (Segment 1217A_01) did not meet the criteria for aquatic life use and had low 24 hour dissolved oxygen concentrations (Table 2.3). As a result, TCEQ initiated a Total Maximum Daily Load (TMDL) project to determine measures to restore water quality within the stream. TMDLs determine the amount of a specific pollutant that a water body can receive and still support its designated uses. This allowable load is then allocated to the potential sources within the watershed. Measures to reduce pollutant loads are then developed as necessary.

The TCEQ evaluated the sources of oxygen-demanding materials and their impacts in Rocky Creek by conducting 24-hour dissolved oxygen measurements over a two year period. Measurements were collected between August 2002 and September 2004. All monitoring locations on Rocky Creek were in compliance with the standards except the site located on the North Fork Rocky Creek. The main stem of Rocky Creek was delisted from the 2008 303(d) List; however, North Fork Rocky Creek was listed as having a dissolved oxygen impairment and 'non-supporting' of its aquatic life use designation. Further biological data collection indicates that the North Fork Rocky Creek supports a relatively healthy biologic community. The 2010 revision to the SWQS allows for site-specific standards based upon collected data. These new standards will be used in the 2012 assessment and it is expected that the North Fork Rocky Creek will be removed from the 303(d) List.

Sulphur Creek (Segment 1217B_02 Sulphur Creek from the confluence with Burleson Creek upstream to the confluences with Donalson Creek and Espy Branch west of Lampasas) was listed as ‘non-supporting’ of its designated aquatic life use for depressed dissolved oxygen on the 2010 303(d) List.

3. THE LAMPASAS RIVER WATERSHED PARTNERSHIP

After being placed on the 2002 303(d) List, the Lampasas River was selected by TSSWCB and Texas A&M AgriLife Research (AgriLife Research) for the development and implementation a WPP. In addition to being listed as impaired, the Lampasas River also had two active volunteer organizations that were working to protect and improve water resources; the Friends of Sulphur Creek were advocates for Sulphur Creek in Lampasas, while the Lake Stillhouse Cleanwater Steering Committee worked to protect the river and lake in the Killeen area of the watershed.

The Lampasas River Watershed Partnership (The Partnership) was formed to facilitate the development and implementation of the WPP to address the bacteria impairment and other water quality concerns within the Lampasas River watershed (Figure 3.1). The Partnership is comprised of concerned citizens, organizations and municipal and county representatives. Approximately 250 stakeholders have participated in the Partnership, providing their input on the content to be included in the WPP. A stakeholder is an individual or organization that has a vested interest (i.e. stake) in the welfare of a particular natural resource or that is affected in a significant way by the implementation of recommendations designed to protect and restore the resource. The Partnership was officially formed in November 2009.

Figure 3.1 Stakeholders attend a project kickoff meeting in Lampasas, TX on May 12, 2009.

PARTNERSHIP GOALS

The goal of the Partnership is to develop and implement a WPP to improve, protect and meet water quality goals set by the Partnership and supports statewide efforts to meet designated uses for contact recreation and a healthy aquatic ecosystem for the Lampasas River.

PARTNERSHIP ORGANIZATION

The Partnership is structured to allow stakeholders to debate and provide insight and input on decisions while still being able to make recommendations in a timely manner.

To facilitate this process, the Partnership includes 3 levels of participation for stakeholders; a general Partnership, topical work groups and a Steering Committee.

Steering Committee

The Steering Committee serves as the decision-making body for the Partnership and consists of 18 members that either volunteered or were nominated by others within the watershed. The Steering Committee is an independent group of watershed stakeholders and individuals with an interest in restoring and protecting the designated uses and the overall health of the Lampasas River watershed. Members include both individuals and representatives of organizations and agencies. A variety of members serve on the Steering Committee to reflect the diversity of interests within the Lampasas River watershed and to incorporate the viewpoints of those who will be affected by the WPP.

Early in the formation of the Partnership, the Steering Committee members agreed upon a set of Ground Rules to operate under and to provide direction for roles and responsibilities (Appendix A). The Steering Committee worked towards a consensus when making decisions and recommendations. Consensus was defined as everyone being able to live with the decisions made. If consensus could not be reached, the issue was decided by a simple majority vote. Members made formal recommendations with a two-thirds majority vote. Steering Committee members were specifically tasked with the following responsibilities:

- Identify the desired water quality conditions and measurable goals;
- Prioritization of programs and practices to achieve goals;
- Help develop a WPP document;

- Lead efforts to implement WPP at the local level; and
- Communicate implications of the WPP to other affected parties in the watershed.

In order to accomplish these tasks, the Steering Committee formed Work Groups to assist in developing inputs for the characterization of the watershed, recommended management measures and to prioritize implementation strategies.

Work Groups

Topical work groups were formed to focus on specific areas of concern. Work Groups were composed of Steering Committee members and any other member of the Partnership with a vested interest or expertise within that topic. Five Work Groups were initially formed. However as the WPP process developed, the Steering Committee agreed to consolidate the original five into two work groups. The two final groups were Agriculture and Wildlife Work Group and Urban Nonpoint Source Work Group. Work Groups were facilitated by AgriLife Research and TSSWCB and met on an as needed basis, typically bimonthly.

Within each Work Group, members brought their own expertise about individual topics, knowledge of particular geographic areas of the watershed and familiarity of the needs and concerns of their peers. The Work Groups utilized this personal knowledge, along with guidance from state and federal technical agencies, to develop inputs for the characterization of the watershed, identify reasonable management measures and areas of priority for implementation. The Steering Committee relied upon the Work Group members to be mindful of their peers needs and concerns. Their recommendations were then presented to the Steering Committee and Partnership for discussion and approval.

The Agriculture and Wildlife Work Group focused on bacteria contributions from livestock, including cattle, goats, sheep and horses; as well as contributions from feral hogs and whitetail deer. The Urban Nonpoint Source Work Group prepared recommendations on bacteria contributions from wastewater systems, including WWTFs and on-site sewage facilities (OSSF), pet waste and urban stormwater. Approximately 56 stakeholders participated on the various Work Groups.

General Partnership

All meetings were open to the general public and the General Partnership members. The General Partnership consists of interested stakeholders who wished to attend meetings and be kept informed of the WPP process, but didn't wish to be involved in developing recommendations. All inputs for watershed characterization, management recommendations and implementation strategies were discussed in open Steering Committee meetings where members of the Partnership were able to offer discussion and voice any concerns.

TECHNICAL ADVISORY GROUP

A Technical Advisory Group (TAG) was formed that consisted of state and federal agencies with water quality responsibilities and other technical expertise in land and water management. AgriLife Research hosted a meeting of all participating agencies in February 2010 to discuss the water quality data and needs of the Lampasas River watershed. Members of the TAG also participated in the Work Group and Steering Committee meetings as needed to provide expertise in their particular field. The TAG includes representatives from the following agencies and organizations:

- Texas A&M AgriLife Extension Service;
- Texas A&M AgriLife Research;
- Texas Commission on Environmental Quality;
- Texas Department of Agriculture;
- Texas A&M Forest Service;
- Texas Parks and Wildlife Department (TPWD);
- Texas State Soil and Water Conservation Board;
- Texas Water Development Board (TWDB);
- Texas Water Resources Institute;
- Texas A&M Wildlife Services (TWS);
- Environmental Protection Agency; and
- Natural Resources Conservation Service (NRCS).

ADAPTIVE IMPLEMENTATION

As recommended management measures are put into place in the Lampasas River watershed, it will be necessary to track changes in water quality over time and make adjustment to the implementation strategy as necessary. Utilizing adaptive implementation will provide the Partnership the flexiblity needed to make such adjustments throughout the implementation process. Adaptive implementation and how it will be utilized in during implementation by the Partnership will be discussed in further depth in Chapter 8.

4. ESTIMATES OF POLLUTANT LOADS AND LOAD REDUCTIONS

LOAD DURATION CURVES

The Load Duration Curve (LDC) approach was developed for the assessment of nutrient loading within streams (EPA 2007) and has become a popular method of analysis in the development of WPPs to differentiate between point and nonpoint sources that contribute to bacterial contamination within a stream system.

An LDC is developed by first constructing a flow duration curve (FDC) using streamflow data. FDCs use historical streamflow data to determine how frequently stream conditions exceed different flows. Flow data are then multiplied by a threshold concentration (desired target or an official water quality criterion) of a pollutant; in this case *E. coli*. A threshold concentration of 126 CFU/100 mL for *E. coli* bacteria was used in developing the LDC analysis for the Lampasas River watershed, which is the Texas *E. coli* standard. Water quality data collected prior to 2001 was reported as fecal coliform and in these cases the Steering Committee recommended that a fecal coliform to *E. coli* conversion factor of 0.63. This is the same conversion factor utilized in the SWQS.

Once daily flow and threshold concentrations are multiplied together, they graphically illustrate the estimated pollutant load (Figure 4.1). The resulting LDC demonstrates the maximum pollutant load that a stream can carry without exceeding regulatory criteria across the five flow regimes.

Historical stream monitoring data can be plotted for that specific pollutant on the curve to illustrate when and to what extent the regulatory criteria are exceeded. In Figure 4.1, the solid red line indicates the maximum allowable stream load for *E. coli* bacteria and the squares, diamonds, X's, asterisks, and circles represent the monitored loads from the water quality data for the different flow regimes. When the monitored loads are above the solid red line, the actual stream load has exceeded the regulatory maximum standard. When monitored loads are below the solid red line, the stream load is below the state standard and meets the SWQS. A regression analysis of the monitored data (the solid blue line) can be calculated to produce estimates of percent reduction needed to achieve acceptable pollutant loads.

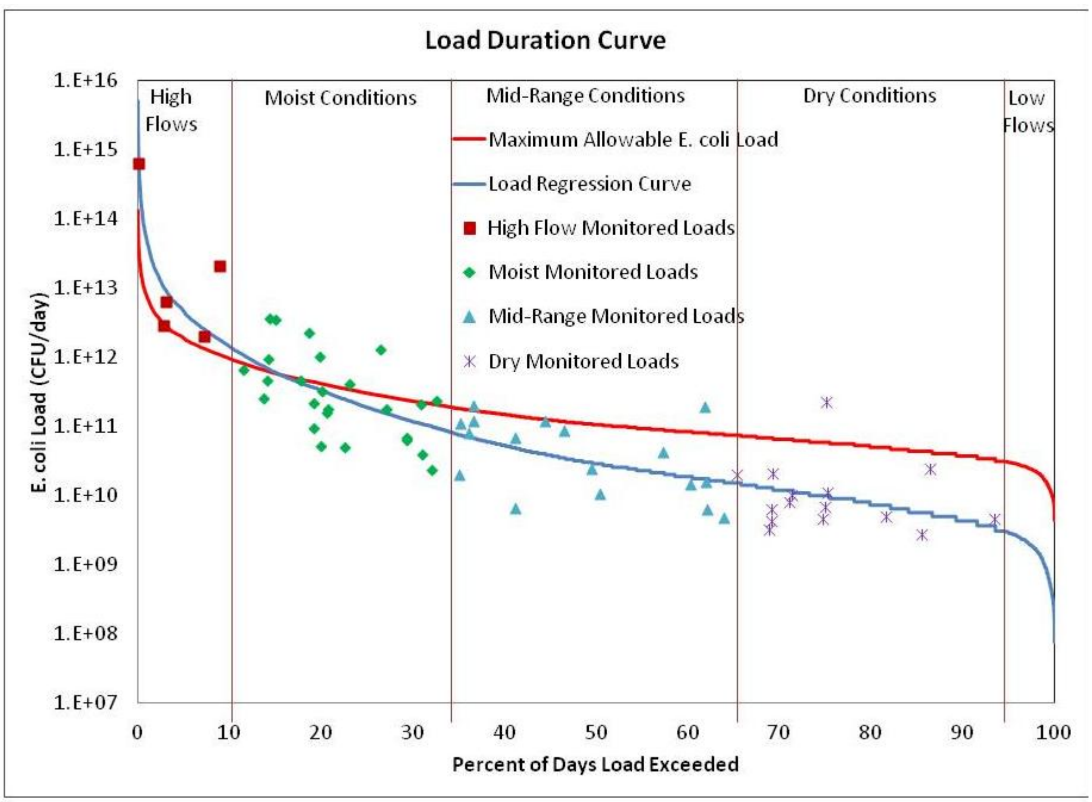

Figure 4.1 Example of a load duration curve.

The resulting graphics illustrate the estimated load and the maximum allowable load for a specific pollutant in five flow regimes, allowing stakeholders to make assumptions about possible pollutant sources within each flow regime. Point sources are assumed to be present with constant loadings during all flow regimes, while nonpoint sources are typically present in streams during high flows due to rainfall and runoff events. Table 4.1 illustrates some typical pollutant sources and which flow conditions they are most likely to be present in.

Table 4.1 Potential pollutant sources and their relative influence under given flow conditions.

Contributing Source Area	Duration Curve Zone				
	High Flow	Moist Conditions	Mid-Range Conditions	Dry Conditions	Low Flow
Point Source				*M*	*H*
On-site wastewater systems			*H*	*M*	
Riparian Areas		*H*	*H*	*H*	
Stormwater: Impervious Areas		*H*	*H*	*H*	
Combined sewer overflows	*H*	*H*	*H*		
Stormwater: Upland	*H*	*H*	*M*		
Bank erosion	*H*	*M*			

Note: Potential relative importance of source area to contribute loads under given hydrologic conditions (H: High; M: Medium)

LDC analyses were performed for *E. coli* at 6 monitoring sites within the Lampasas River watershed (Figure 4.2). Four monitoring sites were located on the main stem of the Lampasas River, while the remaining two were on different major tributaries, Sulphur Creek and Rocky Creek. Although several of the monitoring sites are currently part of routine water quality sampling, LDCs were completed using data collected on or prior to July 31, 2010.

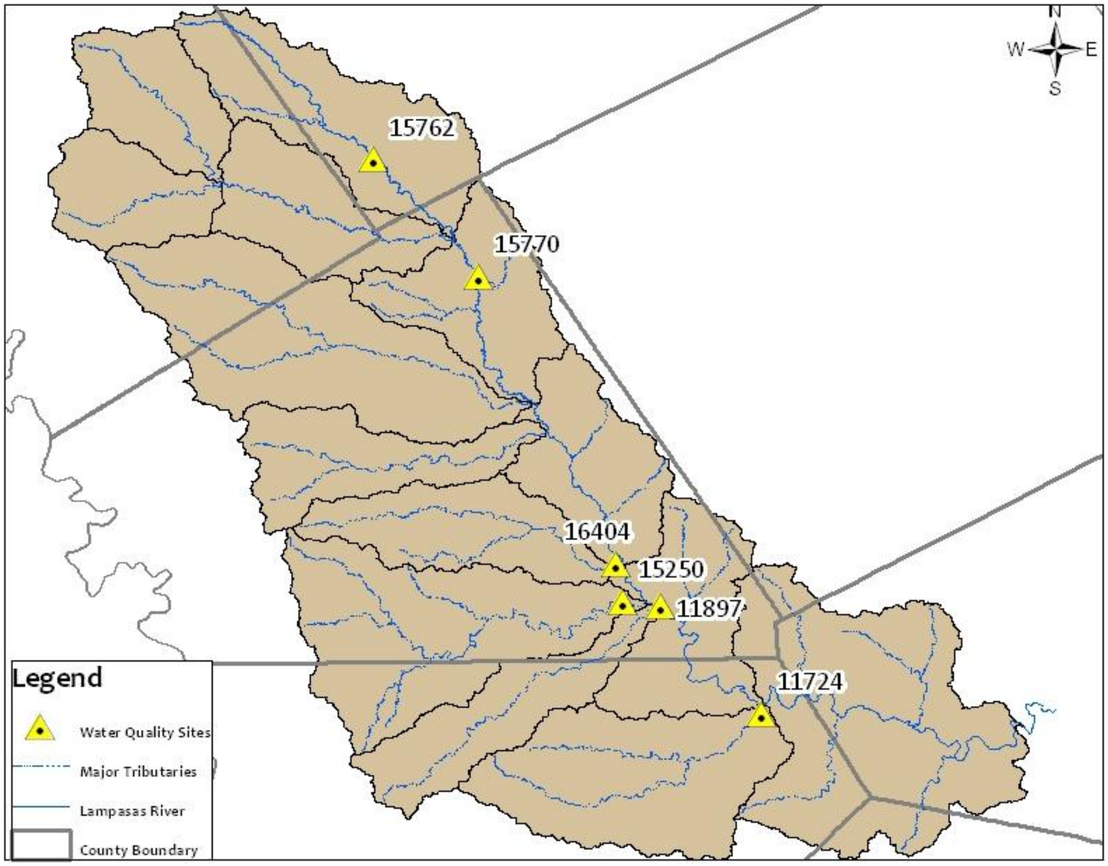

Figure 4.2 LDC analyses were performed for 6 monitoring sites within the watershed.

DATA LIMITATIONS

Although there have been many water quality monitoring sites throughout the watershed over the past 30 years, most of the sites lack continuity and longetivity in their sampling period. Unfortunately, several of the sites deemed important and most representative of their upstream drainage area have this same problem (Table 4.2). Sites 15762, 15770 and 16404 each have less than 20 data points. The majority of the data points have been collected during moist conditions, leaving the other flow regimes with insufficent data points to make assumptions. The Partnership decided to include those sites with the caveat that additional data would be collected through the WPP to validate the initial LDC analyses.

Table 4.2 The number of samples and the sample period used in the LDC analyses varied by individual water quality monitoring site.

Site ID	Description	Sample Period	Number of Samples
15762	Lampasas River at US 84	1998 - 1999	14
15770	Lampasas River at CR 105	1998-1999; 2009-2010	18
16404	Lampasas River at FM 2313	1998-1999	15
15250	Sulphur Creek at Lampasas CR 8	1996-2010	77
11897	Lampasas River at US 190	1988; 1998-2010	62
11724	Rocky Creek at FM 963	1988-1989; 1998-1999; 2006-2010	38

LAMPASAS RIVER AT US HWY 84

The Lampasas River at US Hwy 84 monitoring site, TCEQ Site 15762 (Figure 4.3), is located in the northern portion of the watershed in Hamilton County and is the most upstream sampling location. The upstream drainage area is primarily rangeland and drains approximately 56 square miles. Water quality samples were collected on a monthly basis in 1998 and 1999 and then discontinued due to intermittent flow at sampling site (Table 4.2). There are insufficient data points to make assumptions in all flow conditions, with the exception of moist conditions (Figure 4.4). The geomean of the nine samples collected in moist conditions is 109 cfu/100 mL, which is below the state surface water quality standard of 126 cfu/100 mL and does not indicate a bacteria impairment.

Figure 4.3 Monitoring site 15762 Lampasas River at US HWY 84, Hamilton County, TX.

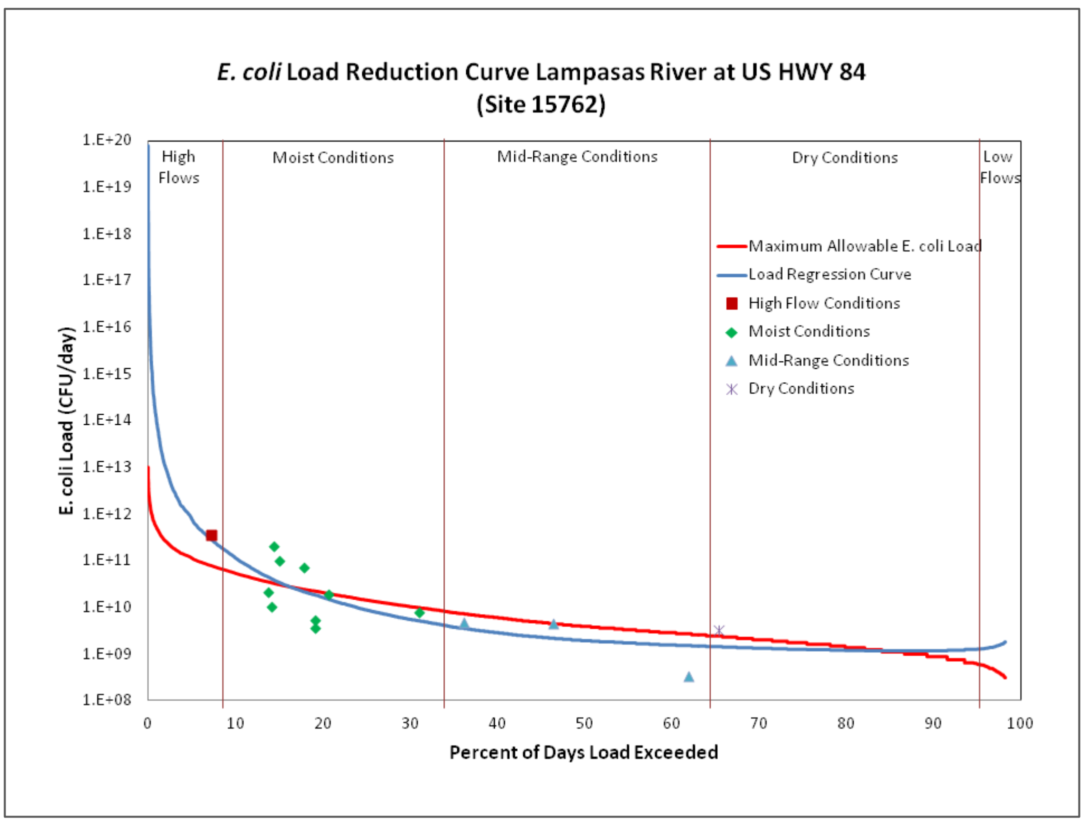

Figure 4.4 *E. coli* load duration curve for site 15762.

LAMPASAS RIVER AT LAMPASAS CR 2925

The Lampasas River at Lampasas CR 2925 monitoring site, TCEQ Site 15770 (Figure 4.5), is located in northern Lampasas County approximately 2.5 miles (or 3.3 river miles) downstream of the Bennett Creek confluence. The upstream drainage area is primarily rangeland and drains 279 square miles. Water quality samples were collected on a monthly basis in 1998 and 1999 and then discontinued due to intermittent flow. Although this particular sampling site was placed on the 2002 303(d) List because of those data points, no additional water sampling was conducted until 2009. TCEQ began a two year monthly water quality sampling protocol in September 2009. The limited number of samples collected make it difficult to make any assumptions about potential pollutant sources; only the Moist Conditions flow regime includes adequate sampling points (Figure 4.6). While the geomean for the Moist Conditions regime is 128 cfu/100 mL, when correlated with flow in the LDCs, it is below the maximum allowable loading and shows no reductions are necessary to meet state standards. The LDC does indicate a rise of the load regression curve during “Low Flow” conditions. However, this is an anomally and is caused by the lack of monitored data points during that flow condition and the equation used to derive the regression line.

Figure 4.5 Monitoring site 15770; Lampasas River at CR 2925, Lampasas County, TX.

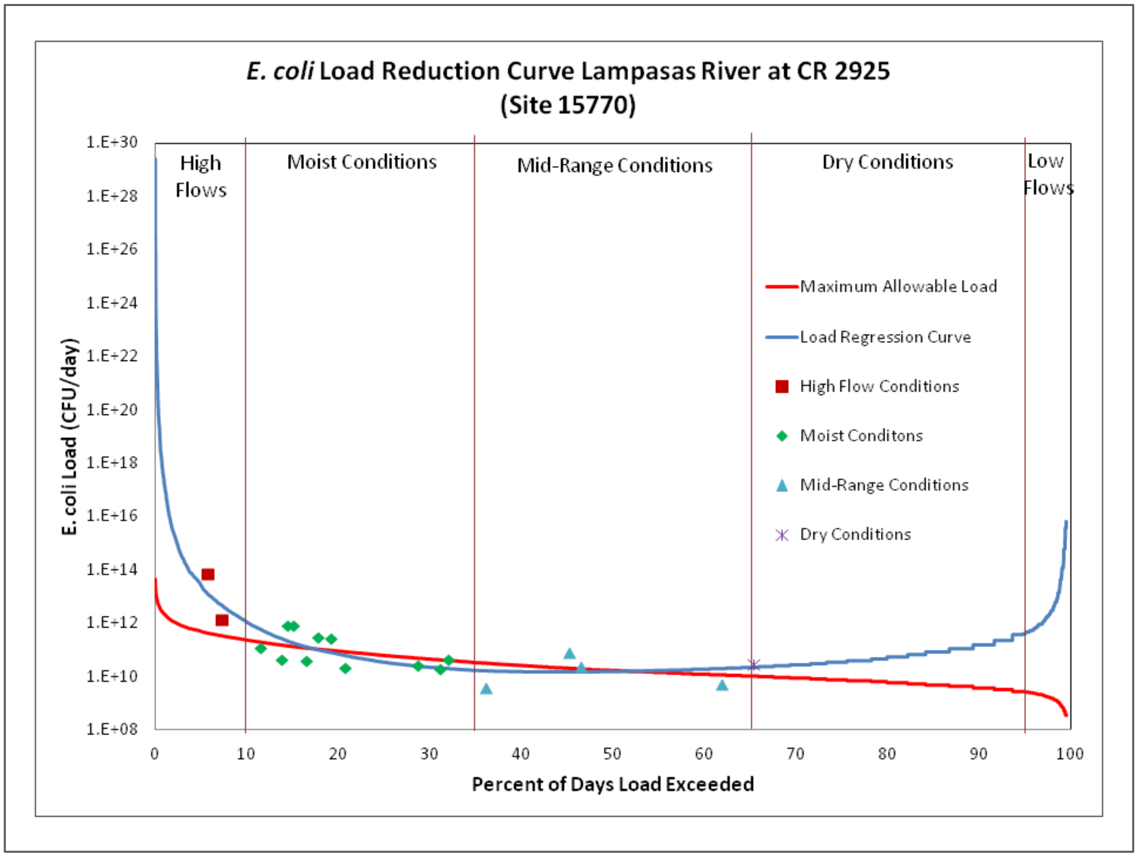

Figure 4.6 *E. coli* load duration curve for site 15770.

LAMPASAS RIVER FM 2313

The Lampasas River at FM 2313 monitoring site, TCEQ Site 16404 (Figure 4.7), is located in southern Lampasas County approximately 2.8 miles (or 3.4 river miles) upstream of the Sulphur Creek confluence. The upstream drainage area is primarily rangeland and drains 609 square miles. Water quality samples were collected on a monthly basis in 1998 and 1999 and then discontinued. The limited number of samples collected (Table 4.2) make it difficult to make any assumptions about potential pollutant sources; only the Moist Conditions flow regime includes adequate sampling points

(Figure 4.8). While the geomean for the Moist Conditions regime is 165 cfu/100 mL, when correlated with flow in the LDCs, it is well below the maximum allowable loading and indicates that no reductions are necessary.

Figure 4.7 Monitoring site 16404; Lampasas River at FM 2313, Lampasas County, TX.

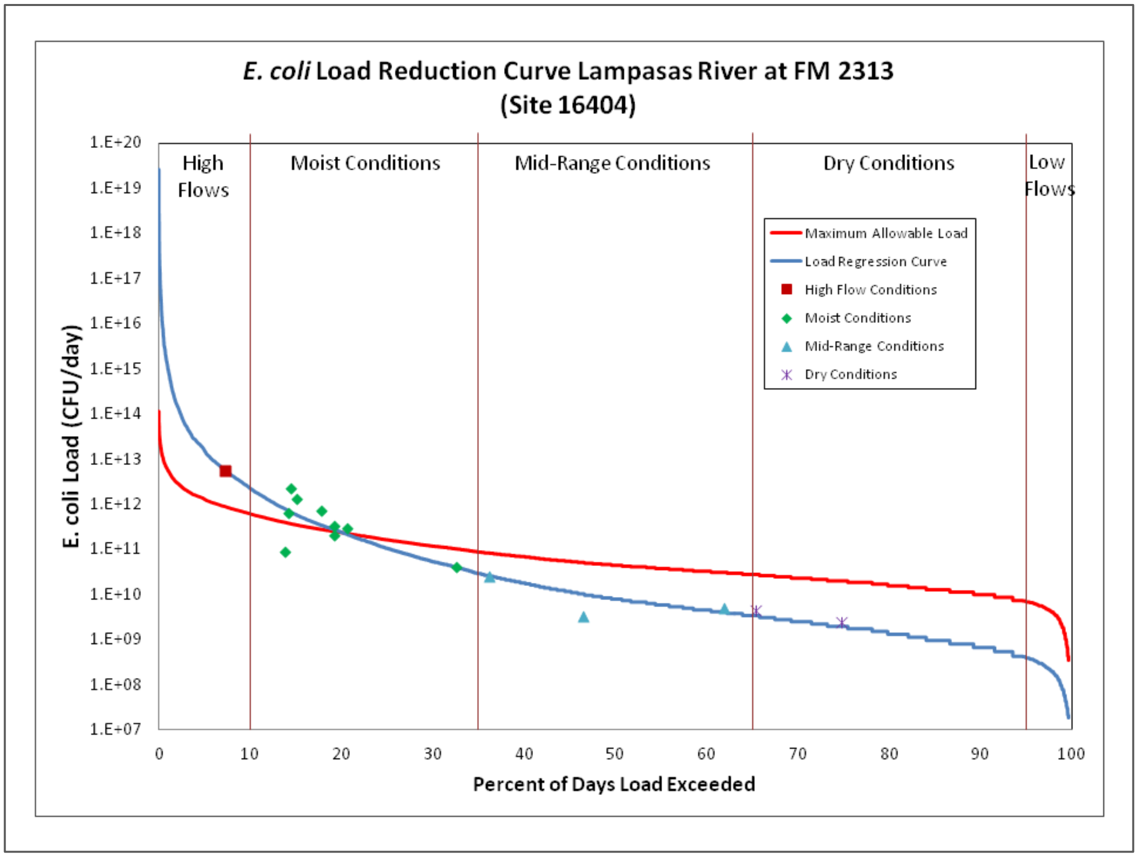

Figure 4.8 *E. coli* load duration curve for site 16404.

SULPHUR CREEK AT LAMPASAS CR 3050

The Sulphur Creek at Lampasas CR 3050 monitoring site, TCEQ Site 15250 (Figure 4.9), is located in southern Lampasas County approximately 1.2 miles (or 1.6 river miles) upstream of its confluence with the Lampasas River. The upstream drainage area is mixed rural and urban and drains 130 square miles. The City of Lampasas and the city-owned WWTF is also upstream of this sampling site. Water quality samples have been collected on a monthly or quarterly basis since 1996. With the exception of the

High Flow category, *E. coli* loads are well within the SWQS in all other flow regimes and do not indicate a bacteria impairment (Figure 4.10).

Figure 4.9 Monitoring site 15250; Sulphur Creek at CR 3050, Lampasas County, TX.

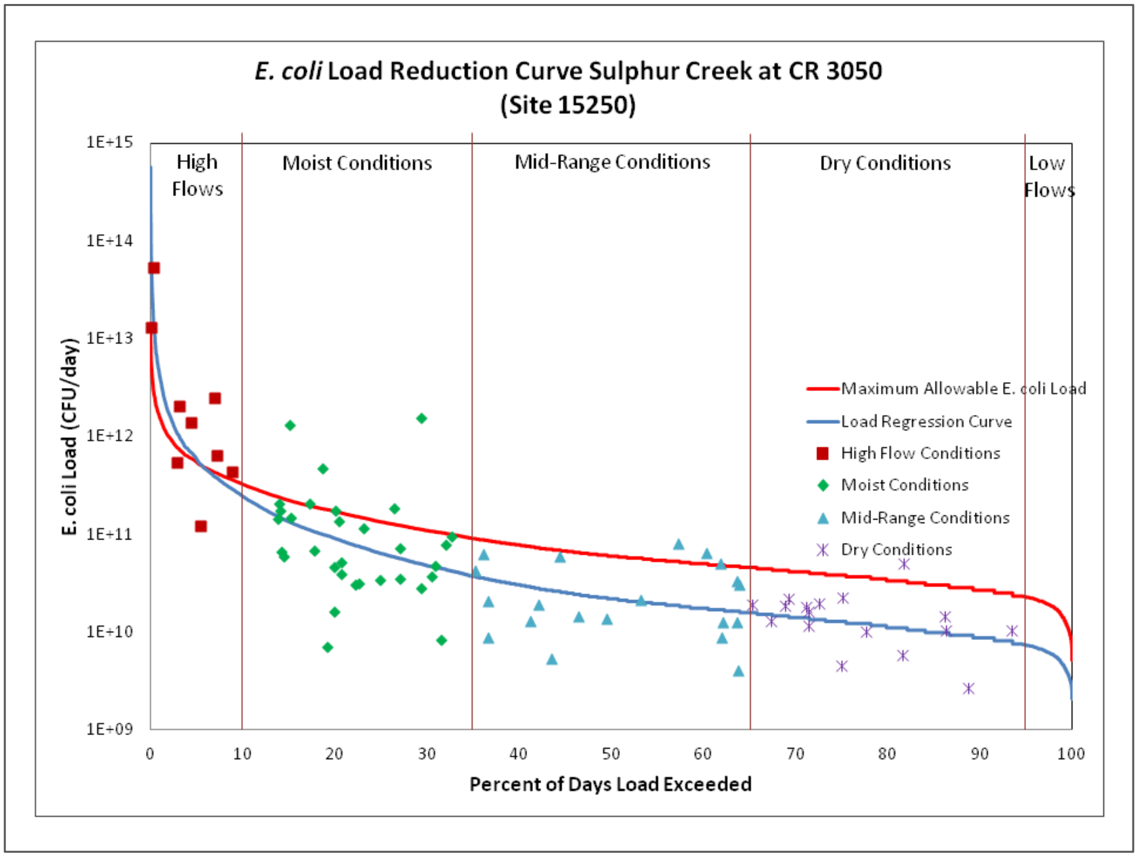

Figure 4.10 *E. coli* load duration curve for site 15250.

LAMPASAS RIVER AT US HWY 190

The Lampasas River at US HWY 190 monitoring site, TCEQ Site 11897 (Figure 4.11) is located in southern Lampasas County approximately 0.8 miles (or 1.1 river miles) downstream of its confluence with Sulphur Creek. The upstream drainage area (816 square miles) is primarily rangeland and includes the City of Lampasas. Water quality samples have been collected on either a monthly or quarterly basis since 1998 and is still being actively sampled. Once again, with the exception of the High Flow regime, *E. coli* loads are well within the SWQS in all other flow regimes and do not indicate a bacteria impairment (Figure 4.12).

Figure 4.11 Monitoring site 11897; Lampasas River at US HWY 190, Lampasas County, TX.

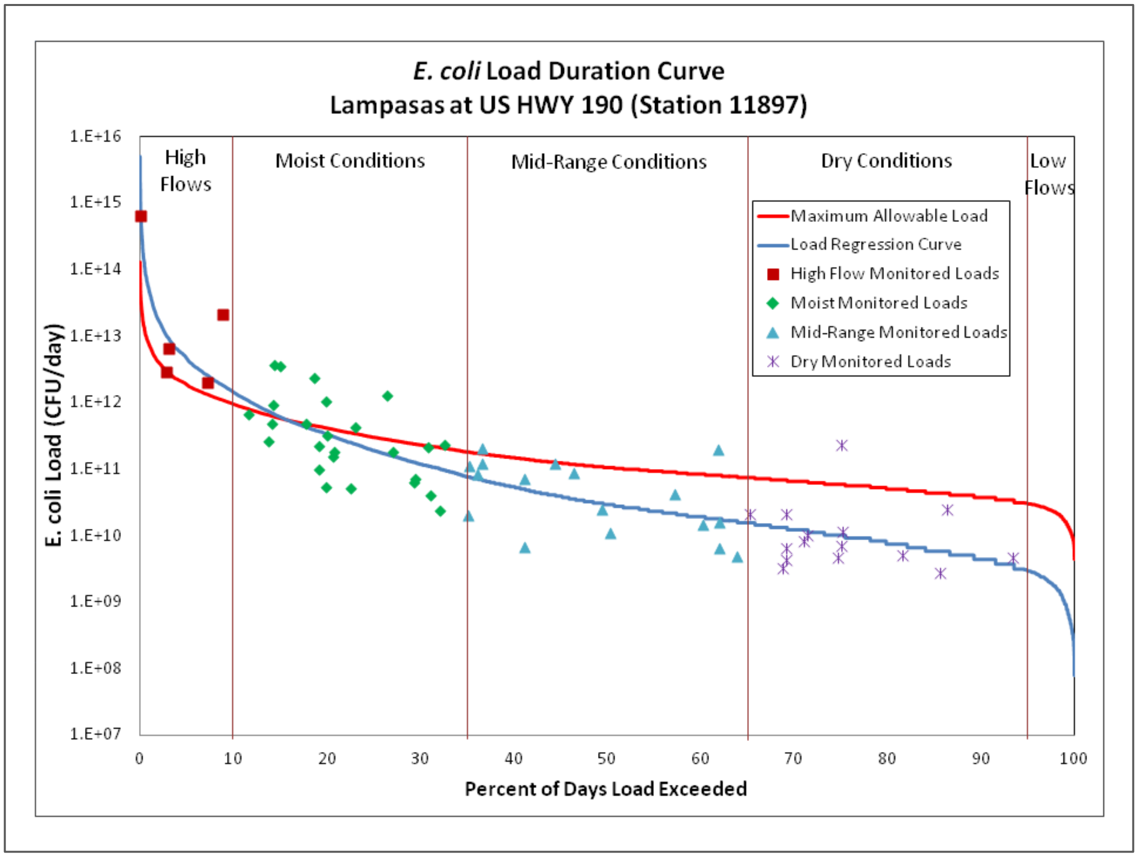

Figure 4.12 *E. coli* load duration curve for site 11897.

ROCKY CREEK AT FM 963

The Rocky Creek at FM 963 monitoring site, TCEQ Site 11724 (Figure 4.13), is located in eastern Burnet County approximately 0.8 miles (or 0.9 river miles) upstream of its confluence with the Lampasas River. The upstream drainage area is primarily rangeland and managed pasture and drains 114 square miles. Water quality samples have been collected on a monthly or quarterly basis since 1998. Once again, with the exception of the High Flow regime, *E. coli* loads are well within the SWQS in all other flow regimes and do not indicate a bacteria impairment (Figure 4.14).

Figure 4.13 Monitoring site 11724; Rocky Creek at FM 963, Burnet County, TX.

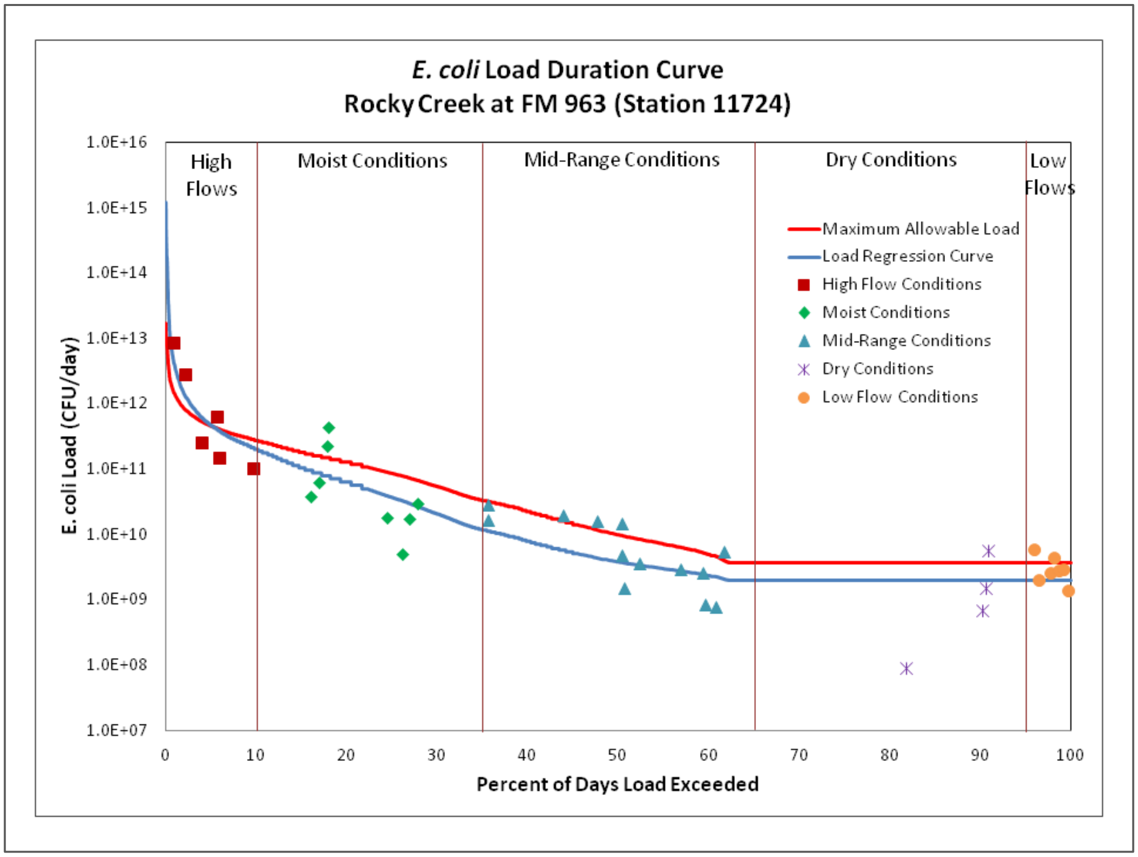

Figure 4.14 *E. coli* load duration curve for site 11724.

BACTERIA TRENDS AND PROCESSES

LDCs for all six sites indicated that the highest loads occurred during the High Flow conditions; these samples represent loadings during extreme wet conditions when the water body is typically at flood stage. These types of events only represent flow conditions 10% of the time. High flows occur in association with runoff events which carry high concentrations of bacteria, sediments and nutrients in to the river from the upland landscape. As flows and contributions from nonpoint sources decrease, bacteria loadings decrease as well. All sampling sites are well within maximum allowable loads for mid-range, dry conditions and low flows and do not indicate a bacteria impairment.

RECOMMENDED PERCENT LOAD REDUCTIONS

The LDCs do not indicate a necessary reduction in bacteria loading to achieve state standards at any of the water quality sites analyzed. However, the Partnership has determined that a 10% reduction in bacteria loads at sites 15770 (Lampasas River at CR 105) and 11897 (Lampasas River near Kempner) in the moist conditions range should be utilized as the target load reduction applied to all potential sources of bacteria within the Lampasas River watershed. This represents a conservative approach designed to allow for changes within the watershed while continuing to achieve water quality standards. The Partnership deemed a 10% reduction to be sufficent to meet the needs of the changing watershed as well as allow for growth. This load reduction has been applied across the watersehd for all sources and all flow regimes. Most BMPs have an impact across all flow regimes, with highest effeciecies at their design flows. It is anticipated that application of the 10% load reduction, accomplished via a 10% reduction in source contribution will eliminate possible exceedances in the future.

ANNUAL LOADS AND REDUCTIONS

Mean annual loads, load reductions and target loads for bacteria (billions of cfu/year) were calculated from the LDC analyses using data from monitoring sites Lampasas River at CR 105 and Lampasas River near Kempner (Table 4.3). Calculations were developed based upon the data collected during moist conditions; those occuring between the 10^{th} and 35^{th} percentile flows. This flow range not only included the most data points for each site, but is also the range of flows for which the effective implementation of managment measures is considered to be feasible.

Table 4.3 Mean annual loads, load reductions and target loads (billions of cfu/year) for monitoring sites 15770 and 11897.

Monitoring Site	Mean Annual Load	Mean Annual Load Reduction	Mean Annual Target Load	Reduction Goal (%)
Lampasas River at CR 105 (15770)	50,297	5,030	45,267	10
Lampasas River near Kempner (11897)	136,986	13,699	123,287	10

5. POLLUTANT SOURCES IN THE LAMPASAS RIVER WATERSHED

SPATIALLY EXPLICIT LOAD ENRICHMENT CALCULATION TOOL

While LDCs are useful in narrowing down the causes of potential exceedances to either point or nonpoint sources, they do not include a spatial reference to potential sources. The Partnership utilized the Spatially Explicit Load Enrichment Calculation Tool (SELECT) methodology to estimate the likely distribution of potential pollutant sources across the watershed and the degree of contribution by each. The SELECT model was developed by the Spatial Sciences Laboratory and the Biological and Agricultural Engineering Department at Texas A&M University. The SELECT model was used to identify potential pollutant sources and estimate daily potential *E. coli* loads from each source based upon populations and *E. coli* production rates of various sources and their distribution across the watershed (Teague et al. 2009). This method illustrated areas and sources with the greatest ptential for impacting water quality, allowing the Partnership to identify and target areas for implementation. A more complete explanation of the SELECT approach can be found in Appendix D.

DATA LIMITATIONS

In order to determine relationships between instream conditions and landscape factors, it is important to consider all potential sources of pollution and rely upon the most dependable and current data available. In addition to stakeholder input, information was gathered from a number of sources for the SELECT model, including local and regional groups and county, state and federal agencies. This data represents a snapshot view of the potential current conditions. Watersheds are dymamic in nature, whether due to human activities, urban growth, weather patterns, or animal distributions and can change dramatically between years and even within a given season. There is also typically a time lag between population census counts and updating of land cover and land use information. As a result of all of these processes, contributions from individual pollutant sources may vary considerabley over time.

It is also important to note that SELECT evaluates the potential for pollution from the possible sources and subwatersheds, resulting in a realtive approximation for each area. The subwatershed loads provided in the SELECT figures do not account for attenuation (pollutant removal during transport to streams and reductions within streams) or bacteria regrowth (population regeneration over time). However, they do provide valuable information as to which subwatersheds have land use activities that result in greater potential loads of bacteria to the land.

SELECT ANALYSIS RESULTS

While all warm blooded mammals are potentially sources of bacteria, to be considered in the SELECT analysis, the source populations, *E. coli* production rates (EPA 2001) and their distribution across the watershed must be known. Because of these requirements, livestock (including cattle, sheep, goats and horses), CAFOs, OSSFs, WWTFs and domestic dogs were considered in the SELECT analysis to estimate total *E. coli* loads from each subwatershed. Total estimated daily *E. coli* loads are summed for all potential sources in each of the 14 subwatersheds and presented in Figure 5.1.

Results from the SELECT analysis are presented as maps of the subwatersheds and of the potential bacteria contributions from each source. Each potential source is represented as its own map. The graduated color breaks in each of the maps in the SELECT analysis correspond to ranges of level of contribution from each source. The darkest brown subwatersheds have a higher potential for bacteria contributions from a particular source than the lighter colors; these areas should be considered as areas of concern and have the "high" potential *E. coli* load. The lightest tan areas are subwatersheds that have the lowest ("very low") potential *E. coli* load for that particular source in the watershed. The color breaks are not consistent across all of the sources. A dark brown area (high potential) for one source may be a light tan area (very low potential) for another source; this difference in scale is due to the *E. coli* production rates of each species. As a result, the legends for the colors typically differ by orders of magnitude between the different sources.

The following sections present and discuss results of the SELECT analysis for each of the potential sources identified by the Steering Committee. Additional background information specific to each identified potential source in the watershed can be found in Appendix D.

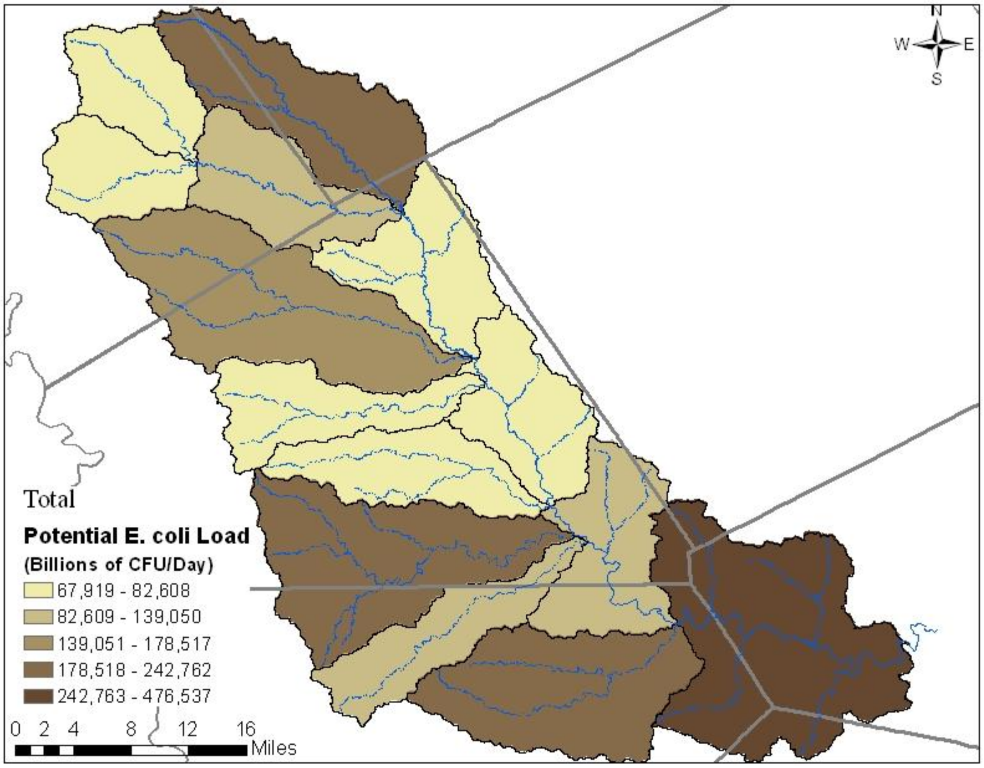

Figure 5.1 Distribution of potential *E. coli* loads from all estimated sources by subwatershed.

AGRICULTURE

Farm and ranch operations continue to play an important role in the Lampasas River watershed, particularly in the middle and upper reaches of the watershed. Agriculture production is a significant source of revenue for all counties in the Lampasas River watershed. According to the 2007 Census of Agriculture (USDA 2007), the average market value of crop and livestock products sold within the seven counties in the watershed is over $58,000,000. Land use analysis indicated that rangeland and pasture makeup more than 65% of land use within the watershed. Rangeland and pasture within the watershed are primarily devoted to agriculture production for the grazing of domestic livestock, including cattle, horses, sheep and goats. Livestock production is the primary agricultural operation in the watershed, with nominal row cropping and orchard operations.

Feces from all livestock are considered nonpoint sources of bacteria. Pollutants can be transported to streams in stormwater runoff during rainfall events or as direct deposition when animals are permitted direct access to streams and riparian corridors.

CATTLE

The Agriculture and Wildlife Work Group utilized the 2007 United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) for an estimate of the number of cattle within the watershed (USDA 2007). An estimated 34,388 cattle were equally distributed across the three different land uses in each subwatershed deemed appropriate by the stakeholders; rangeland, forest and managed pasture (Figure 5.2). Using this population estimate and *E. coli* concentration, daily potential *E. coli* loads resulting from cattle were estimated for each subwatershed and then totaled. While there are two dairies and one feedlot operation within the watershed, they are not included in the "cattle" SELECT analysis. They are presented as a separate source for analysis because they operate under a permit issued by TCEQ. Figure 5.3 illustrates the potential bacteria contributions from cattle within each subwatershed. While cattle production is dominant throughout the watershed, results from the SELECT analysis indicate higher densities of cattle and therefore higher potential *E. coli* loadings within the Lampasas River 5, Sulphur Creek and Rocky Creek subwatersheds.

Figure 5.2 Cattle graze in the northern portion of the watershed.

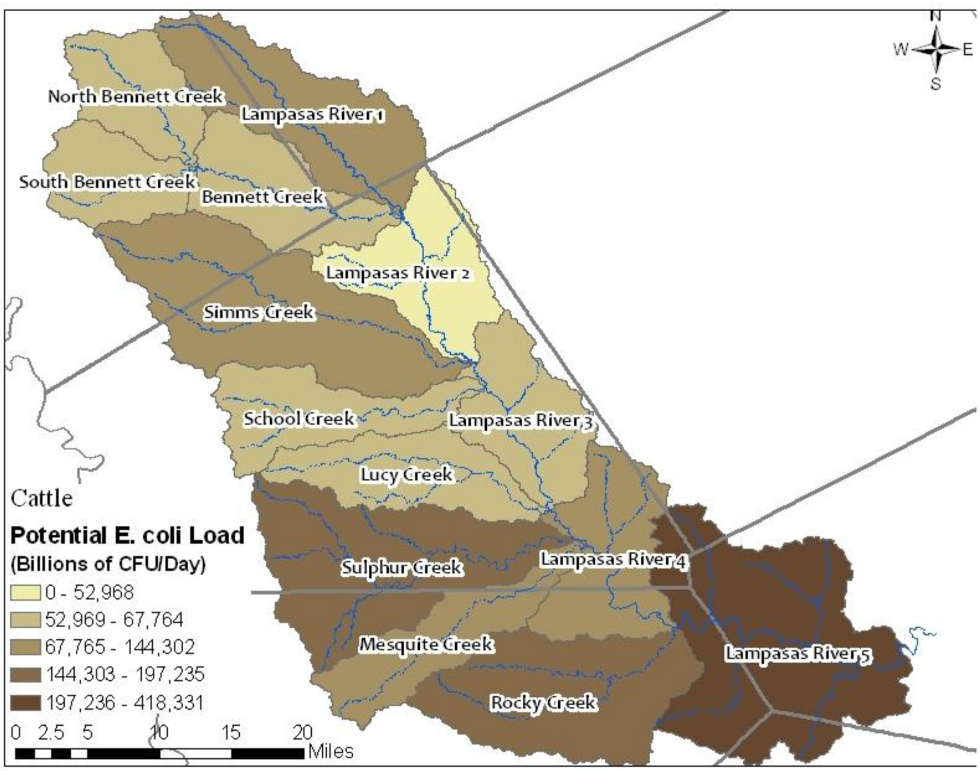

Figure 5.3 Distribution of potential *E. coli* loads from cattle by subwatershed.

SHEEP

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of sheep within the watershed. An estimated 7,311 sheep were equally distributed across three different land uses in each subwatershed as deemed appropriate by stakeholders; rangeland, forest and managed pasture. Using this population estimate and *E. coli* concentration, daily potential *E. coli* loads resulting from sheep were estimated for each subwatershed and then totaled. Figure 5.4 illustrates the potential bacteria contributions from sheep within each subwatershed. Results indicate that sheep are more likely to be found in the northern and southern reaches of the watershed with the highest densities found in the Lampasas River 1 subwatershed.

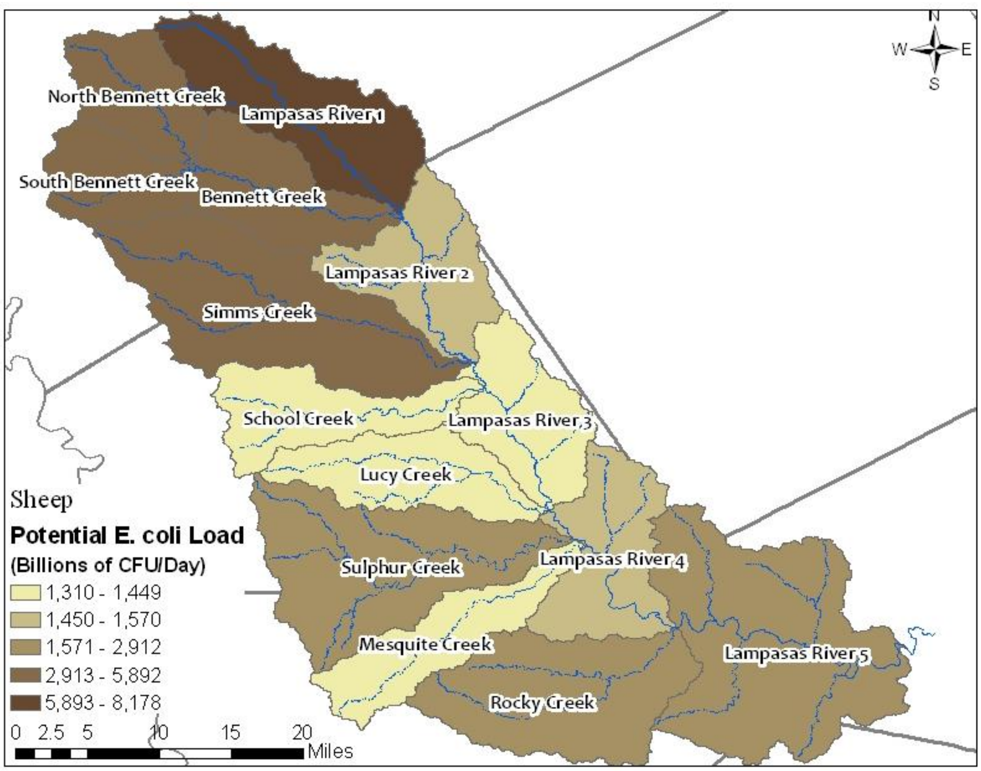

Figure 5.4 Distribution of potential *E. coli* loads from sheep by subwatershed.

GOATS

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of goats within the watershed. An estimated 11,162 goats were equally distributed across the three different land uses in each subwatershed as deemed appropriate by stakeholders; rangeland, forest and managed pasture (Figure 5.5). Using this population estimate and *E. coli* concentration, daily potential *E. coli* loads resulting from goats were estimated for each subwatershed and then totaled. Figure 5.6 illustrates the potential bacteria contributions from goats within each subwatershed. Results from the SELECT analysis indicate that goat production is more dominant in the Lampasas River 1 and Lampasas River 5 subwatersheds.

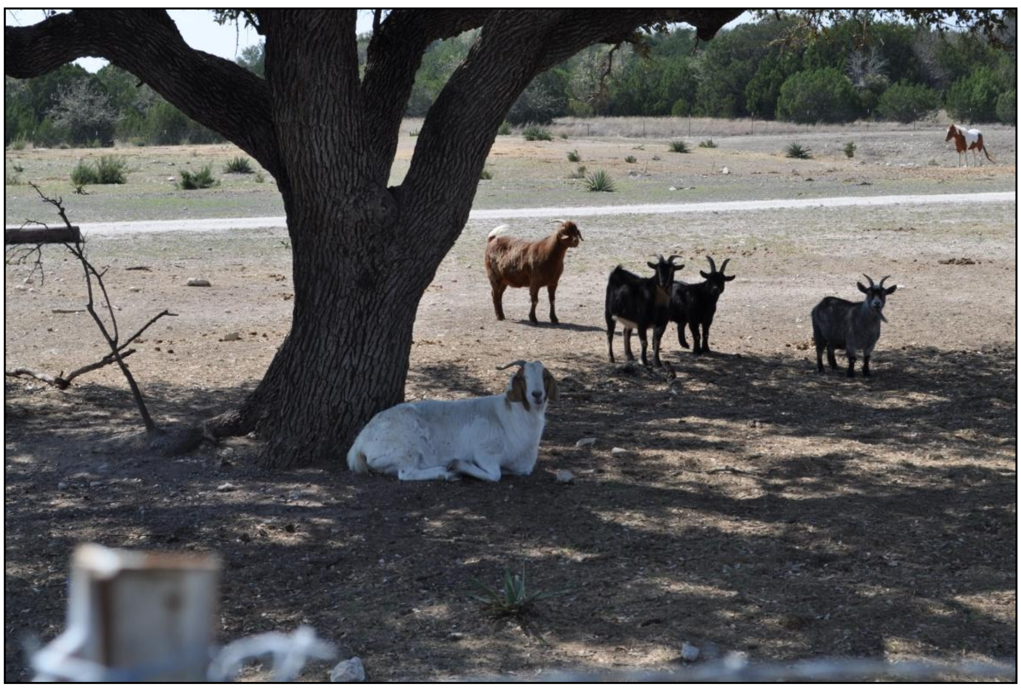

Figure 5.5 Goats are a potential source of bacteria in the watershed.

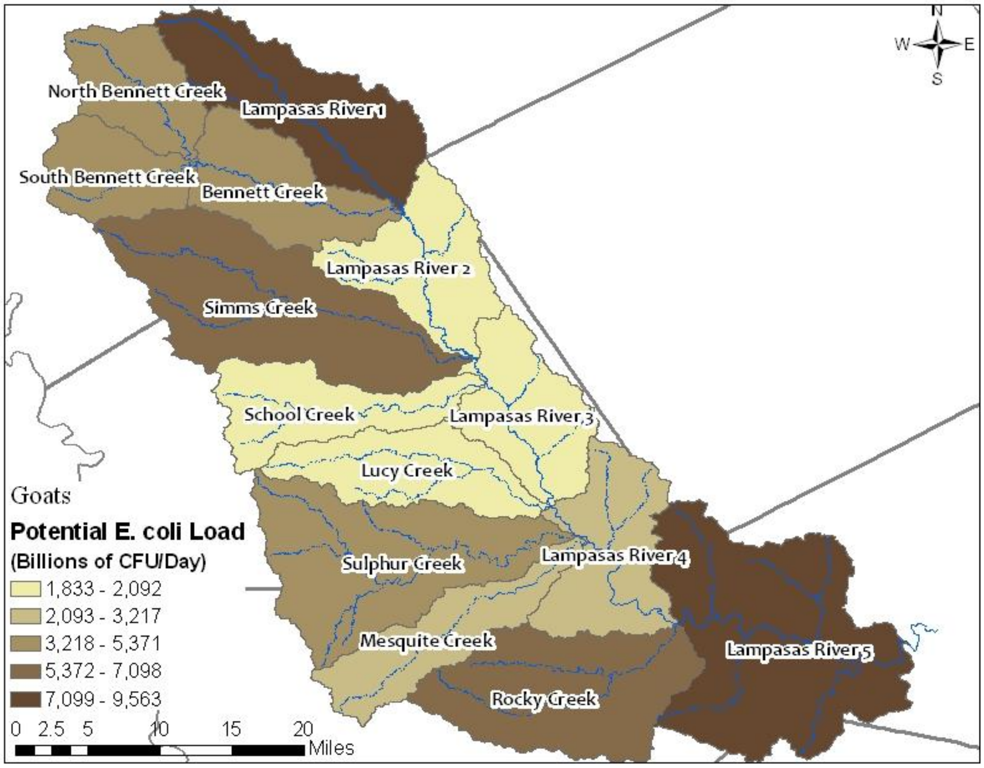

Figure 5.6 Distribution of potential *E. coli* loads from goats by subwatershed.

HORSES

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of horses within the watershed. An estimated 1,288 horses were distributed across rangeland. Using this population estimate and *E. coli* concentration, daily potential *E. coli* loads resulting from horses were estimated for each subwatershed and then totaled. Figure 5.7 illustrates the daily potential bacteria contributions from horses within each subwatershed.

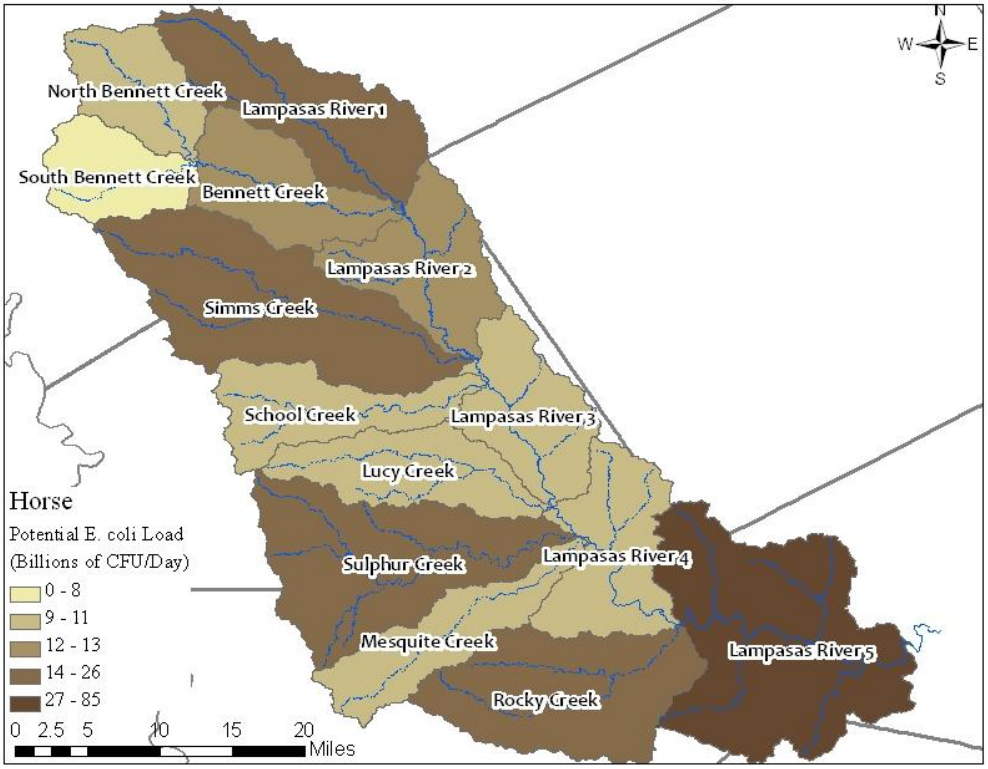

Figure 5.7 Distribution of potential *E. coli* loads from horses by subwatershed.

LIVESTOCK

Because most BMPs that would be implemented within the watershed to address bacteria concerns are not species-specific, after reviewing the SELECT analysis for individual species of livestock, stakeholders asked to group them all together in one SELECT analysis based upon animal unit equivalents (AUE). AUEs are based on the concept of one animal unit being a 1,000 pound beef cow who will consume an average of 2.6% of her body weight throughout her yearly production cycle and makes comparison of other types of livestock and wildlife to that 1,000 pound beef cow. The NRCS standard AUE conversion was used to determine populations (Table 5.1). By grouping all livestock categories into one analysis, this allowed stakeholders to better identify areas of high density livestock production to better target implementation.

Table 5.1 Animal Unit Equivalents utilized in the development of the SELECT model.

Type of Animal	Animal Unit Equivalency
Cow with calf	1.00
Cow (dry)	0.92
Horse	1.25
Sheep	0.20
Goat	0.15

The SELECT map for all livestock sources (Figure 5.8) indicates that the lower portion of the subwatershed, Lampasas River 5 has the highest potential for livestock contribution with Rocky Creek, Sulphur Creek and Lampasas River 1 having the next highest potential for contributions from all livestock.

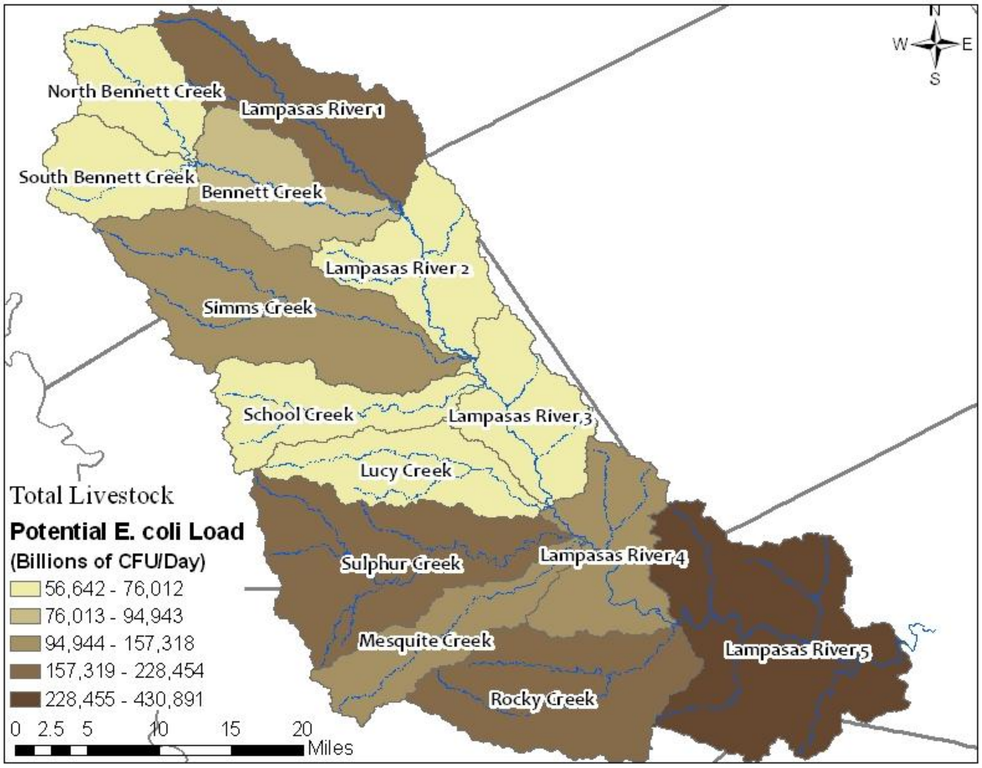

Figure 5.8 Distribution of potential *E. coli* loads from all livestock, including cattle, sheep, goats and horses by subwatershed.

CONFINED ANIMAL FEEDING OPERATIONS (CAFO)

There are three confined animal feeding operations that are permitted with TCEQ within the Lampasas River watershed, all in the northern part of the watershed. Lawrence Clowdus Dairy and PX Feeders are located in the Lampasas River 1 subwatershed, while DSM Dairy is located in the Bennett Creek subwatershed (Table 5.2).

All three CAFOs located within the watershed operate under a general permit with the TCEQ through the TPDES. As part of the permit, all facilities must operate under a nutrient management plan filed with the TCEQ. Because of the nature of the CAFO operation and because the manure undergoes treatment in the form of lagoons and sludge and land application, the SELECT analysis assumed that all materials were treated to remove 80% of bacteria with no direct discharge into nearby streams. The SELECT analysis used the permitted number of cattle for each CAFO within the watershed (Figure 5.9).

Table 5.2 Name, location and permitted number of cattle of the three CAFOs located within the watershed.

CAFO	County	Permitted Number of Cattle
Clowdus Dairy	Hamilton	1598
DSM Dairy Star	Mills	1200
PX Feeders	Hamilton	3815

The SELECT analysis for the majority of the watershed indicates no potential loading from CAFOs, which is to be expected, while both Lampasas River 1 and Bennett Creek subwatersheds are illustrated as areas of potential contribution.

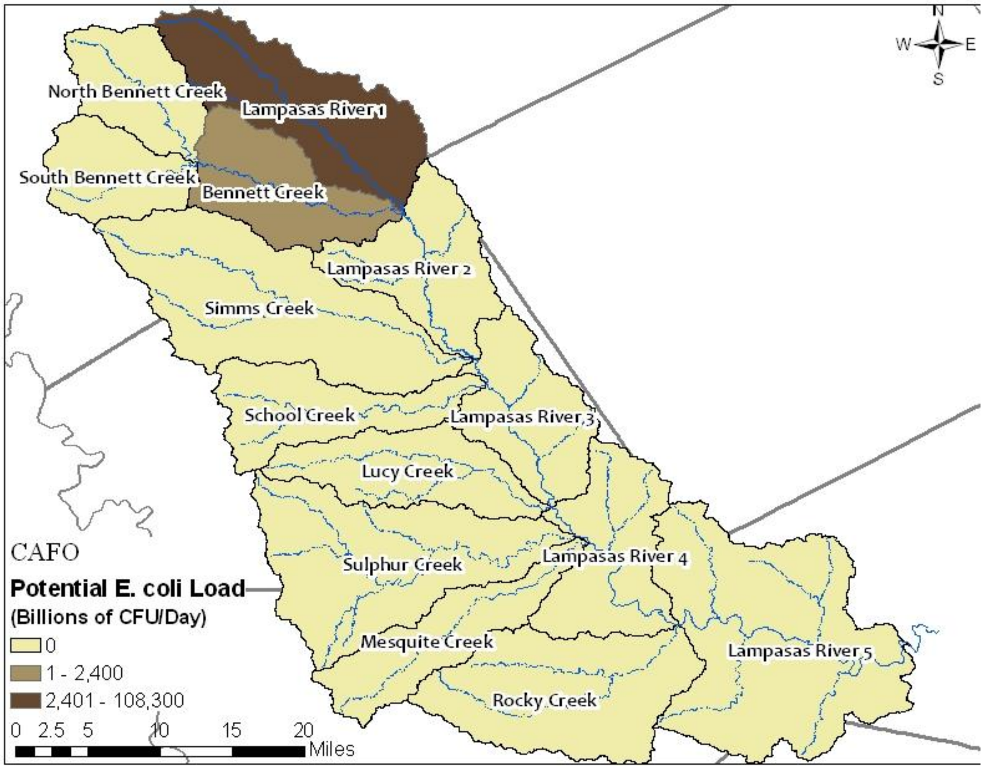

Figure 5.9 Distribution of potential *E. coli* loads from permitted CAFOs by subwatershed.

WILDLIFE AND FERAL HOGS

WHITETAIL DEER

Whitetail deer populations are managed and their harvest is regulated by TPWD. There are many factors that determine the management of whitetail deer in Texas, including carrying capacity of the land, recent population trends, hunter preferences, population densities and competition with other species.

Waste products from deer can be a potential source of bacteria since deer spend a portion of their time almost daily in riparian areas to drink and browse for food. As a result, both direct deposition into the stream and on the landscape in close proximity to the receiving streams can occur.

Due to their numbers, whitetail deer are a significant potential contributor of bacteria within the Lampasas River watershed. The Agriculture and Wildlife Work Group used several different data sources from TPWD to estimate whitetail deer populations within the watershed.

There are multiple Wildlife Management Associations (WMA) operated in conjunction with TPWD throughout the watershed. WMAs are groups formed by landowners to improve wildlife habitats and associated wildlife populations. Each of the WMAs complete annual deer surveys to monitor changes in the deer populations. The Work Group was able to utilize those surveys into the SELECT analysis to give a more precise population estimate. Averages of the 2005 – 2009 surveys were distributed equally across all land uses in each of the individual boundaries of the WMAs.

The Work Group also utilized a deer density study by TPWD (Lockwood 2007) along with personal knowledge to develop population estimates throughout portions of the watershed that were not included in the boundaries of WMAs.

Using the deer densities agreed upon by the stakeholders and *E. coli* concentration in deer fecal material, daily potential *E. coli* loads resulting from deer were estimated (Figure 5.10). The SELECT anaylsis indicated that subwatershed Lampasas River 5 had the highest potential for contributions from whitetail deer.

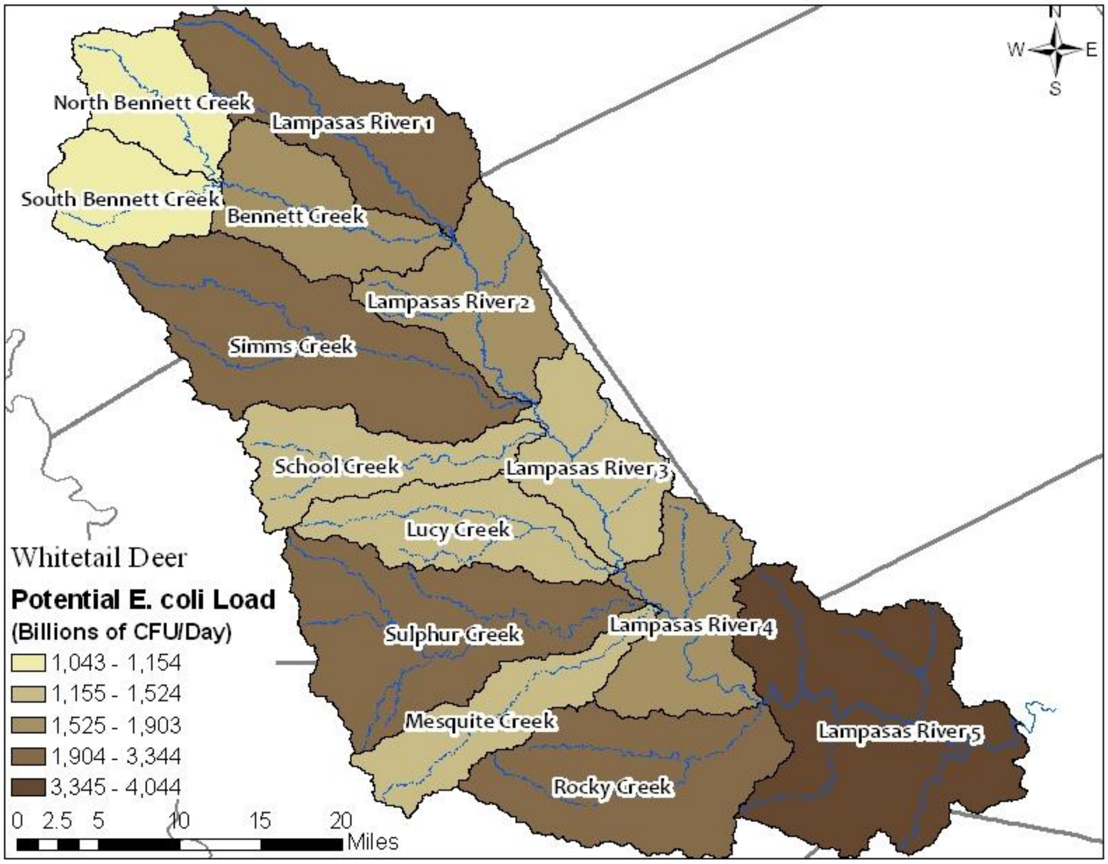

Figure 5.10 Distribution of potential *E. coli* loads from whitetail deer by subwatershed.

FERAL HOGS

Feral hogs have become a concern throughout many watersheds across Texas as well as much of the Southern United States. Feral hogs are, by definition, not wildlife, but are either domesticated hogs that have become feral, Russian boars and/or hybrids of the two (Figure 5.11). For this reason, they are considered non-native, invasive species and are not classified as a game species. There is no regulation in the state of Texas, nor is there a coordinated massive control strategy in place. A hunting license is requireed to hunt feral hogs but there are no limitations such as bag limits or closed seasons.

They represent a concern to not only water quality but also many other factors, such as crop loss and as vectors of many diseases, both to domestic hogs and humans in rural areas. Although feral hogs are non-native animals and not considered wildlife, population estimates and subsequent discussion of management practices were included in the Agriculture and Wildlife Work Group tasks. Population estimates are scarce for feral hogs as they tend to travel large distances in search of food and also have a high reproduction with low mortality rate. Feral hogs also tend to congregate around water sources to drink, wallow and scavenge for food, thus making the likelihood of direct deposition high. Hellgren (1997) reported an average range of 12 hogs per square mile. Because this estimate was more than 10 years old and to account for the high reproduction rate of feral hogs, the Work Group felt that an estimate of 20 hogs per square mile was more appropriate for the Lampasas River watershed.

Figure 5.11 Feral hogs are a potential bacteria source within the Lampasas River watershed.

For the SELECT analysis (Figure 5.12), a density of 32 acres per animal was applied uniformly across range lands, managed pasture lands, crop lands, barren and forests within a 100 m buffer around the stream network of each subwatershed. Using this feral hog density and *E. coli* concentration in hog fecal material, daily potential *E. coli* loads resulting from feral hogs were estimated. The SELECT analysis indicates that the lower portion of the watershed (Lampasas River 5) has the highest potential bacteria contributions due to feral hogs.

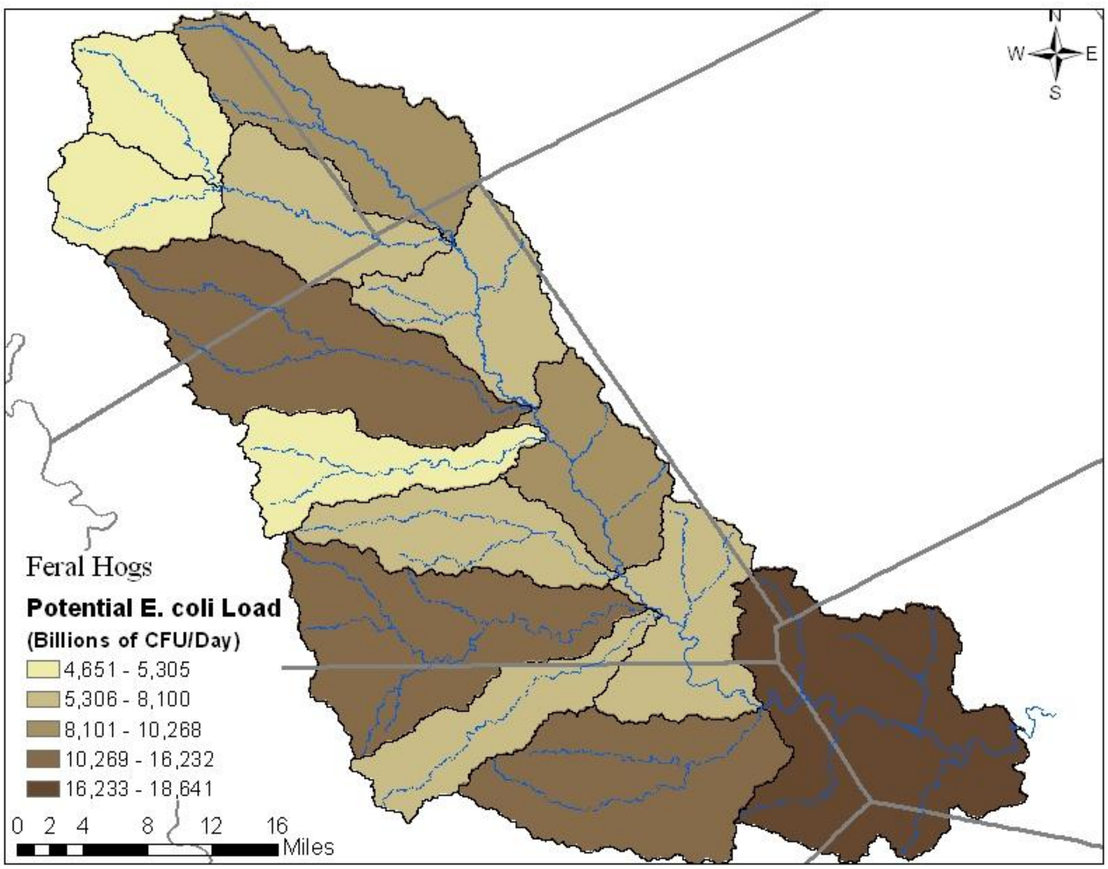

Figure 5.12 Distribution of potential *E. coli* loads from feral hogs by subwatershed.

URBAN SOURCES

SEPTIC SYSTEMS

Since the Lampasas River watershed is primarily rural, many residences treat household waste with septic systems, or OSSFs. New systems are installed when homes and businesses are constructed outside of municipal system service areas. This is typically outside of the city limits but not always. The maintenance and operation of OSSFs are the responsibility of the homeowner or business owner; if regular maintenance is not done, major problems can occur. Failing OSSFs can be found across the landscape, however, those closest to streams or drainage areas are most likely to contribute to water quality impairments. System failures are typically caused by several factors, soil suitablity for the type of installed system, system age, a general lack of homeowner knowledge of OSSFs and a lack of proper maintenance. Failures can also result from overload of the system by adding additional homes to an existing sytem that was not designed to treat an increased load. Improper system installation and/or design can also contribute to system failure. When OSSFs fail, wastewater is not properly treated and can be a source of bacteria, pathogens and nutrients to the surrounding water sources.

Local information about the number and location of OSSFs was not available for the watershed. The number and location of systems was taken from the 911 addresses on record. All homes that fall within areas served by municipal WWTFs were excluded from the analysis. A complete explanation of the SELECT calculations can be found in Appendix D. The SELECT analysis (Figure 5.13) indicated that the area with the highest potential loads from OSSFs was Lampasas River 5, while subwatersheds Sulphur Creek and Lampasas River 4 were the second highest.

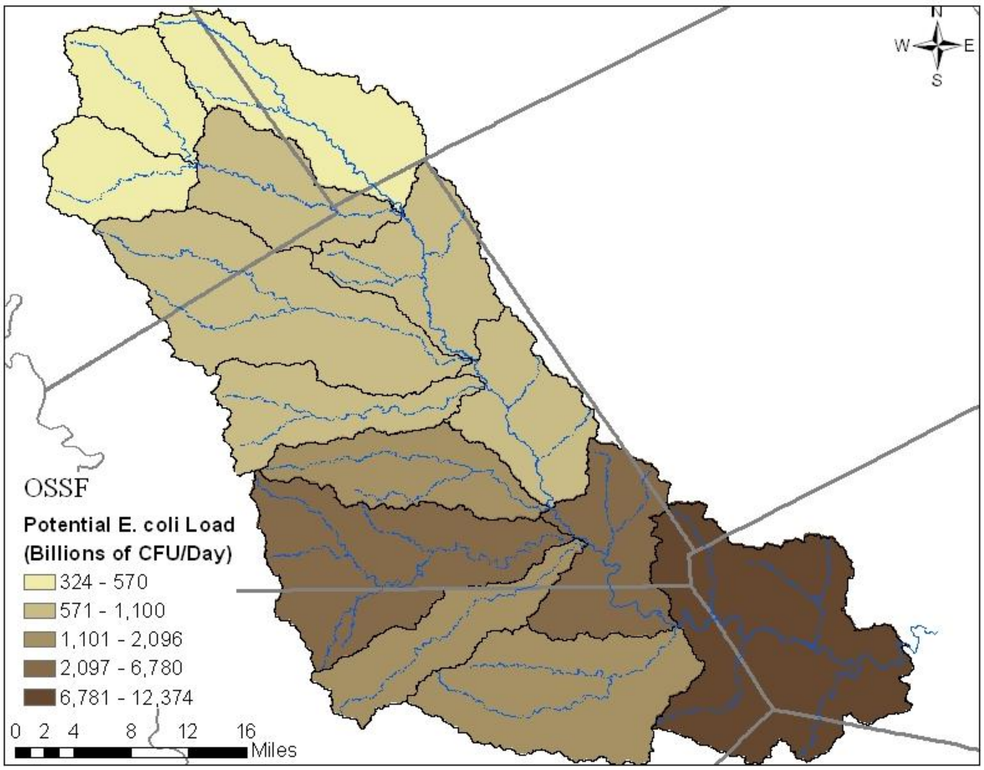

Figure 5.13 Distribution of potential *E. coli* loads from on-site sewer facilities by subwatershed.

WASTEWATER TREATMENT FACILITIES

There are only two permitted WWTFs that discharge within the Lampasas River watershed (Table 5.3). The City of Lampasas WWTF discharges into Sulphur Creek while the City of Copperas Cove WWTF discharges into Clear Creek. While actual daily discharges are currently a fraction of each WWTFs permitted discharge, as populations in both cities increase, so will potential discharges. In dry periods, the receiving streams and thus the Lampasas River are dominated by wastewater effluent.

Both WWTFs utilize a Ultraviolet (UV) light to treat bacteria within the effluent and reduce the concentrations of pathogenic virueses and bacteria to levels that are considered safe for discharge under normal operating systems. The City of Copperas Cove WWTF's most recent permit renewal placed a maximum daily *E. coli* limit on the effluent of 126 CFU/100 mL. The City of Lampasas WWTF does not have a permitted limit on *E. coli* in place, however self monitoring records indicate that concentrations within the effluent are much lower than the standard. For WWTFs, the maximum permitted discharge and the *E. coli* concentration of 126 CFU/100 mL was applied to the subwatershed in which the WWTFs were located (Figure 5.14).

Table 5.3 Permit information for WWTFs within the watershed.

Operator	Permitted Discharge (MGD)	Year Built	Year Updated	Last Permit Renewal	Disinfectant System	*E. coli* Monitoring Frequency
City of Copperas Cove	2.45	1970	1996	2010	Ultraviolet	Daily
City of Lampasas	1.547	1998	NA	2010	Ultraviolet	Daily

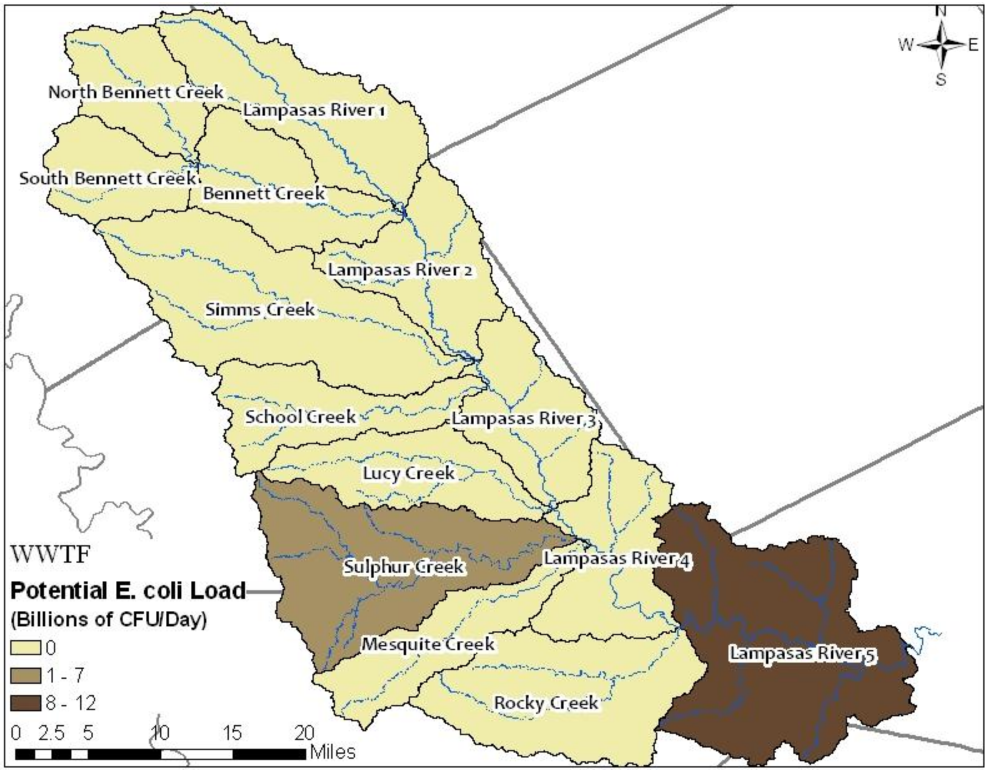

Figure 5.14 Distribution of potential *E. coli* loads from municipal wastewater treatment facilities by subwatershed.

DOGS

Improper disposal of pet waste can affect water quality, particularly in urban areas where pets are concentrated into smaller spaces. Just like any other warm blooded animal, when a pet deposits its waste outside and it is left uncollected, bacteria can be transported over the landscape during a rainfall event or by irrigation systems. The result can be a significant impact on the surrounding water bodies. Dog waste was the only domestic pet source considered in the SELECT analysis because cat and other domestic pet waste is typically disposed of via litter boxes or cage waste into local landfills.

According to the American Veterinary Medical Association (2002), the average Texas household owns 0.8 dogs. The Urban Nonpoint Source group estimated that this number may be higher in the Lampasas River watershed and adjusted this number to 1.0 dogs per household based on personal experience. All addresses on the 911 Emergency address listed as 'residences' were used in this estimate. The SELECT analysis (Figure 5.15) indicated that subwatershed Lampasas River 5 had the highest potential loadings from dogs, while Sulphur Creek and Lampasas River 4 subwatersheds had the second highest potential.

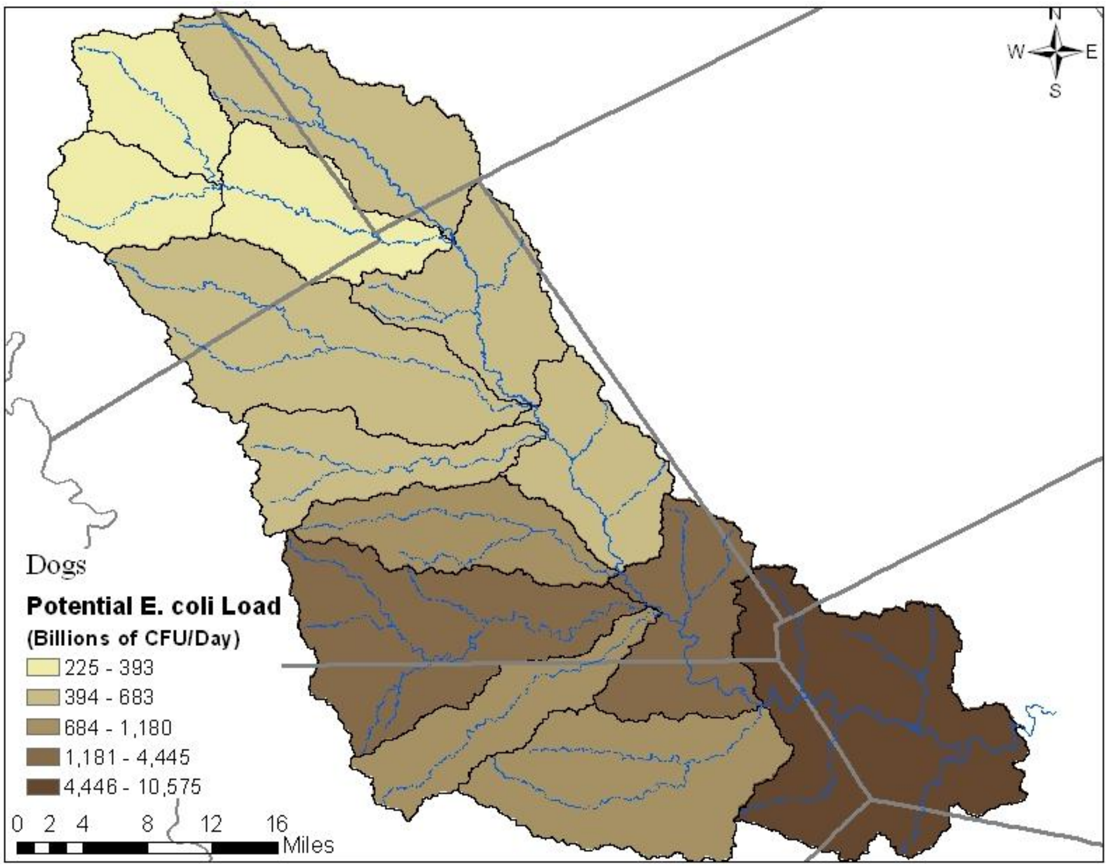

Figure 5.15 Distribution of potential *E. coli* loads from domestic dogs by subwatershed.

RELATIVE RANGES OF BACTERIA LOADINGS

Because of the inherent differences found in each of the potential sources, there is a broad range of the average daily potential load from each of the sources analyzed in the

SELECT analysis. Population size and distribution, density and daily production potentials all impact the potential loading from an individual source. Figure 5.16 illustrates the relative ranges of bacteria loads across all subwatersheds from individual pollutant sources.

The largest contributor for the Lampasas River watershed is cattle with feral hogs the second largest. OSSFs and dogs are also high contributors. CAFOs contribute more than feral hogs in the two subwatersheds where they are present. Goats, sheep, and deer are not significant contributors, and they contribute *E. coli* loads with minimums and maximums all to the order of 10^{12}. The sources that contribute the least *E. coli* are horses and WWTFs. The subwatershed considered to be the highest contributor in the Lampasas River watershed, Lampasas River 5, as predicted by SELECT, is most likely because of 1) the large size of the subwatershed in comparison to the other subwatersheds and 2) the subwatershed's land uses of forest, rangeland, and managed pasture, which are suitable areas for almost all of the animal contributors. The second highest potentially contributing subwatersheds have land use that is primarily rangeland, which is suitable for cattle, the highest contributing source for the Lampasas River watershed.

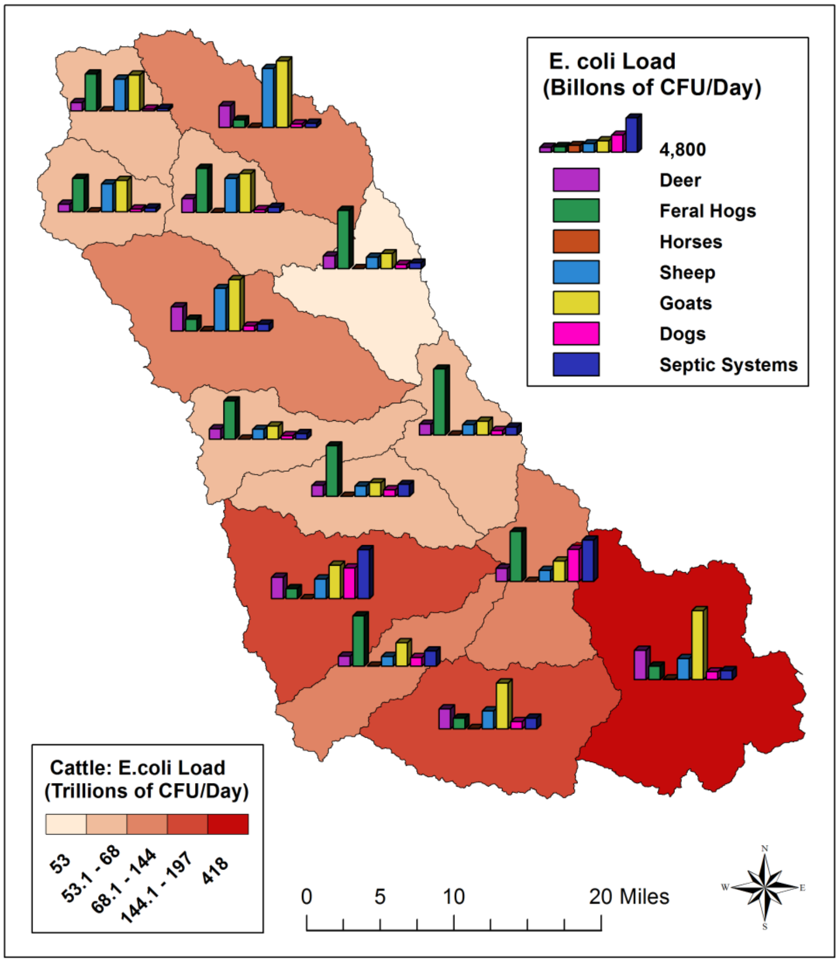

Figure 5.16 Relative ranges in loading by potential source across subwatersheds.

6. MANAGEMENT MEASURES

AGRICULTURE NONPOINT SOURCE MEASURES

Although, the LDCs do not indicate a necessary reduction in bacteria loading to achieve state standards, the Partnership has determined that a 10% overall reduction in bacteria loading should be implemented to maintain the current quality of life as the watershed undergoes land use changes. After much disscusion, the Agriculture and Wildlife Work Group agreed that the best way to achieve this goal was through development of Water Quality Management Plans (WQMP) for agriculture operations. WQMPs are voluntary, site-specific management plans that are developed and approved by local Soil and Water Conservation Districts (SWCDs) for agricultural lands. They include appropriate land treatment practices, production practices, management measures, technologies, or combinations thereof and are certified by the TSSWCB to be consistent with the SWQS. Financial incentives may be available through TSSWCB and NRCS to offset implementation costs. To facilitate development and implementation of these management plans, the Partnership will pursue funds to support a financial incentive program as well as create a new position at the SWCD level to provide technical support to landowners and producers.

FOCUS AREAS

The Agriculture and Wildlife Work Group determined that 10% of AUEs should be enrolled in WQMPs to achieve a 10% load reduction. Based upon 2007 USDA NASS estimates and input from local NRCS and AgriLife Extension personnel, the average farm size was estimated to be 20 AUE. This was used to estimate the number of farms within each subwatershed. The bacteria reduction goal of 10% was then applied to the total number of farms to determine that approximately 194 WQMPs would be necessary (Table 6.1).

Table 6.1 Recommended number of WQMPs by subwatershed.

Focus Area	Subwatershed	Total AUE	Number of Farms Based on AUE	WQMPs Per Subwatershed
Primary	Lampasas River 1	2,980	149	21
	Lampasas River 2	1,546	77	21
	Lampasas River 5	8,530	427	21
	Focus Area Total	13,055		
Secondary	Lampasas River 3	1,424	71	13
	Lampasas River 4	2,131	107	13
	Simms Creek	3,509	175	13
	Rocky Creek	4,901	245	13
	Sulphur Creek	3,487	174	13
	Focus Area Total	15,452		
Remaining	North Bennett Creek	1,563	78	11
	Bennett Creek	1,873	94	11
	South Bennett Creek	1,372	69	11
	School Creek	1,352	68	11
	Lucy Creek	1,401	70	11
	Mesquite Creek	2,476	124	11
	Focus Area Total	10,038		
Total	Watershed Total	38,546		194

Using this information, along with the results from the SELECT and LDC analyses, and personal knowledge, stakeholders prioritized the subwatersheds into three focus areas, primary, secondary and tertiary (or remaining). One-third of the number of recommended WQMPs were equally distributed across all three focus areas, with approximately 64 WQMPs necessary in each focus area.

The primary focus area included three subwatersheds; Lampasas River 1 and Lampasas River 2, which are both located upstream from where the original bacteria impairment occurred and Lampasas River 5, the most downstream subwatershed and indicated by the SELECT model as having a high potential for bacteria impairment (Figure 6.1). The Work Group chose Lampasas River 1 and 2 subwatersheds as part of the primary focus area because of their proximity to monitoring sites with previous water quality concerns. Lampasas River 5 was chosen as a primary focus because the SELECT results indicated it had the highest potential loadings from livestock. Twenty-one WQMPs are recommended in each subwatershed in this priority area.

The secondary focus area includes the remaining subwatersheds along the main stem of the Lampasas River (Lampasas River 3 and 4), Simms Creek, Sulphur Creek and Rocky Creek and recommends that 13 WQMPs be implemented in each. These five subwatersheds were selected for the secondary focus area because the SELECT model identified each of these subwatersheds as having a moderate potential daily *E. coli* loading.

The remaining six subwatersheds were grouped into a final focus area. These subwatersheds were indicated by the SELECT analysis to have the lowest potential daily *E. coli* loading rates and stakeholders felt that implementation efforts in these areas would have the least impact on the bacteria impairment within the Lampasas River.

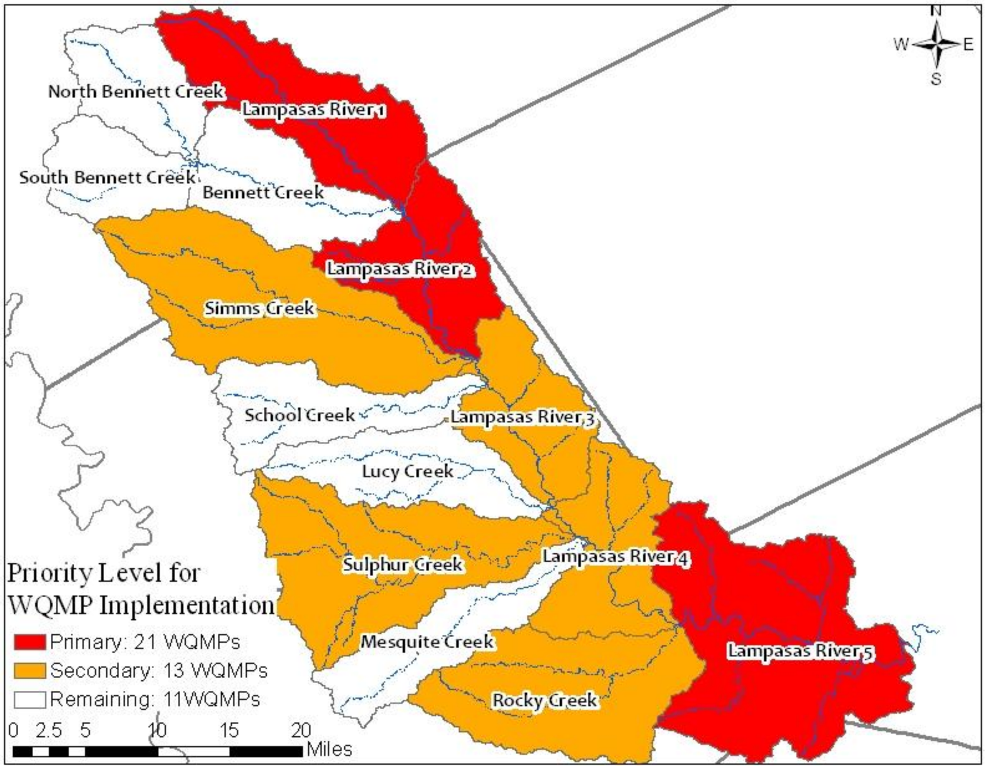

Figure 6.1 Prioritized focus areas for WQMP implementation.

MANAGEMENT MEASURES

While WQMPs are site-specific plans, the Agriculture and Wildlife Work Group recommended that several key BMPs be encouraged for implementation. Stakeholders felt that these BMPs would be most effective in addressing the bacteria impairment within the watershed. Included practices would not be limited to this list, however preference would be given to those WQMPs that included any of these practices. Appendix E includes measures of efficiency of agriculture management practices in reducing bacteria contributions.

- **Prescribed grazing:** Manages the controlled harvest of vegetation with grazing animals to improve or maintain the desired species composition and vigor of plant communities, which improves surface and subsurface water quality and quantity.
- **Conversion to native grasses and forbs:** Establishes permanent, perennial conservation cover consisting of native grass mixes. Grass planting is common on retired marginal cropland as a stand-alone practice to prevent wind and water erosion.
- **Alternative watering facilities:** Places a tank, trough, or other water supply system that provides animal access to water and protects nearby surface water resources from contamination by decreasing livestock presence through alternative water supply.
- **Cross-fencing:** A constructed barrier to livestock, wildlife or people to facilitate the application of conservation practices that protect surface water quality.
- **Riparian Forest Buffers:** Establishes area dominated by trees and shrubs located adjacent to surface water resources to reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff.
- **Stream crossings:** Creates a stabilized area or structure constructed across a stream to provide a travel path for people, livestock, equipment or vehicles to improves water quality by reducing sediment, nutrient, organic and inorganic loading of the stream.
- **Riparian Herbaceous Buffers:** Establishes an area of grasses, grass-like plants and forbs along water courses to improve and protect water quality by reducing sediment

and other pollutants in runoff as well as nutrients and chemicals in shallow groundwater.

- **Brush management on uplands with subsequent herbaceous cover:** Removal, reduction or manipulation of non-herbaceous plants to restore desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality and enhance stream flow.
- **Filter strips:** Establishes a strip or area of herbaceous cover between agricultural lands and environmentally sensitive areas to reduce pollutant loadings in runoff.
- **Pasture and hayland planting:** Establishes native or introduced forage species to reduce soil erosion and improve water quality.
- **Terraces:** An earthen embankment, a channel or a combination ridge and channel constructed across the slope that reduces erosion, retains runoff for moisture conservation and improves water quality.
- **Vegetative waterways:** Natural or constructed channel shaped or graded and established with suitable vegetation to protect and improve water quality.
- **Nutrient Management:** The management of the amount, placement and timing of plant nutrients to obtain optimum yields and minimize the risk of surface and groundwater pollution.

WILDLIFE AND FERAL HOG MANAGEMENT MEASURES

The Partnership recognized that all wildlife and feral hogs are potential contributors of bacteria to the watershed. Other non-domestic animals such as feral dogs and cats are contributors but their populations and locations can not be predicted or estimated because of insufficent data. Small native wildlife, such as racoons and birds are also contributors but again, their populations can not be predicted. The contribution from these sources is likely to be small and is considered background nonpoint source pollution. It should be noted that active management of native wildlife for water quality purposes is generally not promoted in Texas. However, stakeholders raised concerns about both the feral hog population and the whitetail deer population impacts on water quality so they have been addressed to varying degrees within the WPP.

FERAL HOGS

Managing the feral hog population and their associated bacterial contribution was high among the stakeholders' priorities. The Agriculture and Wildlife Work Group recommended that strong measures be undertaken to control and reduce the population of feral hogs and minimize their impacts on water quality and the surrounding habitat. The subwatersheds were divided into two focus areas (Figure 6.2); the primary focus area included all subwatersheds along the main stem of the river (Lampasas River 1 – 5) and the remaining subwatersheds were placed in a secondary focus area. The work group felt that the greatest impact would be seen by addressing the mainstem of the river as the top priority. Although the Partnership recommended an overall reduction of source contributions by 10% to achieve the water quality goals, it was also decided that a 10% in the feral hog contribution was too conservative. The Partnership recommended reducing the current feral hog population by 50% to account for future population growth over the next 10 years (Table 6.2). Although, the watershed is divided into priority areas, the work group also recommended that the removal be carried out across the watershed. This amounts to the removal of 12,133 feral hogs from within the watershed.

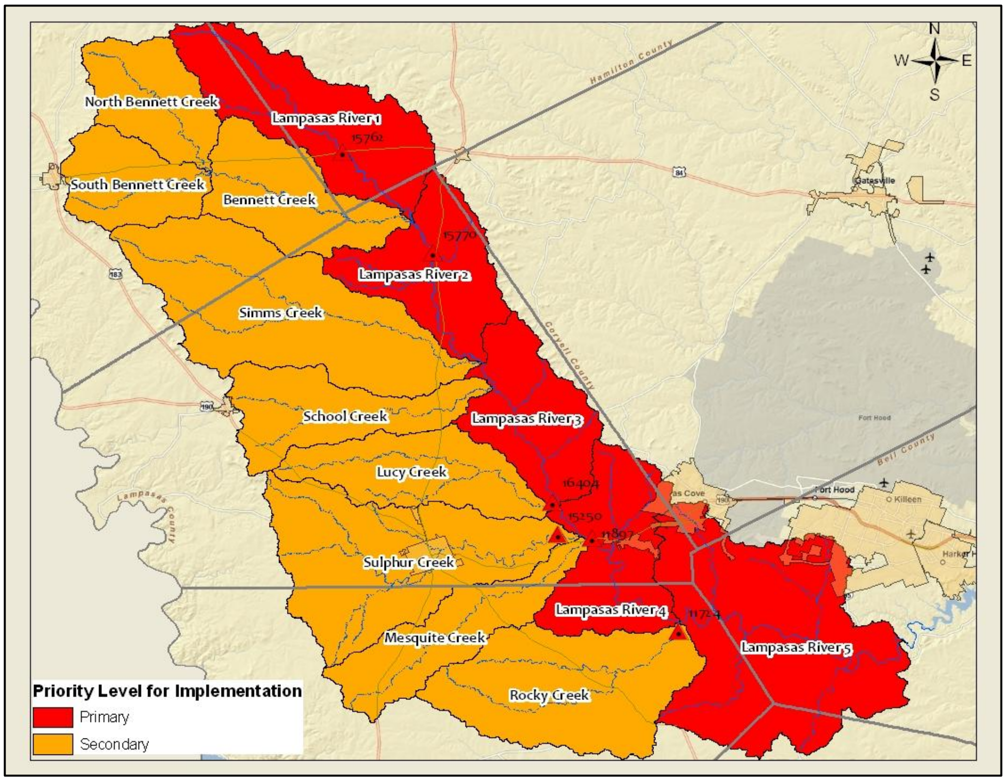

Figure 6.2 Priority areas for feral hog management.

The work group recommended several different measures to address the feral hog issue in the watershed. Stakeholders recognized the need to bring in more technical and educational resouces about feral hog management into the watershed and have recommended the creation of a local Watershed Feral Hog Specialist, most likely through AgriLife Extension. This person would be responsible for working with landowners to develop trapping plans and recommended management measures specific to their needs. The Partnership will also seek funds to purchase several hog traps and develop a free or low-cost trap rental program for landowners within the watershed. The trap rental program may be administered by the Watershed Feral Hog Specialist.

Table 6.2 Recommended number of feral hogs to be removed by subwatershed.

Focus Area	Subwatershed	Total Hogs	Hogs to be Removed	Percent Removal of Total Hogs
Primary	Lampasas River 1	1,867	1,213	65%
	Lampasas River 2	1,473	1,213	82%
	Lampasas River 3	1,667	1,213	73%
	Lampasas River 4	1,260	1,213	96%
	Lampasas River 5	3,389	1,213	36%
	Focus Area Total	9,656	6,065	
Secondary	North Bennett Creek	930	674	72%
	Bennett Creek	1,114	674	61%
	South Bennett Creek	846	674	80%
	Simms Creek	2,951	674	23%
	School Creek	965	674	70%
	Lucy Creek	1,276	674	53%
	Sulphur Creek	2,561	674	26%
	Mesquite Creek	1,266	674	53%
	Rocky Creek	2,700	674	25%
	Focus Area Total	14,609	6,066	
Total		24,265	12,131	

Also, in an effort to better target removal efforts, the work group recommended that the existing online Feral Hog Damage Tracking System be modified and utilized within the watershed. This module allows landowners to report the date, time, location and approximate number of hogs observed or harvested as well as feral hog damage to property, crops or livestock. The results of the tracking system will be utilized through adaptive implementation to ensure that resourcs are being targeted to areas with the highest likelihood of making an impact on water quality and the feral hog population.

In addition, the Partnership will support county trapping efforts. Currently, each county within the watershed employs at least 1 full-time predator trapper that works with local landowners. The cost of these positions are typically funded 50/50 by the county and Texas A&M Wildlife Services (TWS), although in times of budget uncertainity, counties may have to shift priorities.

In September 2011, House Bill 716 was signed into law, allowing landowners to sell “seats” on helicopter aerial hunts for feral hogs. This may open up another method for large landowners to recoup some of the costs associated with aerial hunting. The Partnership will explore ways to promote this new opportunity to landowners.

The Partnership also recommended developing a feral hog bounty program as an incentive to landowners to harvest more feral hogs. The program would pay a specified amount of money to hunters after a verified harvest. Management of this program would possibly fall under the responsiblities of the Watershed Feral Hog Specialist or under the participating counties’ jurisdiction.

WHITETAIL DEER

While historically, whitetail deer have not been managed for water quality concerns, the work group did recommend a few management measures. These measures address the issue from a habitat management perspective. The Partnership will work to raise landowner awareness about the Wildlife Management Plan (WMP) program and

Managed Land Deer permits that are available through TPWD. WMPs address multiple facets of habitat and population. Components of a management plan include an objective as established by the land manager, the past history of hunting and other land use, and a description and appraisal of the habitat. Specific recommendations are given concerning habitat management practices, wildlife considerations in livestock management, availability of water and wildlife, foods, management of wildlife populations, and harvest of game species. Once a TPWD WMP is in place, the landowner has more flexible seasons and increased harvest opportunities. The program is incentive based and habitat focused. The Partnership also will work with TPWD to encourage landowners to enroll and participate in WMAs to improve the wildlife resources on their land by cooperating with neighbors to enhance habitat values at a larger landscape level.

The Partnership will also encourage landowners to enroll in NRCS's Wildlife Habitat Incentive Program (WHIP) to assist with restoration of declining or important native fish and wildlife habitats; reduce the impacts of invasive species on fish and wildlife habitats and restore, develop or enhance declining or important aquatic wildlife species habitats.

The Partnership also recognized the importance and impact that hunters have on the local economy. They recommended developing a more efficient way of pairing hunters in need of a hunting lease with landowners that may want to better manage their deer populations but have no interest in personally hunting.

URBAN MANAGEMENT MEASURES

The Urban NPS work group engaged each of the cities and counties that have jurisdiction within the watershed to develop strategies that support the goals of the Lampasas River Watershed Partnership as well as their own individual goals. The work group worked with each entity to develop recommendations to address bacteria contributions from municipal WWTFs, wastewater collection systems, OSSFs, and stormwater. Domestic dog waste was also included in urban management recommendations because the SELECT results indicated that it may be a significant source within the areas of heavy population concentrations.

WASTEWATER MANAGEMENT MEASURES

Wastewater management by municipal systems and private OSSFs is an important issue within the watershed. Both WWTFs and associated collection systems located within the watershed are operated by its respective city, Copperas Cove and Lampasas. All WWTFs must comply with site-specific regulations outlined in a TPDES permit which is issued by TCEQ (Table 6.3). Individual municipalities also manage maintenance and upkeep of the wastewater collection systems. The Partnership worked with each city to outline common management recommendations for the WWTFs and city-specific recommendations for individual collection systems. Each city also has areas that continue to be served by OSSFs; the Partnership worked with individual cities to develop management recommendations for those areas.

Table 6.3 Current permitted municipal wastewater treatment levels within the Lampasas River watershed.

Operator	Flow (MGD)	BOD (mg/L)	TSS (mg/L)	NH3 (mg/L)	TP (mg/L)	*E. coli* (cfu/ 100 mL)	Receiving Water body
City of Copperas Cove	2.45	10	15	3	-	126	Clear Creek
City of Lampasas	1.547	10	15	3	-	-	Sulphur Creek

Because the Lampasas River watershed is primarily rural, many homes are not served by municipal wastewater systems and operate on OSSFs, particularly outside of the city limits and associated extraterritorial jurisdictions. In these areas, county governments have authority over the installation and inspection of OSSFs. The counties are also responsible for reviewing complaints for those systems outside of the city limits. The Urban NPS work group worked with the counties to develop recommendations to be implemented watershed-wide, rather than on a county-by-county basis.

WWTFs

Both the City of Copperas Cove and the City of Lampasas WWTFs are either relatively new or recently updated (Table 6.3) and currently operate well below state standards for bacteria concentrations within the effluent. Although there aren't any additional planned WWTFs within the watershed, the Urban NPS recommends that all new plants strive to operate at the same high standards that have been set previously by both the cities of Copperas Cove and Lampasas.

Both WWTFs renewed their individual permits in 2010. The City of Copperas Cove's permit includes a permitted level of 126 cfu/100 mL for *E. coli*. Although the City of Lampasas permit does not include a permitted level for *E. coli*, self-reported data indicates that the effluent concentrations are consistently well below 126 cfu/100 mL. While both WWTFs currently monitor bacteria daily, the Work Group recommended that a method be developed to make this data more easily accessible to the citizens within the watershed. It was also recommended that the TCEQ implement an unannounced inspection program for WWTFs to ensure compliance with permit requirements.

Wastewater Collection Systems

City of Copperas Cove

The City of Copperas Cove lies partially within the watershed. Currently, sanitary sewer lines are inspected on an as-needed basis although consideration has been given to developing a routine inspection scheme. The city has stated that funding would need to be secured for the necessary additional man-power in order to conduct routine inspections. Aging sewer lines are repaired or replaced on an as needed basis. Lift stations are physically inspected twice daily, seven days a week by city personnel. Copperas Cove has a Sanitary Sewer Overflow (SSO) Plan in place with TCEQ to address any chronic sanitary sewer overflows. SSO Plans are voluntary plans that address the increasing number of sanitary sewer overflows due to aging systems through encouraging corrective action before human health and safety and the environment are impacted.

City of Killeen

Most of the current city area lies outside of the Lampasas River watershed and therefore most of its water, sewer and drainage resources are outside of the watershed as well. However, with Fort Hood acting as a barrier to the north and Harker Heights and Copperas Cove to the east and west, future growth will most certainly be south into the watershed. Currently, only 17% of the city's jurisdiction lies within the watershed, agreements by the city to particular recommendations are reflected proportionately.

The city has agreed to the following recommendations:

- Dry weather screening on both Reese and Rock Creek in 2012
- Inspect and TV 12,000 linear feet of sewer line per year in 2011 and 2012*
- Clean 350,000 linear feet of sewer line per year in 2011 and 2012*

An asterisk (*) indicates measures that will be completed in proportion to the amount of city area located within the watershed as mentioned earlier.

The city has already transitioned all lift stations to a Supervisory Control and Data Acquisition (SCADA) system that allows constant monitoring of each station. In addition, the city enacted an ordinance that regulates the disposal of Fats, Oils and Greases from commercial businesses and has a 24-hour Illicit Discharge hotline to allow citizens to report illegal dumping.

City of Lampasas

The City of Lampasas is wholly located within the boundaries of the watershed as are all of its wastewater resources. Although much of the city's collection system is composed of aging, clay pipes, the city currently dedicates $100,000 from its annual budget for repair/replacement of these lines. The City also recieves an additional $250,000 biannually from existing Community Block Development Grants which is dedicated to repair/replacement of aging pipes. The city expects to maintain this level of maintenance barring unforseen circumstances. The city also cited the need for an updated wastewater collection system study. The last study was conducted in 1993; an update would include mapping and an evaluation of the existing collection system.

The work group and the city also recommend re-initation of the routine Sanitary Sewer Inspection program of wastewater resources. This program was once an active part of the city's Public Works Department, however the city will need to purchase a new camera unit to re-instate the program. Lampasas also currently has a Fats, Oils and Grease ordinance in place, although it does not include routine inspections completed by the city.

OSSFs

Watershed-Wide

Most septic systems located within the watershed are located outside of city limits and fall within the various counties' jurisdiction. The permitting, recording and inspection of these OSSFs vary greatly between counties based upon funding resources. The work group recognized this as the first hurdle that needed to be overcome to address failing and malfunctioning OSSFs. They recommended the development of a database to initially identify and map all OSSFs within the watershed, both permitted and unpermitted systems. It was also recommended to develop a system that would allow for uniform permitting and inspections throughout the watershed.

After these initial steps have been completed, the work group recommended repair or replacement of 10% of failing systems to achieve a 10% reduction of the bacteria contribution from OSSFs, which amounted to 824 systems over 10 years (Table 6.4). The work group determined that efforts would be most effective by dividing the watershed into focus areas based upon both the results from the SELECT analysis and their knowledge of the areas. Areas most likely to have higher concentrations of older failing systems were placed into the primary focus level with the remaining subwatersheds falling into the secondary focus level. The primary focus area includes the following subwatersheds: Lampasas River 1, Lampasas River 2, Lampasas River 4, Sulphur Creek and Lampasas River 5 (Figure 6.3). Subwatersheds Lampasas River 1 and 2 were included in the primary focus area because although the SELECT model was unable to evaluate failures due to system age, these two subwatersheds have not experienced growth in many years. The work group felt that this suggested that the OSSFs would all be older systems, more likely to fail and included them in the primary focus area. Subwatersheds Lampasas River 4 and 5 and Sulphur Creek were included because the SELECT analysis ranked them as having a higher potential bacteria loading.

Approximately 50% of the systems to be repaired/replaced will be divided evenly among the 5 primary focus subwatersheds; with the other 50% being divided evenly among the 9 secondary focus subwatersheds. Repair/replacement activities will occur in years 4 – 10. These priority levels may change based upon the results from current water quality sampling programs and the results from the development of the OSSF database and mapping program.

Table 6.4 Recommended number of OSSFs to be repaired or replaced by subwatershed.

Focus Area	Subwatershed	Total Systems	Number of OSSFs to Repair/ Replace	Repair/ Replace Percentage of Total Systems
Primary	Lampasas River 1	189	82	43%
	Lampasas River 2	240	82	34%
	Lampasas River 4	1,241	82	7%
	Lampasas River 5	2,789	82	3%
	Sulphur Creek	1,436	82	6%
	Focus Area Total	5,895	410	
Secondary	Lampasas River 3	259	46	18%
	Mesquite Creek	473	46	10%
	Rocky Creek	399	46	12%
	North Bennett Creek	91	46	51%
	Bennett Creek	154	46	30%
	South Bennett Creek	126	46	37%
	Simms Creek	273	46	17%
	School Creek	200	46	23%
	Lucy Creek	374	46	12%
	Focus Area Total	2,349	414	
Total		8,244	824	

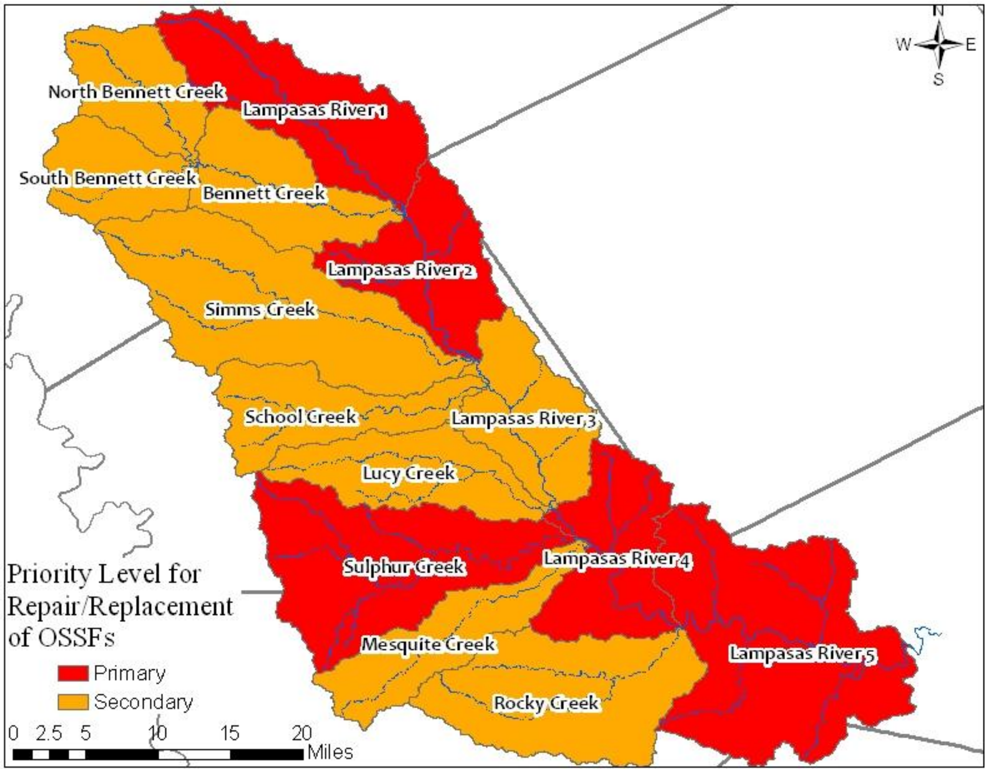

Figure 6.3 Map of priority subwatersheds for repair or replacement of OSSFs.

The work group also felt that it was important to address homeowners that may need additional resources on the proper function of OSSFs in specific subwatersheds. There are several areas within the watershed that have experienced rapid urbanization which may have a higher number of homeowners that have relocated from areas that were served by municipal WWTFs to homes that are on OSSFs. The work group identified these areas as more likely to have failures from inadequate maintenance and improper usage rather than age and suggested programs to educate the homeowners. The work group identified three subwatersheds as target areas for an intensive education and outreach program directed towards homeowners, Sulphur Creek, Lampasas River 4 and Lampasas River 5.

City of Copperas Cove

Copperas Cove currently has an agreement with both Coryell and Bell counties to defer oversight of OSSFs within the city's jurisdiction to the corresponding county's per view. At this point, the city has no plans of connecting the remaining OSSFs to the municipal system because of financial and physical limitations. It has, however, enacted a city ordinance that requires all new OSSFs built within the city limits to be an aerobic system.

City of Kempner

All residences and businesses within the city of Kempner operate on OSSFs. There is no municipal collection system within the city. The city has conducted exploratory studies on the feasiblity of constructing a WWTF and collection system, but it was determined that it was not economically feasible to do so. All OSSFs within the city of Kempner are deferred to the oversight of Lampasas County for permitting, inspections and complaints.

City of Killeen

The City of Killeen has been actively working towards reducing the number of OSSFs within the city limits over the last few years by offering citizens the opportunity to participate in the city's Septic Tank Elimination Program (STEP). STEP provides city funding to install city sanitary sewer mains within city right of way or easements to existing properties which are served by septic tanks. The intent of the program is to eliminate existing septic tanks and to encourage connection to the municipal system. Eligible applicants to the program are ranked with all other eligible applicants according to established criteria set by the City Council. The STEP program is offered in specific areas in accordance with the city's master plan. At this time, no additional STEP work has been planned in the watershed, but will be expanded as the city develops into the watershed.

All OSSFs within the city's boundaries are deferred to the oversight of Bell County for permitting, inspections and complaints.

City of Lampasas

All OSSFs within the City of Lampasas are under the jurisdiction of Lampasas County for permitting, inspection and complaints. The most recent Unsewered Area Study was completed in 2000 and indicated that it was not economically feasible to connect the remaining OSSFs to the municipal collection system, primarily due to the physical constraints of the landscape and the location of those OSSFs. The Wastewater Collection System study that the city has requested as part of the WPP would update this information and allow for more consideration.

STORMWATER MANAGEMENT

Stormwater from urban areas is managed by the TCEQ Municipal Separate Storm Sewer System (MS4) Permit program. In areas with populations of greater than 100,000, a Phase I MS4 permit is required. For smaller urbanized areas that do not meet those requirements, but have a residential population density of at least 1,000 per square mile, a Phase II MS4 permit is required. Based on the 2010 census, there are no areas that require a Phase I MS4 permit, however, both the City of Copperas Cove and the City of Killeen meet the requirements for the smaller urbanized areas and operate under a Phase II MS4 permit. Cities operating under a Phase II permit are required to develop a stormwater management plan (SWMP) that includes at least the following six control measures:

- Public education and outreach;
- Public involvement;
- Detection and elimination of illicit discharges;
- Controls for stormwater runoff from construction sites;
- Post-construction stormwater management in areas of new development and redevelopment; and
- Pollution prevention and "good housekeeping" measures for municipal operations.

Although all measures will compliment the efforts of the Lamapsas River WPP, they are not eligible for under the Federal Clean Water Act Section 319(h) Nonpoint Source Grant Program. However, the Partnership thought it was prudent to included these activities in the WPP. More information about the types of activities included in MS4 permits can be found in Appendix F.

The updated land use analysis indicated that less than 3% of the watershed was classified as 'urban' (Figure 6.4). Although current stormwater management measures were identified, no additional measures were recommended. Although the Cities of Copperas Cove and Killeen are expected to expand in the coming years, their current MS4 permit will also be extended into the watershed. The Partnership will determine if additional urban stormwater management measures, above and beyond MS4 activities, are deemed necessary in the future at milestone years during implementation (Chapter 8). Appendix

E includes measures of efficiency of urban management practices in reducing bacteria contributions.

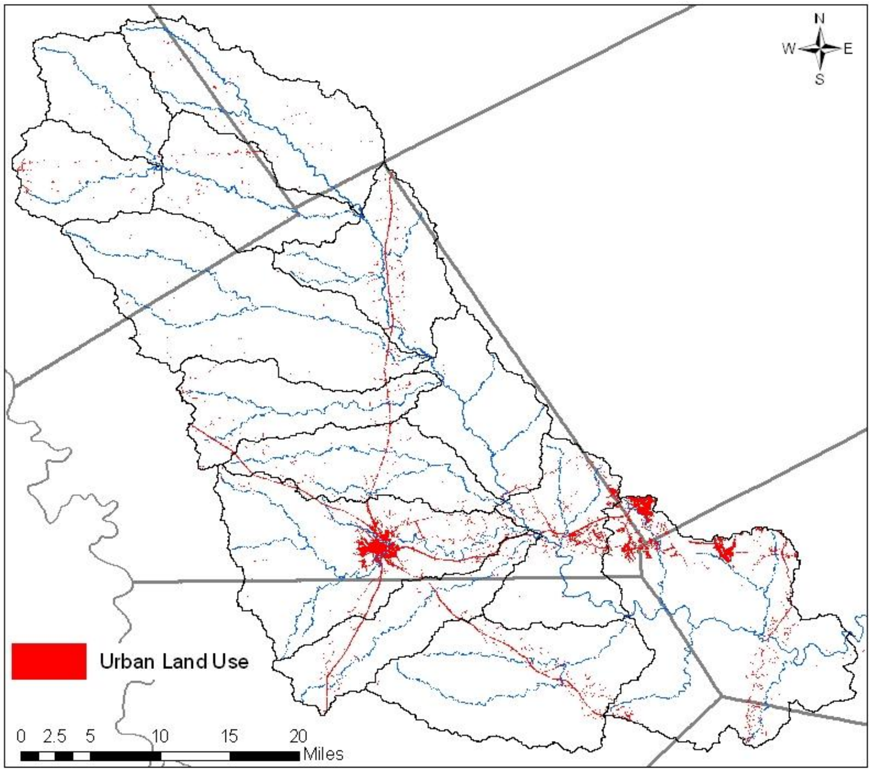

Figure 6.4 Land use analysis indicated that less than 3% of the watershed is classified as 'urban' use.

City of Copperas Cove

The City of Copperas Cove's Phase II MS4 permit was issued in April 2009. The measures defined in the SWMP will be completed within the city as a whole, without regards to watershed boundaries. Some of the measures the City of Copperas Cove has included in their SWMP include:

- Develop and maintain a City Stormwater website;
- Collaborate with Keep Copperas Cove Beautiful for monthly cleanup activities;

- Outreach and education through utility bill inserts, book covers for local schools and distribution of brochures to public;
- Map entire city storm sewer system;
- Stencil all city stormwater inlets;
- Map stormwater system outfalls and receiving streams;
- Require Stormwater Pollution Prevention Plans (SWP3) on all municipal projects;
- Ordinance in place and actively enforced requiring waste containers to control construction debris; and
- Quarterly street sweeping.

City of Killeen

The City of Killeen's Phase II MS4 permit was issued in August 2007. The measures defined in the SWMP will be completed throughout the city as a whole, without regard to watershed boundaries. All measures will compliment the efforts of the Lamapsas River WPP. The following measures are included it the city's SWMP and Phase II MS4 permit:

- Outreach and education through utility bill inserts, book covers for local schools and distribution of brochures to public;
- City Stormwater website developed and maintained;
- Collaborate with Keep Killeen Beautiful for yearly stream cleanup activities;
- Stormwater inlet marking;
- Storm drain system mapping;

- Develop Illicit Discharge Ordinance; and
- Develop Erosion and Sediment Control ordinance.

City of Lampasas

The City of Lampasas currently does not meet the population threshold that would trigger the need for a Phase II MS4 permit. Given the city's current growth rate, it does not expect to meet that threshold in the next 10 years. However, the city has been proactive about controlling stormwater pollution by pursuing voluntary measures. The city is in the midst of a large-scale storm sewer design and installation project along Key Avenue/ HWY 183, a major thoroughfare through town. The city also installs concrete lined drainage ditches as necessary and maintains six grass stormwater detention ponds to control stormwater runoff within the city. The city also has a scheduled street sweeping program in place.

DOMESTIC DOGS

The SELECT analysis was used to determine the total number of dogs within each subwatershed, however, the Urban NPS Work Group determined that efforts would be most effective by concentrating on the urban areas where the dog populations were much denser. The work group felt that utilizing existing resources from other cities and entities to raise public awareness about the proper disposal of pet waste should take priority. A pet waste awareness campaign is outlined in Chapter 8. The work group also recommended the installation of pet waste stations in city parks and along popular walking trails (Figure 6.5). The City of Lampasas identified three locations for pet waste stations in Brook Park, along Sulphur Creek, should funding become available.

Figure 6.5 An example of a pet waste station located within a park to encourage park users to clean up after their pets.

The Cities of Copperas Cove and Killeen do not currently have any city parks where pet waste stations would be appropriate, but as the cities expand into the watershed, pet waste stations will be highly encouraged.

URBAN WILD ANIMALS

Resident Waterfowl

Although resident waterfowl populations were not included in the SELECT analysis, in areas with large populations, they could pose a significant concern as a bacteria source. The waterfowl population at Brook Park along Sulphur Creek in Lampasas is one such place (Figure 6.6). The city currently manages this resident population of ducks through an annual relocation program. The city strives to keep the waterfowl population to approximately 25 birds. Once the park population reaches 50 to 70 birds, the City works with rural landowners with tanks on their property to relocate captured birds. The city typically relocates 25 to 45 birds during this roundup. This program will be continued as long as funding is present.

Figure 6.6 Resident waterfowl at Brook Park in Lampasas. Geese and ducks are routinely fed by park patrons.

Feral Cat Colonies

Contributions from feral cat colonies were also not included in the SELECT analysis, however they can also be a concern as a bacteria source. The City of Killeen has enacted an ordinance as an effort to control these colonies. The city ordinance requires a permit for anyone feeding cat colonies along with requiring that the permittee sterilize/vaccinate 50% of the population annually. While the City of Lampasas does not have an ordinace in place, it has given consideration to the development of a feral cat trapping program should funding become available. Bacteria load reductions were not estimated for a feral cat trapping and management program because the city has not yet determined the feasiblity of such a program.

7. OUTREACH AND EDUCATION STRATEGY

Developing a culture of local watershed stewardship, though outreach and education, is an important component of a successful watershed protection plan. Stakeholders may or may not be aware of the impact that their daily lives make on the health of their watershed. It is crucial to create an awareness of the water quality issues that the Lampasas River watershed faces, as well as provide stakeholders the necessary tools to make informed decisions about their watershed.

INITIAL OUTREACH AND EDUCATION EFFORTS

During the early stages of plan development, several different outreach strategies were utilized to raise stakeholder awareness and increase participation at Steering Committee and Work Group meetings. In conjunction, with the awareness campaign, other programs where included to provide educational resources to the stakeholders throughout the planning process.

PARTNERSHIP WEBSITE

The Lampasas River Watershed Partnership website (http://lampasasriver.org) is hosted by AgriLife Research (Figure 7.1). The Partnership website provides stakeholders with direct access to project background information, as well as meeting information and materials, links to partners, newsletters and contact information. The website launched in January 2009 and has since been viewed over 6,000 times throughout the development of the WPP. The Partnership website will continue to be maintained and updated through the implementation of the WPP.

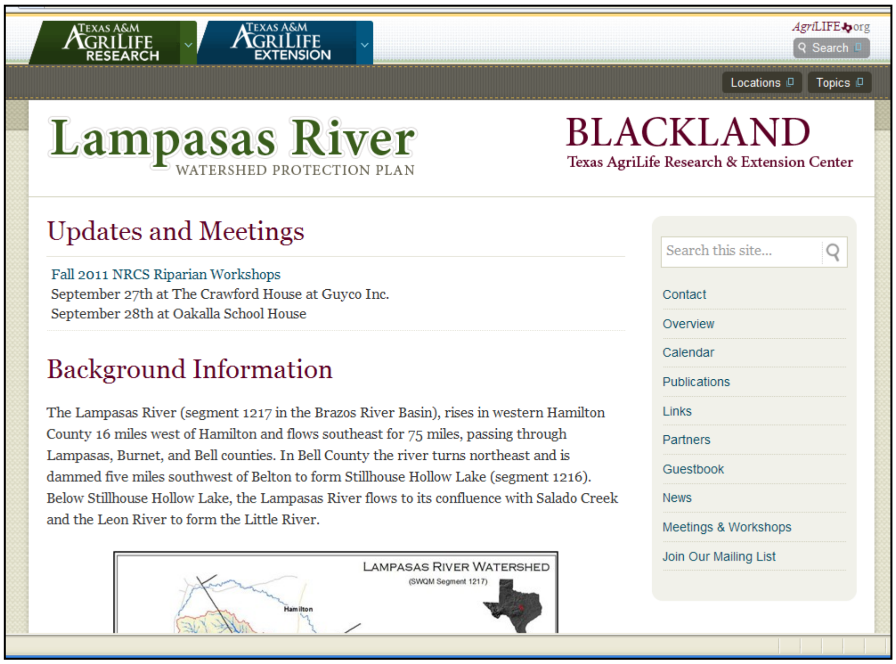

Figure 7.1 The project website is a tool to keep stakeholders informed about the Lampasas River WPP.

NEWS RELEASES

AgriLife Research developed and published press releases in conjunction with the AgNews Service (Texas A&M AgriLife Communications) and Conservation News (TSSWCB). These releases were sent to local media outlets along with various meeting and workshop notices. The local newspapers as well as the Lampasas Radiogram will also be utilized to encourage stakeholder involvement during implementation.

PARTNERSHIP NEWSLETTERS

Newsletters were written and distributed monthly during the stakeholder development phase. These newsletters outlined progress made at previous meetings, information pertaining to upcoming meetings and other programs. Newsletters were distributed via email and postal mail to over 500 stakeholders and were also made available on the Lampasas River Watershed Partnership website and published in local newspapers. Newsletters will continue to provide written updates to stakeholders throughout the implementation of the WPP.

PARTNERSHIP BROCHURE

The Lampasas River Watershed Partnership developed a tri-fold brochure (Figure 7.2) to serve as a marketing tool that would be easily distributed to interested stakeholders and groups. The brochure includes a brief description of the Lampasas River watershed, along with the river's status on the Integrated Report and outlines the Partnership's objectives and goals. Brochures have been distributed to stakeholders through email and postal mail, stakeholder meetings, and other local events and are also available on the Partnership website.

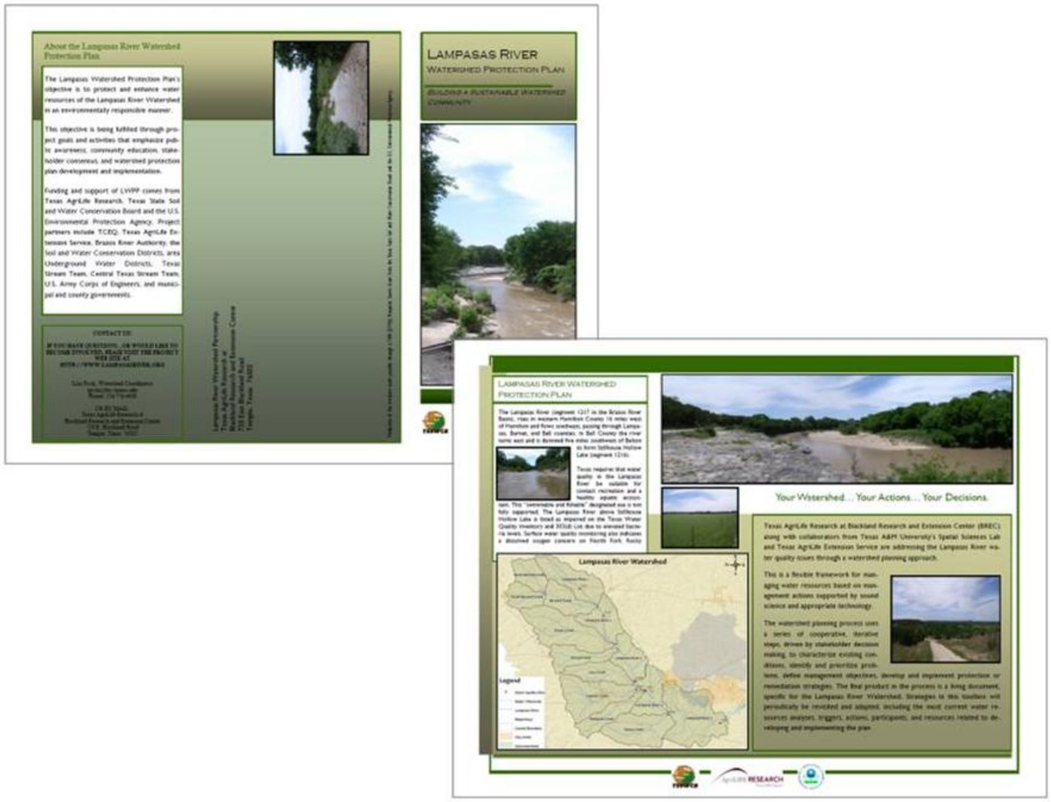

Figure 7.2 Lampasas River Watershed Partnership brochure.

BROAD-BASED PROGRAMS AND TRAINING RESOURCES

LAMPASAS RIVER WATERSHED PARTNERSHIP AWARENESS CAMPAIGN

In order to raise awareness about the Lampasas River Watershed Partnership and its goals, an Awareness Campaign will be developed and implemented. Promotional materials will be developed that detail the Lampasas River watershed and pollutant concerns. These materials may include brochures, fact sheets, posters, maps of the watershed and door hangers. Existing materials such as TWDB's Water IQ program and the Guadalupe-Blanco River Authority's (GBRA) "Don't Be Clueless About Water" handout will also be adapted to fit the Lampasas River watershed.

COMMUNITY OUTREACH

Materials that are developed as part of the Awareness Campaign will be distributed at various local events in an effort to keep the public informed about the Partnership's activities. Annual community events were identified by the Partnership as appropriate venues, including the Lampasas Spring Ho Festival, Celebrate Killeen, Copperas Cove Rabbit Fest, and Lampasas Bloomin' Fest. Other opportunities include the Bell County Crops and Livestock Conference, GIS Day, Texas Recycle Day, Earth Day and the Lampasas Herb and Art Festival. Booths will be set up at these events in order to distribute watershed fact sheets, maps and materials addressing the implementation of the Lampasas WPP.

TEXAS WATERSHED STEWARDS

The Texas Watershed Steward program provides science-based, watershed education to help citizens identify and take action to address local water quality impairments. Texas Watershed Stewards learn about the nature and function of watersheds, potential impairments, and strategies for watershed protection. The Texas Watershed Steward program is implemented through a partnership between AgriLife Extension and the TSSWCB and is open to all watershed residents including homeowners, business owners, agricultural producers, decision-makers, community leaders, and other citizens.

A Texas Watershed Stewards Program was hosted in the Lampasas River watershed on September 25, 2008, to encourage stakeholder participation in the watershed planning process. Additional programs are planned for 2013 and 2015 and every three years after, contingent upon funding.

RIPARIAN PROPER FUNCTIONING CONDITION WORKSHOPS

Biannual Proper Functioning Condition (PFC) workshops will be conducted in the spring and fall in the watershed in conjunction with NRCS. A primary objective of this training is to develop a common vocabulary and understanding of riparian areas among people who work on the land. Workshops will include a classroom portion as well as spending part of the day visiting streams in the field. The workshops will be provided at no cost to private landowners, state, federal, county employees, or any other interested individuals. The Partnership has already hosted four PFC workshops within the watershed to date:

- October 28, 2010 – Parrie Haynes Ranch, Killeen;
- October 29, 2010 – The Meis Ranch, Evant;
- April 26, 2011 – The Lilley Ranch, Lampasas;
- April 27, 2011 – Parrie Haynes Ranch, Killeen;
- September 27, 2011 – The Crawford House, Lampasas; and
- May 3, 2012 – Texas Game Warden Training Center, Hamilton.

TRIBUTARY AND ROADWAY SIGNAGE

Contingent upon funding and cooperation with Texas Department of Transportation (TxDOT), signs will be developed and posted along major roadways entering the watershed, as well as at river and major tributary road crossings to notify travelers when they are entering the watershed or crossing the Lampasas River. In addition to roadway signage, the Partnership will work to gain cooperation from select landowners to place signs on private property near major roadways encouraging residents and travelers to play a positive role in protecting water quality and the Lampasas River watershed.

TEXAS STREAM TEAM

Texas Stream Team is a network of trained volunteers and supportive partners that work 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 water quality data that can be used to detect trends in water resources. In addition to providing water quality monitoring the Texas Stream Team also has developed a Water Monitoring Curriculum, designed for Middle School to High School science teachers. The Texas Stream Team was established in 1991 and is administered through a cooperative partnership between Texas State University, TCEQ, and EPA.

WATER QUALITY IN THE CLASSROOM

The Partnership will work with local school districts to identify an appropriate grade level to partner with to involve school children in water quality issues. AgriLife Research will work to train science teachers in basic water quality monitoring techniques and funding will be sought to purchase testing kits for the classroom. In addition AgriLife Research will present educational materials to classes about the Lampasas River watershed and water quality issues.

The Partnership also recommended that the Watershed Coordinator look into the feasibility of offering something similar to the State 4-H Youth Water Camp on a smaller, more local level. The State 4-H Youth Water Camp is held annually at the George and Opal Bentley 4-H Center in Monahans, Texas. The objective of the 5-day event is to help older youth, throughout the state, become aware of current water issues and appreciate the implications of agricultural, industrial, municipal and home water use on water quality and supply. The camp features field trips, tours and hands-on group project work. The camp focuses on water issues, quality and conservation education. This feasibility study includes meetings with interested partners, such as the local groundwater districts, soil and water conservation districts, Extension personnel and local schools. Feasibility will be determined by interest from the above parties, financial cost and the overall benefit to the Lampasas River watershed.

HOUSEHOLD HAZARDOUS WASTE COLLECTION DAYS

The Partnership will provide support to the Central Texas Council of Governments by providing publicity for annual or biannual hazardous waste collection events to increase public participation within the watershed. Email notifications will be sent to stakeholders announcing events within or near the watershed, as well as publishing notices on the Partnership website and printing and distributing informational fliers.

TARGETED POLLUTANT SOURCE OUTREACH EFFORTS

SEPTIC SYSTEMS

Septic System Informational Campaign

AgriLife Extension and many other agencies have developed extensive educational programs geared towards homeowners with a septic system. The Partnership will adapt and distribute existing technical guidance for owning and operating a septic system through mailings, door hangers, point of sale displays in hardware/plumbing supply stores, and real estate closing agreements. The Partnership will also make these resources available to the city and county governments within the watershed.

Online Module for Septic System Owners

In conjunction with the Plum Creek Watershed Partnership, GBRA has developed an informational module that illustrates a proper functioning septic system and necessary maintenance to ensure efficiency and to extend the life of the system. This module will be on the Partnership website and also made available to other city or county governments within the watershed that want to place it on their website.

Homeowner Septic System Maintenance Workshops

The Partnership will work with AgriLife Extension to host one-day, educational workshops. Operation of both aerobic and anaerobic systems, proper maintenance and the repair of septic systems will be discussed with homeowners. These workshops will be offered in the watershed every three years, pending funding.

WASTEWATER

Online Module for Wastewater Treatment Facilities

GBRA has developed an online module that depicts the procedures of wastewater treatment and explains why it is important to properly manage wastewater at all steps in the process, from the home all the way to the stream where the treatment facility discharges. The module also addresses proper waste management for the homeowners on a municipal collection system. This module will be on the Partnership website and also made available to other cities operating a WWTF within the watershed that want to place it on their website.

Online Module for Fats, Oils and Grease Training

GBRA has also developed an online training module for both businesses and homeowners that addresses proper disposal and handling of fats, oils, greases and other household chemicals. This module will be on the Partnership website and also made available to other city or county governments within the watershed that want to place it on their website.

DOMESTIC PET WASTE

Pet Waste Management

TCEQ and many larger municipalities have begun to address pet waste management and have developed programs geared towards pet owners in urban areas about proper pet waste management. The Partnership will adapt and distribute these materials about the effects of pet waste on water quality through mailings, utility bill inserts and signage posted at veterinary offices and pet supply stores. The Partnership will also make these resources available to the city and county governments within the watershed.

URBAN STORMWATER RUNOFF

Nonpoint Education for Municipal Officials Workshops

Nonpoint Education for Municipal Officials (NEMO) workshops will be hosted as needed within the watershed to provide community planners a resource for materials on smart growth, low impact design, stormwater management and reducing impervious surfaces. NEMO is a national program that is a confederation of 32 educational programs in 31 states dedicated to protecting natural resources through better land use planning.

Low Impact Development Workshops

AgriLife Research will work with TCEQ and Texas Low Impact Development to host workshops and provide informational resources to municipal officials, community planners and developers about utilizing Low Impact Design when planning community growth. Workshops will be held once every 3 years in the first 6 years of implementation. Additional workshops will be added if deemed necessary by the Partnership.

Stormwater BMP Demonstration

As preferred urban stormwater BMPs are implemented within the watershed, AgriLife Research will work in conjunction with TCEQ and cities to host field days demonstrating the effectiveness of the BMPs. Field days will be geared towards builders and developers, city staff, and engineers as well as the general public.

Online Stormwater Training Module

GBRA has developed an online module that demonstrates proper stormwater management and control practices for municipal employees. Training is geared towards entities that must satisfy municipal stormwater regulations. This module will be placed on the Partnership website and made available to other city or county governments within the watershed that want to utilize it for employee training purposes.

Sports Athletic Fields Education Program

AgriLife Research will work with AgriLife Extension's Sports and Athletic Field Education (SAFE) Program to educate athletic field and golf course managers and employees about nutrient management practices. The SAFE program addresses proper fertilizer and pesticide selection and use, as well as water management of turfgrasses. Program events will be held every other year.

Urban Nutrient Management

The Partnership will work with programs like Grow-Green and Earth-Kind Landscaping to provide materials to homeowners about proper application rates for fertilizer and pesticides, in addition to resources on BMPs for urban lawn maintenance. Resources for sustainable landscape management are also available through AgriLife Extension's Master Gardener and Master Naturalist programs. With assistance from these resources, AgriLife Research will also work with AgriLife Extension to develop an Urban Soil

Nutrient Test Campaign to encourage homeowners and landscape managers to utilize a recent soil nutrient analysis to ensure proper fertilizer application rates.

AGRICULTURE

Grazingland Management Education

In conjunction with local SWCDs, NRCS and TSSWCB, promotional materials will be developed that encourage landowners to participate in the WQMP Program. In addition to the promotional materials and with the cooperation of AgriLife Extension, BMP demonstrations and field days will be held to demonstrate proper grazing and nutrient management practices. These field days will allow local farmers and ranchers to see BMPs at work on neighboring operations.

Soil and Water Nutrient Testing Campaign

AgriLife Research will work with AgriLife Extension to encourage beneficial soil and water testing prior to fertilizer application to forage and row crops. The Partnership will seek funding to provide tests at a free or reduced rate, when possible.

Lone Star Healthy Streams Program

AgriLife Extension's Lone Star Healthy Streams Program focuses on educating farmers, ranchers and landowners about mitigating bacteria runoff through management practices for various agriculture operations. Resources for beef cattle operations and feral hog management will be particularly useful within the watershed.

WILDLIFE AND FERAL HOGS

AgriLife Research will work with AgriLife Extension to develop and adapt existing materials concerning management of feral hog populations to fit the needs of the Lampasas River watershed. Resources will be made available to interested landowners and land managers.

Feral Hog Management Workshops

Feral Hog Workshops will be conducted by AgriLife Extension for landowners and land managers to provide them with information regarding the damaging effects of feral hog populations and with the most effective methods of controlling the populations. Participants will receive information on feral hogs, including their status and distribution, hog biology, interactions with native wildlife, disease concerns, laws and regulations associated with feral hogs and information on various control strategies. Other topics relating to feral hogs may be added as needed. Workshops will be hosted annually throughout the watershed.

Whitetail Deer Management

AgriLife Research will work with TPWD and NRCS to disseminate informational materials about the benefits of developing a WMP and enrolling in the WHIP program to direct habitat management and participating with other landowners in a WMA. AgriLife Research will also provide support to TPWD in the development and hosting of Landowner Field Days and workshops as needed.

ILLEGAL DUMPING CAMPAIGN

Don’t Mess With Texas Water

H.B. 451 creates the Don't Mess with Texas Water program to be administered by the TCEQ. The bill was signed by the governor on June 17, 2011, and was effective September 1, 2011. This program will place signs on major highway water crossings that display a toll-free hotline to report illegal dumping. Calls to the hotline will be forwarded to the appropriate authorities. Local governments may work with TCEQ to participate in the program and can contribute to the cost of operating the toll-free number. TxDOT will be required to work with TCEQ in placing the signs.

Texas Waterway Cleanup Program

The Partnership will coordinate with Keep Texas Beautiful to organize yearly roadway cleanups at bridge and stream crossings within the watersheds. The waterway cleanup will be open to all stakeholders and local civic groups will be invited to participate. Yearly records of the amount of waste removed will be kept.

Recreationalist Anti-Litter Campaign

Develop or adapt existing material about respecting property rights and disposing of trash while recreating on the river. Resources will be geared towards the general public who utilize the river for recreational purposes, such as fishing, boating or swimming. Materials will be distributed at sporting good centers and kayak rental facilities and other points deemed appropriate.

Recreationalist Waste Disposal

AgriLife Research will work with stakeholders and other agencies to develop educational materials about disposal methods for human waste and effluent at rustic hunting camps.

The Partnership also recommended working with counties to place waste sacks and trash barrels at popular recreational areas along the main stem of the river. Bridge crossings that allow access to the water for fishing and boating were of particular importance.

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8. MEASURES OF SUCCESS

ADAPTIVE IMPLEMENTATION

Watersheds are dynamic by nature and countless variables govern landscape processes across scales of time and space. Because of this, some uncertainty should be expected when developing and implementing a WPP. As recommended management measures are put into place in the Lampasas River watershed, it will be necessary to track changes in water quality over time and make adjustment to the implementation strategy as necessary. Utilizing adaptive implementation will provide the Partnership the flexiblity needed to make such adjustments throughout the implementation process.

Adaptive implementation is the ongoing process of accumulating knowledge of the cause of impairment as implementation efforts progress. This results in reduced uncertainty associated with modeled loads. Water quality is tracked as implementation activities are instituted to assess impacts and guide adjustments to future implementation activities. This ongoing, cyclic implementation and evaluation process serves to focus project efforts and optimize impacts.

The constant input of watershed information and the establishment of intermediate and final water quality targets are necessary for adaptive implementation to be effective. Instream pollutant concentration targets for the Lampasas River watershed were developed based upon complete implementation of the WPP and assume full accomplishment of expected load reductions by the end of the 10 year project period

(Table 8.1). Water quality targets are based upon the concentration geomean for moist conditions. Although some of the recommended management measures may be relatively simple to implement early in the timeline, implementation of other measures will require more time, energy and funding. Because of these factors, reductions in pollutant loads and associated concentrations may be gradual. However, it can be assumed that the reduction in loadings will be tied to the implementation of management measures throughout the watershed. These projected pollutant targets will serve as benchmarks of progress, allowing the Partnership to determine if changes are necessary to achieve the final water quality goal. Although water quality conditions will likely change and may not follow these projections precisely, these estimates will serve as a tool for the Partnership for evaluation and decisionmaking based on adaptive implementation.

Table 8.1 *E. coli* pollutant target concentrations for two sampling sites located in the watershed during the 10-year implementation schedule.

Year	Lampasas River at CR 105 15770	Lampasas River Near Kempner 11897
	E. coli Concentration (cfu/100mL)	
Year 3	125	90
Year 6	123	88
Year 10	115	82

MONITORING AND WATER QUALITY CRITERIA

Water quality data will be analyzed using a three year geometric mean for *E.coli* to evaluate trends within the watershed. These values will be compared to the expected reductions identified in Table 8.1 to determine if adjustments to the implementation strategy are necessary. The Partnership will review water quality data in regards meeting expected reductions yearly and especialy at milestone years three, six and ten. In addition, water quality data will be analyzed yearly using a seven year geometric mean to examine trends and assess the health of the river and its tributaries for the Integrated Report.

While the success of the WPP will be evaluated against the criteria in Table 8.1, water quality monitoring and evaluation will not be limited to those two sites (Sites 15570 and 11897). Water quality monitoring throughout the watershed will provide data to evaluate the effects of implementation in priority areas. Water quality data within the watershed has historically been collected by several entities; Brazos River Authority (BRA), TCEQ and AgriLife Research. Unintterupted, routine, monthly monitoring will be key to providing accurate data to reflect changes within the watershed.

Although many routine sampling sites have been utilized through the years for the Integrated Report, the Partnership selected ten locations for continued routine monthly sampling (Table 8.2) during the first three years of implementation to supplement current pre-implementation data. The Partnership deemed these ten sites as “critical” for evaluating the effects of implementation. These sites were identified because they will yield a dataset that is all encompassing of areas where implemention will be focused and is spatially representative (Figure 8.1) of the watershed.

Table 8.2 Recommended long term monitoring sites to be evaluated monthly.

TCEQ ID	Site Name
15762	Lampasas River at US 84
15770	Lampasas River at Lampasas CR 2925
16404	Lampasas River at FM 2313
18782	Sulphur Creek at Naruna Rd
15781	Sulphur Creek at Lampasas CR 3010
15250	Sulphur Creek at CR 3050
11897	Lampasas River at US 190
21016	Clear Creek at Oakalla Rd
18759	Reese Creek near FM 2670
11896	Lampasas River at SH 195

Ambient in-stream data collected will include field parameters: pH, temperature, dissolved oxygen and specific conductance; conventional parameters: total suspended solids, nitrate + nitrite nitrogen, total kjeldahl nitrogen, chlorophyll-a, pheophytin and total phosphorus. Flow will will be collected and *E. coli* will be enumerated. Observed data should also be collected, such as number of days since last rainfall, appearance and odor of water, biological activity and anything else deemed important by sample collector. After the initial intense monthly sampling scheme during the first 3 years has been analyzed, the Partnership will reevaluate the recommended sites and intensity. New recommendations will be made based upon results from the collected data to ensure the most efficient use of resources. Flow biased water quality samples will also be collected at least quarterly for the first three years at ten sites identified in Table 8.2.

Parameters measured will be the same as the routine samples, with the exclusion of chlorophyll-a and pheophytin.

Not all of the monitoring parameters are necessary to assess current impairments or concerns. However, routine monitoring of these parameters will allow the Partnership to detect the development of additional water quality problems as changes within the watershed occur.

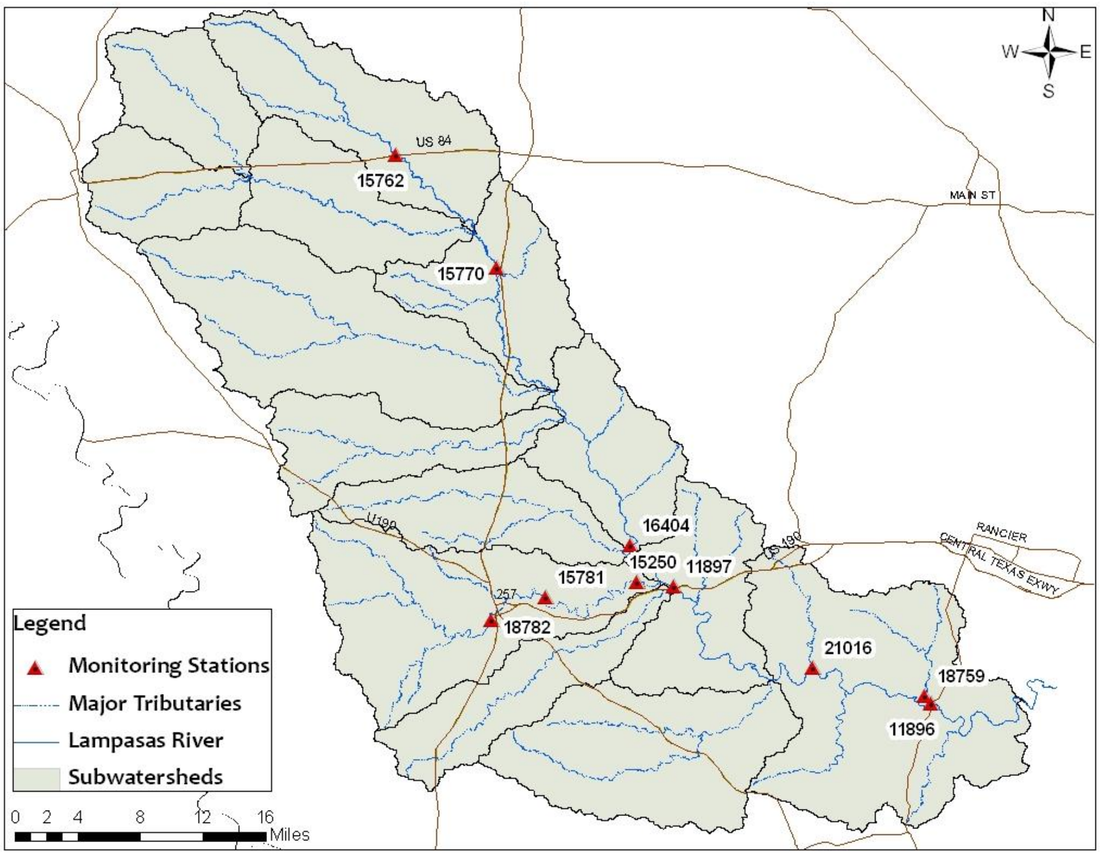

Figure 8.1 Location of recommended sites for long-term water quality monitoring.

The Partnership will review water quality data in regards to meeting expected reductions yearly and especially at milestone years three, six and ten. At the end of these milestone years, the Partnership will assess the effectiveness of each sampling site in regards to implementation efforts. Water quality monitoring sites may be moved, discontinued or added through adaptive implementation. In addition, water quality data will be analyzed yearly using a seven year geometric mean to examine trends and assess the health of the river and its tributaries for the Integrated Report. A similar water quality monitoring program will also be utilized in the last three years of implementation. The Partnership will also evaluate the need for automated storm flow sampling and continous base flow sampling at the three year milestone based upon the technology available and the costs of such a rigorous monitoring scheme and the historical data.

The Partnership will collaborate with BRA's Clean Rivers Program (CRP) when possible for water quality monitoring in order to economize resources. The CRP was established in 1991 as a partnership between TCEQ and regional water authorities to coordinate and conduct water quality monitoring, assessment, and stakeholder participation to improve the quality of surface water within each river basin in Texas. The CRP is a fee-funded, non-regulatory program, with 50% of its budget allocated to water quality monitoring. However, it is important for the Partnership to seek out other funds for water quality monitoring to achieve the intensity and longevity needed to measure the effectiveness of the WPP in improving water quality.

BACTERIAL SOURCE TRACKING

An intensive bacterial source tracking (BST) program was conducted in the watershed. TSSWCB funded the Bacterial Source Tracking to Support the Development and

Implementation of Watershed Protection Plans for the Lampasas and Leon Rivers Project in 2010. This project paired intensive water quality monitoring and bacterial source tracking and was designed to produce useful information to improve local knowledge of pollutant sources contributing bacteria to the watershed. Historically, water quality data was collected in the watershed on a quarterly basis at a limited number of sampling locations. The intensive water quality monitoring implemented through this project collected monthly samples at 15 Partnership recommended monitoring sites over the course of a year (Figure 8.2). This provided a much clearer look at seasonal and spatial trends in water quality. Additionally, this expansive set of water quality samples was used for BST and allowed estimates of bacteria source contributions to be made at each sampling site.

AgriLife Research's Water Sciences Laboratory cooperated with the University of Texas Health Science Center at Houston School of Public Health, El Paso Regional Campus (UTSPH-EP) to measure stream flow and collect, enumerate, and genetically type *E. coli* from watershed sources. Known fecal source *E. coli* were collected within the watershed and genetically typed to supplement the Texas *E. coli* BST Library for identifying the sources of *E. coli* isolated from water samples. Water samples were filtered and *E. coli* present were selectively cultured and enumerated by AgriLife Research. Following enumeration, cultures were shipped to El Paso for genetic typing by UTSPH-EP. Using BST, the human and animal sources of *E. coli* isolated from water can be determined.

Collectively, these data and associated analysis will provide an enhanced look at water quality and pollutant source contributions that will aid watershed stakeholders in their implementation efforts. This data will be available to be included in the first biennial WPP update and will be used to better direct implementation activities through adaptive implementation. At that point, the Partnership will make the determination whether additional BST data is necessary.

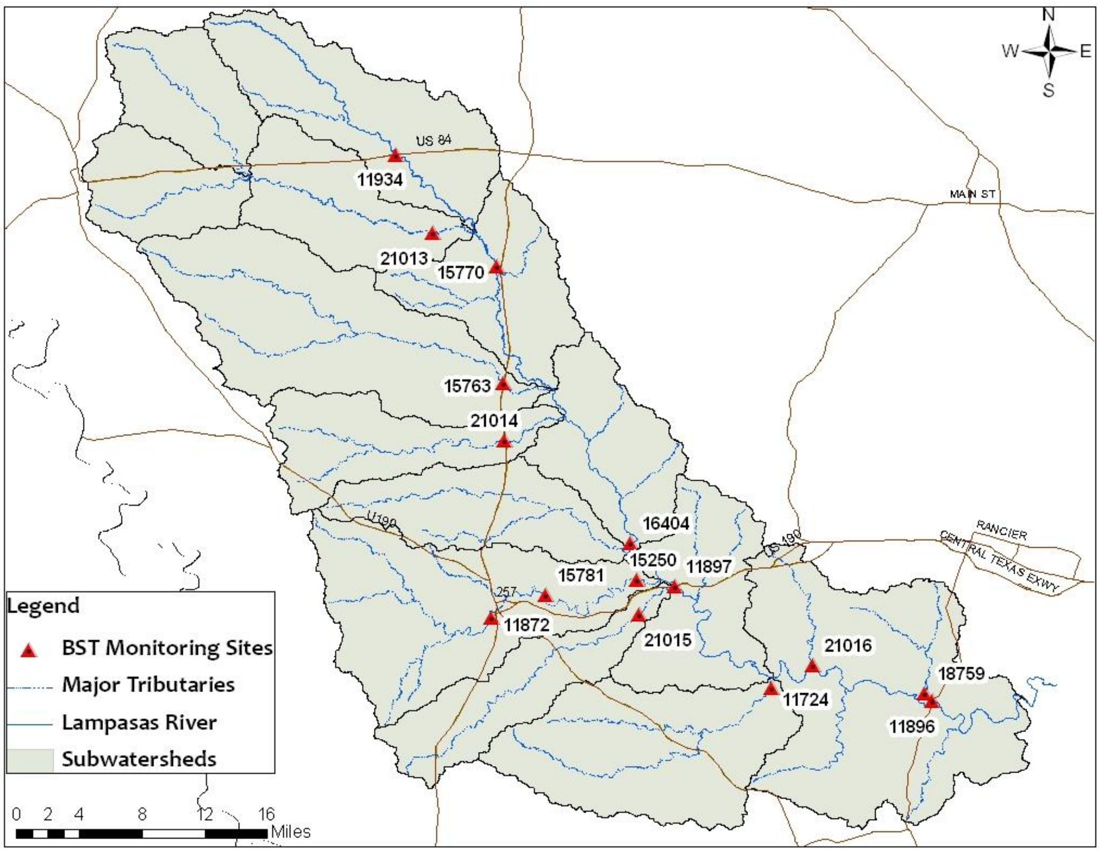

Figure 8.2 Water quality monitoring locations for the "Bacterial Source Tracking to Support the Development and Implementation of Watershed Protection Plans for the Lampasas and Leon Rivers" project, within the Lampasas River watershed.

SOIL AND WATER ASSESSMENT TOOL

To support adaptive implementation, the Soil and Water Assessment Tool (SWAT) may be used to model hydrologic processes and fate and transport of *E. coli* within the watershed. The SWAT model is a basin-scale model that simulates daily flows and events in the watershed. This tool allows prediction of management impacts on water volume and loads of nutrients, bacteria, and other pollutants over long periods of time. The existing dataset does not support the use of SWAT within the watershed. However, as the dataset grows over time, the Partnership will determine if SWAT should be utilized to model and predict changes within the watershed.

9. PROJECT IMPLEMENTATION

This chapter outlines technical assistance needed, a schedule for implementation of the recommended management measures as well as an estimate of the expected costs of the measures. This chapter also identifies potential sources of funding that may be pursued to offset the costs of implementation of management measures outlined in the Lampasas River WPP.

TECHNICAL ASSISTANCE

Successful implementation of the Lampasas River WPP will require support and assistance from a variety of sources. While highly motivated and invested, the technical expertise, equipment and manpower for many of the recommended management measures are beyond the capacity of the the individual stakeholders. Direct support from various entities will be essential to achieve water quality goals in the watershed. Implementation of key restoration measures will require the creation of several full-time positions within the watershed to coordinate and provide technical assistance to stakeholders.

AGRICULTURAL MANAGEMENT MEASURES

Technical support from local SWCDs and NRCS personnel is critcal to the selection and placement of appropriate management measures on individual agricultural properties. However, the number of managment plans recommended by the Partnership will necessitate the creation of a new position dedicated specifically to the development of WQMPs. This position will develop information and resources to promote implementation of BMPs and provide direct assistance to agricultural producers.

Technical assistance for agricultural producers and landowners may also come from other state agencies, such as AgriLife Extension and Texas A&M Forest Service.

WILDLIFE AND NON-DOMESTIC ANIMAL MANAGEMENT MEASURES

Although each county within the watershed employs at least one full-time trapper, resources available directly to landowners are scarce. The Partnership recommends coordination with AgriLife Extension to create a new position, located within the watershed to provide landowners with techncial and educational resources. This position will not only provide technical assistance, but will also oversee the feral hog online tracking and damage website.

OSSF MANAGEMENT MEASURES

A key initial recommendation for the management of OSSFs within the watershed is the development and population of a database to determine the location of all permited and unpermitted OSSFs. This will prove to be a large undertaking for any one county; the creation of a staff position may be necessary to successfully develop the database. This position would not only develop the database but also work with local counties, cities and homeowners to identify the locations and types of OSSFs.

SCHEDULE, MILESTONES AND ESTIMATED COSTS

Milestones are used to evaluate progress in the implementation of management practices recommended in the WPP. They are goals for when a specific practice or measure is targeted for implementation. The implementation schedule, milestones and estimated costs of implementation (Table 9.1and Table 9.2) are the result of planning efforts of the Steering Committee and work groups, in conjuction with county and city officials and other watershed stakeholders. The Partnership recommended operating on a 10-year timeline broken incrementally into years 1 – 3, 4 – 6 and 7 – 10. Most management measures have quantitative targets established throughout the 10-year timeline. This allows key milestones to be tracked over time so that progress is more easily measurable. Multi-year increments also allow for the process of funding acquisition, hiring of staff and the implementation of new programs, all of which take time. In the event that a particular milestone takes longer to achieve, efforts will be intensified or adjusted as necessary. If at some point the milestone is deemed unattainable, the Partnership will address the issue through adaptive implementation.

PROJECT COORDINATION

In addition to the technical and financial assistance required for implementation of management measures and outreach programs, the Partnership recommended that a full-time Watershed Coordinator be employeed to facilitate the implementation of the

Lampasas River WPP. This position will oversee project activities, seek additional funding to support implementation of recommended management measures, organize and coordinate regular updates for the Partnership, maintain the Partnership website, and coordinate outreach and education efforts.The Watershed Coordinator will also track implementation efforts and progress made towards meeting milestones which will be included in biennial updates to the WPP. An estimated $100,000 per year including travel expenses will be necesasary for this position.

Table 9.1 Schedule of milestones, responsible parties and estimated costs for recommended management measures.

Management Measure	Responsible Party	Unit Cost	Number Implemented			Total Cost
			Year			
			1 - 3	4 - 6	7 - 10	
Agricultural Management Measures						
WQMP Technician (New Position)	SWCD	$75,000/year	1			$750,000
Water Quality Management Plans	SWCD	$15,000/plan	65	64	64	$2,895,000
Non-Domestic Animal and Wildlife Management Measures						
Feral Hog Specialist (New Position)	AgriLife Extension	$90,000/year	1			$900,000
Feral Hog Managment (Equipment)	AgriLife Extension	$500/trap	10	---	---	$5,000
Monitoring Component						
Targeted Water Quality Monitoring	AgriLife Research	$150,000/year for 10 sites	3	---	---	$450,000[1]
Wastewater Management Measures						

Management Measure	Responsible Party	Unit Cost	Number Implemented			Total Cost
			Year			
			1 - 3	4 - 6	7 - 10	
Wastewater Collection System Line Replacement	City of Lampasas	$100,000/ year	3	3	4	$1,000,000[2]
Wastewater Collection System Line Replacement	City of Lampasas	$250,000/ biennium	3	3	4	$1,250,000[3]
Wastewater Collection System Study	City of Lampasas	$50,000/ study	1	---	---	$50,000
Sanitary Sewer Inspection Program	City of Lampasas	$20,000/ camera	1	---	---	$20,000
OSSF Inventory and Database Development	Counties	$42,000/year	1	---	---	$126,000
OSSF Inspector	Counties	$42,000/year	---	1	1	$294,000
OSSF Repair / Replacement	Counties	$5,000 - $10,000/system	---	412	412	$4,120,000 - $8,240,000[4]
Urban Stormwater Management Measures						
Expand Street Sweeping Program (Equipment)	City of Killeen	$280,000/ vacuum-camera truck	1	---	---	$280,000
Pet Waste Collection Stations (Installation)	City of Lampasas	$620/ station	3	---	---	$1,860
Pet Waste Collection Stations (Maintenance)	City of Lampasas	$85/ year / station	3	3	4	$2,550
Brook Park Resident Waterfowl Relocation	City of Lampasas	$1,000 /year	3	3	4	$10,000[2]

Management Measure	Responsible Party	Unit Cost	Number Implemented Year			Total Cost
			1 - 3	4 - 6	7 - 10	
Develop and Implement a Feral Cat Management Program	City of Lampasas	$5,000/year	3	3	4	$50,000

[1]Additional monitoring may be necessary in years 4 - 10, but at lower frequency
[2]Currently underway using City of Lampasas Funds
[3]Currently underway by the City of Lampasas using Community Block Development Funds
[4]OSSFs will be repaired or replaced depending upon results from database development

Table 9.2 Responsible party, program milestones and estimated financial costs for outreach and education programs.

Management Measure	Responsible Party	Number of Programs Year			Total Cost
		1 - 3	4 - 6	7 - 10	
Broad-Based Programs					
Partnership Awareness Campaign	Partnership	3	3	4	$10,000
Displays at Local Events	AgriLife Research	5	5	5	$3,000
Texas Watershed Stewards Program	AgriLife Extension	2	1	1	N/A
Riparian Management Workshops	AgriLife Research / NRCS	6	4	6	N/A
Tributary and Roadway Signage	Partnership	---	18	---	$3,600[1]
Illegal Dumping Campaign	Partnership	3	3	4	TBD
“Don't Mess With Texas Water” signage	Counties / TCEQ	--	3	--	$3,000
Texas Waterway Cleanup Program	Keep Texas Beautiful	3	3	4	N/A
Water Quality in the Classroom Kits	BRA / Texas Stream Team	3	3	2	$8,000
Volunteer Monitor Training	Texas Stream Team	1	1	1	N/A

Management Measure	Responsible Party	Number of Programs			Total Cost
		Year			
		1 - 3	4 - 6	7 - 10	
Household Hazardous Waste Days	CTCOG	2	2	2	N/A
Texas Well Owner Network Trainings	AgriLife Extension	2	2	2	N/A
Urban Stormwater Programs					
Urban Soil and Water Testing Campaign	AgriLife Extension	3	3	4	$36,000
Pet Waste Awareness	Partnership	3	3	4	$35,000
SAFE Workshops	AgriLife Extension	1	2	2	$22,500
Advertise Stormwater Control Training Module	Partnership	3	3	4	$10,000
Low Impact Design Workshop	AgriLife Extension	1	1	---	$10,000
Wastewater Programs					
Advertise Online WWTF Module	Partnership	3	3	4	$10,000
Advertise Online OSSF Module	Partnership	3	3	4	$10,000
Advertise Fats, Oils and Grease Module	Partnership	3	3	4	$10,000
Fats, Oils and Grease Workshops	TCEQ/ AgriLife Extension	---	2	---	$10,000
NEMO Workshops	TCEQ/ AgriLife Extension	1	---	1	$10,000
Introduction to OSSFs for Homeowners Workshop	AgriLife Extension	1	1	1	$7,500
Aerobic OSSF for Homeowners Workshop	AgriLife Extension	1	1	1	$7,500
Agriculture Programs					
Soil and Water Testing Campaign	AgriLife Extension	3	3	4	$36,000
Agriculture Field Days	AgriLife Extension	3	3	4	$1,000

Management Measure	Responsible Party	Number of Programs			Total Cost
		Year			
		1 - 3	4 - 6	7 - 10	
Lone Star Healthy Streams - Grazing Cattle	AgriLife Extension	1	1	1	N/A
Lone Star Healthy Streams - Horse	AgriLife Extension	1	1	1	N/A
Non-Domestic Animal and Wildlife Management Measures					
Lone Star Healthy Streams - Feral Hog	AgriLife Extension	1	1	1	N/A
Advertise Online Feral Hog Damage Tracking System	Partnership	3	3	4	$10,000

[1] Pending TXDOT's approval to place roadway signs

SOURCES OF FUNDING

There are many federal and state programs available to provide funding for the various recommended management strategies identified in the Lampasas River WPP. Successful acquisition of funding will be critical to the Partnership's success in meeting set water quality goals. Some key potential funding sources that may be pursued are discussed below.

AGRICULTURAL WATER ENHANCEMENT PROGRAM (AWEP)

The Agricultural Water Enhancement Program is administered by the NRCS. This voluntary conservation initiative provides financial and technical assistance to producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and groundwater and improving water quality. This program will be utilized to assist agricultural producers in the development of conservation plans and implementation of BMPs that will improve water quality.

CLEAN WATER STATE REVOLVING FUND (SRF)

The Clean Water State Revolving Fund is administered by TWDB to provide low-interest loans to entities with the authority to own and operate wastewater treatment facilities. Funds are used in the planning, design, construction of facilities, collection systems, stormwater pollution control projects and nonpoint source pollution control projects. Wastewater operators and permittees in the Lampasas River watershed will pursue these funds when treatment upgrades become necessary.

CONSERVATION RESERVE PROGRAM (CRP)

The Conservation Reserve Program is adminstered by the USDA Farm Services Agency and is a voluntary program for agricultural landowners. Through the CRP program, landowners can receive annual rental payments and cost-share assistance to establish long-term resource conservation groundcover on eligible farmland. The program provides financial incentives for up to 50% of the participant’s cost in establishing approved conservation practices. Landowners in the Lampasas River watershed may seek enrollment in this program to support the implementation of agricultural management measures.

ECONOMICALLY DISTRESSED AREA PROGRAM (EDAP)

The Economically Distressed Area Progam is administered by TWDB and provides assistance in the form of grants, loans or a combination of financial assistance for wastewater projects in economically distressed areas where present facilities are inadequate to meet residents' minimal needs. Communities within the watershed that qualify may pursue funding to improve wastewater infrastructure.

ENVIRONMENTAL EDUCATION GRANTS

The Environmental Education Grants program is sponsored by EPA's Environmental Education Division, Office of Children's Health Protection and Environmental Education to support environmental education projects that enhance the public's awareness, knowledge and skills to help people make informed decisions that affect environmental quality. EPA awards grants annually based upon funding appropriated by Congress. Funding from this program may be pursued to support the development of outreach and education programs for the Lampasas River Watershed Partnership.

ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP)

The Environmental Quality Incentives Program is administered by the NRCS and is a voluntary program for agricutural producers. The program promotes agricultural production and environmental quality as compatible national goals. EQIP offers both technical and financial assistance to eligible participants for the installation or implementation of structural controls and management practices on eligible agricultural land. Agricultural producers in the Lampasas River watershed may engage this program to support the implementation of agricultural management measures.

FERAL HOG ABATEMENT GRANT PROGRAM

The Feral Hog Abatement Grant Program is administered by the Texas Department of Agriculture. It is a one-year grant program focused on implementing a long-term statewide feral hog abatement strategy. Texas A&M Wildlife Services and the TPWD have received funding under this grant program.

OUTDOOR RECREATION GRANTS

The Outdoor Recreation Grants program is administered by TPWD's Recreation Grants Branch to provide grant funds to municipalities, counties, municipal utility districts 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. This program may be pursued to plan and develop greenspace in urbanizing areas of the Lamapsas River watershed.

FEDERAL CLEAN WATER ACT SECTION 319(H) NONPOINT SOURCE GRANT PROGRAM

The EPA provides funding to states to support projects and activities that meet federal requirements of reducing and eliminating nonpoint source pollution. Both TCEQ and TSSWCB receive funding to support nonpoint source pollution projects, the TSSWCB funds going to agricultural and silvicultural issues and TCEQ funds going to urban and other non-agricultural issues. Funding will be sought through TSSWCB to support continued facilitation of the Lampasas River Watershed Partnership by employing a full time Watershed Coordinator, development of WQMPs, and feral hog management as well as for water quality monitoring. Funding from TCEQ will be sought to support the implementation of urban stormwater management measures and OSSF management efforts.

SUPPLEMENTAL ENVIRONMENTAL PROJECT PROGRAM (SEP)

The Supplemental Environmental Project program is administered by the TCEQ and directs fines, fees and penalties from environmental violations toward environmentally beneficial uses. Through this program, a respondent in an enforcement matter can choose to invest penalty dollars in improving the environment, rather than paying into the Texas General Revenue Fund. Funds may be directed to the cleanup of unauthorized trash dumps, plugging abandoned water wells and the repair/replacement of failing OSSFs.

TEXAS CAPITAL FUNDS

Texas Capital Funds are administered by the Texas Department of Agriculture as part of the Community Development Block Grant and provides more than $10 million in competitive awards each year to small Texas cities and counties. The Texas Capital Funds provide funding for infrastructure projects that include water and sewer lines and drainage improvements. This program will be pursued to seek funding for implementation of Urban NPS management measures.

TEXAS FARM AND RANCH LANDS CONSERVATION PROGRAM

The Texas Farm and Ranch Lands Conservation Program is administered by the Texas General Land Office and provides grants to landowners for the sale of conservation easements that create a voluntary free-market alternative to selling land for development. This program helps to stem land and habitat fragmentation and loss of agricultural lands.

USDA RURAL DEVELOPMENT PROGRAM

The Rural Development Program is administered by the USDA and offers grants and low-interest loans to rural communities for the planning and development of water and wastewater development projects.

WATER QUALITY MANAGEMENT PLAN PROGRAM

The WQMP Program is administered by the TSSWCB and is also known as the Senate Bill 503 program. The WQMP program is a voluntary mechanism that can be utilized by landowners to develop and implement site-specific plans on agricultural or silvicultural lands to prevent or reduce nonpoint source pollution from those operations. Plans are developed in cooperation with local SWCDs, cover an entire operating unit and allow financial incentives to augment participation. Funding from the WQMP program will be sought and utilized to support the implementation of BMPs on agricultural land within the watershed.

WATER SUPPLY ENHANCEMENT PROGRAM

The Water Supply Enhancement Program is administered by the TSSWCB to enhance water supplies through selective control of water depleting brush. The program is voluntary and provides financial incentives to landowners of up to 80% of the total cost of an approved practice. Assistance is limited to critical areas as designated by the TSSWCB and to methods of brush control approved by the TSSWCB. Landowners in the Lampasas River watershed may seek funding through this program to implement brush removal practices prior to establishing other agricultural management measures.

WILDLIFE HABITAT INCENTIVE PROGRAM (WHIP)

The WHIP is administered by NRCS and is a voluntary program for conservation minded landowners who want to improve wildlife habitat on agricultural land, non-industrial private forestland and Indian land. WHIP provides both technical and financial assistance to establish and improve fish and wildlife habitat. Key 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. Landowners in the Lamapsas River watershed may seek funding through the WHIP program to enhance wildlife habitat.

EXPECTED LOAD REDUCTIONS

Expected load reductions of *E. coli* as a result of full implementation of the Lampasas River WPP are presented in Table 9.3. Estimates of attainable load reductions are difficult to determine and may change as the watershed land use and pollutant sources changes. However, these estimates will be used to demonstrate expected improvement toward water quality targets. With continued support from cooperating groups and agencies, stakeholder engagement and participation during implmentation, the activities outlined here will make significant progress toward improving and protecting water quality in the Lampasas River watershed.

Table 9.3 Estimated pollutant load reductions expected upon full implementation of the Lampasas River Watershed Protection Plan.

Management Measure	Expected E.coli Load Reduction
Agricultrure Nonpoint Source Measures	
WQMP Technician (New Position)	1.80E+14
Water Quality Management Plans	
Wildlife and Non-Domestic Animals	
Feral Hog Specialist (New Position)	6.67E+13
Feral Hog Control (Equipment)	
Feral Hog Control Outreach Programs	
Deer	0
Municipal Wastewater Management Measures	
Wastewater Collection System Study	NQ[1]
Wastewater Collection System Line Testing/Replacement	
OSSF Management Measures	
OSSF Outreach Programs	3.33E+12
Development of OSSF Database	
Identification of OSSFs in Watershed	
OSSF Inspector (New Position)	
OSSF Repair/Replacement	
Urban Stormwater Management	
MS4 Stormwater Permit Activities	NQ
Street Sweeping	NQ
Dog Waste Stations	2.63E+12
Resident Waterfowl Relocation	3.19E+13
Feral Cat Programs	NQ

[1]Programs identified but not reduction was not quantified

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A. Partnership Ground Rules

The Lampasas River Watershed Partnership operates under the following ground rules, which were approved on November 10, 2009.

The signatories to these Ground Rules agree as follows:

The following are the Ground Rules for the Lampasas River Watershed Partnership agreed to and signed by the members of the Lampasas River Watershed Partnership Steering Committee (hereafter referred to as the Steering Committee) in an effort to develop and implement a Watershed Protection Plan (WPP).

Goals

The goal of the Partnership is to develop and implement a WPP to improve, protect and meet water quality goals set by the Partnership and that supports statewide efforts to meet designated uses for contact recreation and a healthy aquatic ecosystem for the Lampasas River (Segment 1217). According to the 2008 Texas Water Quality Inventory and 303(d) List, the Lampasas River is impaired by elevated bacteria concentrations making it unsuitable for contact recreation use. North Fork Rocky Creek, a tributary of the Lampasas River, is also impaired for depressed dissolved oxygen.

The Steering Committee will consider and attempt to incorporate the following into the development and implementation of the WPP:

- Economic feasibility, affordability and growth;
- Unique environmental resources of the watershed; and

- Regional water planning efforts; and Regional cooperation.

Powers

The Steering Committee is the decision making body for the Partnership. As such, the Steering Committee will formulate recommendations to be used in drafting the WPP and will guide the implementation of the WPP to success. Formal Steering Committee recommendations will be identified as such in the planning documents and meeting summaries.

Although formation and continued function of the Steering Committee will be facilitated by Texas A&M AgriLife Research (AgriLife Research) and the Texas State Soil and Water Conservation Board (TSSWCB), the Steering Committee is an independent group of watershed stakeholders and individuals with an interest in restoring and protecting the designated uses and the overall health of the Lampasas River watershed.

The Steering Committee provides the method for public participation in the planning process and will be instrumental in obtaining local support for actions aimed at restoring surface water quality in the Lampasas River.

Time Frame

Development of a Lampasas River WPP will require at least a 12-month period. The Steering Committee will function under an October 2010 target date to complete the initial development of WPP. Achieving water quality improvement in the Lampasas River may require significant time as implementation is an iterative process of executing programs and practices followed by achievement of interim milestones and reassessment of strategies and recommendations. The Steering Committee will function throughout the 12-month initial development period and may continue to function thereafter as a recommendation of the WPP.

Steering Committee Member Selection

The Steering Committee is composed of stakeholders from the Lampasas River watershed. Initial solicitation of members for equitable geographic and topical representation was conducted using three methods: 1) consultation with the Texas A&M AgriLife Extension Service (AgriLife Extension) County Agents, area Soil and Water Conservation Districts and local and regional governments; 2) meetings with the various stakeholder interest groups and individuals; and 3) self-nomination or requests by the various stakeholder groups or individuals.

Stakeholders are defined as either those who make and implement decisions or those who are affected by the decisions made or those who have the ability to assist with implementation of the decisions.

Steering Committee

Members include both individuals and representatives of organizations and agencies. A variety of members serve on the Steering Committee to reflect the diversity of interests within the Lampasas River watershed and to incorporate the viewpoints of those who will be affected by the WPP.

Size of the Steering Committee is not strictly limited by number but rather by practicality. To effectively function as a decision-making body, the membership shall achieve geographic and topical representation. If the Steering Committee becomes so large that it becomes impossible or impractical to function, the Committee will institute a consensus-based system for limiting membership.

Steering Committee members are expected to participate fully in Committee deliberations. Members will identify and present insights, suggestions, and concerns from a community, environmental, or public interest perspective. Steering Committee members are expected to work constructively and collaboratively with other members toward reaching consensus. Committee members will be expected to assist with the following:

- Identify the desired water quality conditions and measurable goals;
- Prioritization of programs and practices to achieve goals;
- Help develop a WPP document;
- Lead the effort to implement this plan at the local level; and
- Communicate implications of the WPP to other affected parties in the watershed.

Steering Committee members will be asked to sign the final WPP. The Steering Committee will not elect a chair, but rather remain a facilitated group. AgriLife Research will serve as the facilitator. In order to carry out its responsibilities, the Steering Committee has discretion to form standing and ad hoc work groups to carry out specific assignments from the Steering Committee. Steering Committee members will serve on a work group and represent that work group at Steering Committee meetings to bring forth information and recommendations.

Work Groups

Topical work groups formed by the Steering Committee will carry out specific assignments from the Steering Committee. Initially formed standing work groups are:

- Wastewater Infrastructure Work Group
- Agricultural Issues Work Group
- Habitat and Wildlife Work Group
- Urban/ Suburban Issues Work Group
- Outreach and Education Work Group

Each work group will be composed of a minimum of 1 Steering Committee member and any other members of the Partnership with a vested interest in that topic. There is no limit to the number of members on a work group.

Tasks such as research or plan drafting will be better performed by these topical work groups. Work Group members will discuss specific issues and assist in developing that portion of the WPP, including implementation recommendations.

Work Groups and individual Work Group members are not authorized to make decisions or speak for the Steering Committee.

Technical Advisory Group

A Technical Advisory Group (TAG) consisting of state and federal agencies with water quality responsibilities will provide guidance to the Steering Committee and Work Groups. The TAG will assist the Steering Committee and Work Groups in WPP development by answering questions related to the jurisdiction of each TAG member.

The TAG includes, but is not limited to, representatives from the following agencies:

- Texas A&M AgriLife Extension Service;
- Texas A&M AgriLife Research;
- Texas Commission on Environmental Quality;
- Texas Department of Agriculture;
- Texas Parks and Wildlife Department;
- Texas State Soil and Water Conservation Board;
- Texas Water Development Board;
- Environmental Protection Agency;
- United States Geological Survey;
- USDA Farm Service Agency; and
- Natural Resources Conservation Service.

Replacements and Additions

The Steering Committee may add new members if (1) a member is unable to continue serving and a vacancy is created or (2) important stakeholder interests are identified that are not represented by the existing membership. A new member must be approved by a majority of existing members. In either event, the Steering Committee will, when practical, accept additional members.

Alternates

Members unable to attend a Steering Committee meeting (an absentee) may send an alternate. An absentee should provide advance notification to the facilitator of the desire to send an alternate. An alternate attending with prior notification from an absentee will serve as a proxy for that absent Steering Committee member and will have voting privileges. An alternate attending without advance notification will not be able to participate in Steering Committee votes. Absentees may also provide input via another Steering Committee member or send input via the facilitator. The facilitator will present such information to the Steering Committee.

Absences

All Steering Committee members agree to make a good faith effort to attend all Steering Committee meetings, however, the members recognize that situations may arise necessitating the absence of a member. Three absences in a row of which the facilitator was not informed of beforehand or without designation of an alternate constitute a resignation from the Steering Committee.

Decision-Making Process

The Steering Committee will strive for consensus when making decisions and recommendations. Consensus is defined as everyone being able to live with the decisions made. Consensus inherently requires compromise and negotiation. If consensus cannot be achieved, the Steering Committee will make decisions by a simple majority vote. If members develop formal recommendations, they will do so by two-thirds majority vote. Steering Committee members may submit recommendations as individuals or on behalf of their affiliated organization.

Quorum

In order to conduct business, the Steering Committee will have a quorum. Quorum is defined as at least 51% of the Steering Committee (and/or alternates) present and a representative of either AgriLife Research or the TSSWCB present.

Facilitator

AgriLife Research serves as the facilitator for the Partnership, Steering Committee, and Work Group meetings. The AgriLife Research project coordinators are independent positions, financed through a Clean Water Act §319(h) Nonpoint Source grant from the TSSWCB and Environmental Protection Agency. Each has specific roles to perform in facilitating the Partnership and Steering Committee.

AgriLife Research Watershed Coordinator

The Watershed Coordinator provides technical assistance to the stakeholders in developing the Lampasas River WPP. The Watershed Coordinator will ensure the planning process culminates in a WPP for the Lampasas River, work with the TSSWCB, Steering Committee, Work Groups and other partners to facilitate the development and implementation of the WPP. The Watershed Coordinator will work with the Steering Committee and Work Groups to prepare meeting summaries, assist in the location and/or preparation of background materials and the distribution of documents developed by the Steering Committee. The Watershed Coordinator also conducts public outreach, moderates public workshops, and provides assistance to the Steering Committee members regarding Committee business between meetings. With the assistance of the Technical Coordinator, the Watershed Coordinator will draft text and prepare the WPP so that it incorporates the Steering Committee recommendations and ensure that the Lampasas River WPP satisfies the 9 elements fundamental to a potentially successful WPP as described by the Environmental Protection Agency.

AgriLife Research Technical Coordinator

The Technical Coordinator will ensure all scientific/technical aspects of the WPP process are carried out satisfactorily by developing, organizing and presenting technical materials and analyses at Steering Committee and Work Group meetings. The Technical Coordinator will develop load duration curves, conduct a watershed inventory and geographic analysis of land use influencing bacteria migration and other nonpoint source pollution and utilize the Spatially Explicit Load Enrichment Calculation Tool (SELECT) for analysis of the Lampasas River watershed and present this information to the Steering Committee and appropriate Work Groups. The Technical Coordinator will also collaborate with the Watershed Coordinator, TSSWCB, Steering Committee and Work Groups and other partners to facilitate the development and implementation of the WPP.

Meetings

All Partnership meetings (Steering Committee and Work Group) are open and all interested stakeholders are encouraged and welcomed to participate.

Over the 12-month development period, regular meetings of either the Steering Committee or Work Groups will occur each month. The Steering Committee may determine the need for additional meetings. Steering Committee and Work Group meetings will be scheduled to accomplish specific milestones in the planning process.

Meetings will start and end on time. Meeting times will be set in an effort to accommodate the attendance of all Steering Committee members. AgriLife Research will notify members of the Partnership, Steering Committee, and work groups of respective meetings.

Open Discussion

Participants may express their views candidly, but without personal attacks. Time is shared because all participants are of equal importance.

Agenda

AgriLife Research and the TSSWCB, in consultation with Steering Committee members are charged with developing the agenda. The anticipated topics are determined at the previous meeting and through correspondence. A draft agenda will be sent to the Steering Committee with the notice of the meeting. Agendas will be posted on the project website. Agenda items may be added by members at the time that the draft agenda is provided. The Watershed Coordinator will review the agenda at the start of each meeting and the agenda will be amended if needed and the Steering Committee agrees. The Steering Committee will then follow the approved agenda unless they agree to revise it.

Meeting Summaries

AgriLife Research will take notes during the meetings and may conduct audio recording (for the sole purpose of note taking). Meeting summaries will be based on notes and/or the recording. AgriLife Research and the TSSWCB will draft meeting notes and distribute them to the Steering Committee for their review and approval. All meeting summaries will be posted on the project website.

Distribution of Materials

AgriLife Research and the TSSWCB will prepare and distribute the agenda and other needed items to the Partnership. Distribution will occur via email and website, unless expressly asked to use U.S. Mail (i.e. member has no email access). To encourage equal sharing of information, materials will be made available to all. Those who wish to distribute materials to the Steering Committee or a Work Group may ask AgriLife Research or the TSSWCB to do so on their behalf.

Speaking in the Name of the Committee

Individuals do not speak for the Steering Committee as a whole unless authorized by the Committee to do so. Members do not speak for AgriLife Research or the TSSWCB and neither AgriLife Research nor the TSSWCB speak for Steering Committee members. If Committee spokespersons are needed, they will be selected by the Steering Committee.

Development and Revision of Ground Rules

These ground rules were drafted by AgriLife Research and the TSSWCB and presented to the Steering Committee for their review, possible revision, and adoption. Once adopted, ground rules may be changed by two-thirds majority vote provided a quorum is present.

These Partnership ground rules become effective on November 10, 2009, and are agreed upon by all members of the Lampasas River Watershed Partnership Steering Committee.

B. Land Use Classification

By utilizing the National Land Cover Dataset (NLCD), Common Land Unit, and other Geographic Information System (GIS) datasets, the Texas A&M Spatial Sciences Laboratory was able to spatially define current land cover types within the Lampasas River watershed. National Agriculture Imagery Program (NAIP) Digital Ortho Imagery (2008) was used to carry out a supervised classification in order to update and refine land cover types within this data layer.

EXISTING DATASETS

The NLCD was developed using a decision-tree classification approach for multi-temporal Landsat imagery and several ancillary datasets. The category of urban land was extracted from the dataset using the ArcGIS Spatial Analyst extension to compare and compliment the NAIP classification.

A Crop Data Layer (CDL) was used in the classification process to gather in depth cropland points in the watershed. A CDL is a small unit of land that has a permanent, contiguous boundary, with a common land use and owner, and a common producer in agricultural land associated with USDA farm programs. CDL boundaries are delineated from relatively permanent features such as fence lines, roads, and/or waterways.

REVISION OF LAND USE/LAND COVER DATASETS

NAIP Ortho photos are collected and compiled each year by the USDA Farm Services Agency during a portion of the agricultural growing season at a one or two meter resolution. 2008 NAIP images for Texas were provided in county mosaics at a spatial resolution of one meter. The NAIP imagery was projected in Arcmap and ENVI, and used as a basis for updating the existing NLCD.

Supervised classification was used to extract current LU/LC cover groups from NAIP datasets. This is an image processing technique in which the analyst classifies an image based on pre-selected pixels or regions of interest. The regions of interest are known types of land cover based on ground truth points, and the regions of interest selected have their spectral value recorded. The remaining pixels are classified based on the characteristics of the regions of interest.

Ground truthing for each LU/LC class were gathered using Trimble GeoXH 2005 and RICOH Caplio 500SE. Additionally, high-resolution aerial photography was digitally sampled. The primary focus of the field collection process was to collect ground control points across the entire area, particularly in classes which were difficult to distinguish. Where access was limited, sample points were offset from the road with comments on each GPS point distinguishing where the point should be placed. The camera that was used for part of the collection process, gave a geo-referenced image to compliment the GPS points. The final classified image was then statistically compared to the 2001 NLCD classification to check the accuracy.

CLASSIFICATION DEFINITIONS

OPEN WATER

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

URBAN

Includes areas with a mixture of some constructed materials and lawn grasses. These areas most commonly include residential and commercial developments.

FORESTED LAND

Areas dominated by trees generally greater than 15 feet tall, greater than 50% of total vegetation cover and areas adjacent to streams, creeks and/or rivers.

MANAGED PASTURE

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

RANGELAND

Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25%, but exceeds the combined cover of the woody species present. These areas are typically utilized for grazing of livestock. Also includes unmanaged pasture, transitional areas that are no longer being managed or planted on an annual or perennial cycle.

BARREN

Barren areas of bedrock, desert pavement, scarps, slides, strip mines, gravel pits, construction sites and other accumulations of earthen material; vegetation generally accounts for less than 15% of total cover and includes transitional areas.

CULTIVATED CROPS

Areas used for the production of annual crops, such as corn, soybeans, vegetables and cotton and also perennial crops such as orchards – also includes all land being actively tilled.

C. Load Duration Curve Analysis

BACKGROUND

The duration curve framework provides a simple-yet-powerful graphical analysis method for examining relationships between flow and a water body's loading capacity when correlations between water quality impairments and flow conditions are suspected. Load duration curves (LDC) characterize water quality monitoring data at different streamflow regimes as an aid to understanding how different flow conditions may affect water quality. LDCs show contaminant loads across all flow regimes along with the magnitude and frequency of water quality standard exceedances in each regime. The basis of the LDC are flow duration curves (FDC) (Figure C.1) which use historical streamflow data to calculate and depict the percentage of time that different streamflow volumes are equaled or exceeded.

Development and analysis of LDCs help identify loading capacities, load allocations, margins of safety, and even seasonal variations. Duration curves also provide a means to link water quality concerns with key watershed processes that may be important considerations in WPPs and TMDL development. Used with knowledge of hydrologic principles, LDCs can, in some cases, help identify the relative importance of watershed characteristics and factors such as water storage or storm events, which affect water quality. In large watersheds like the Lampasas River watershed, multiple LDCs developed at different points along a stream have aided analysts in isolating and identifying impairment sources.

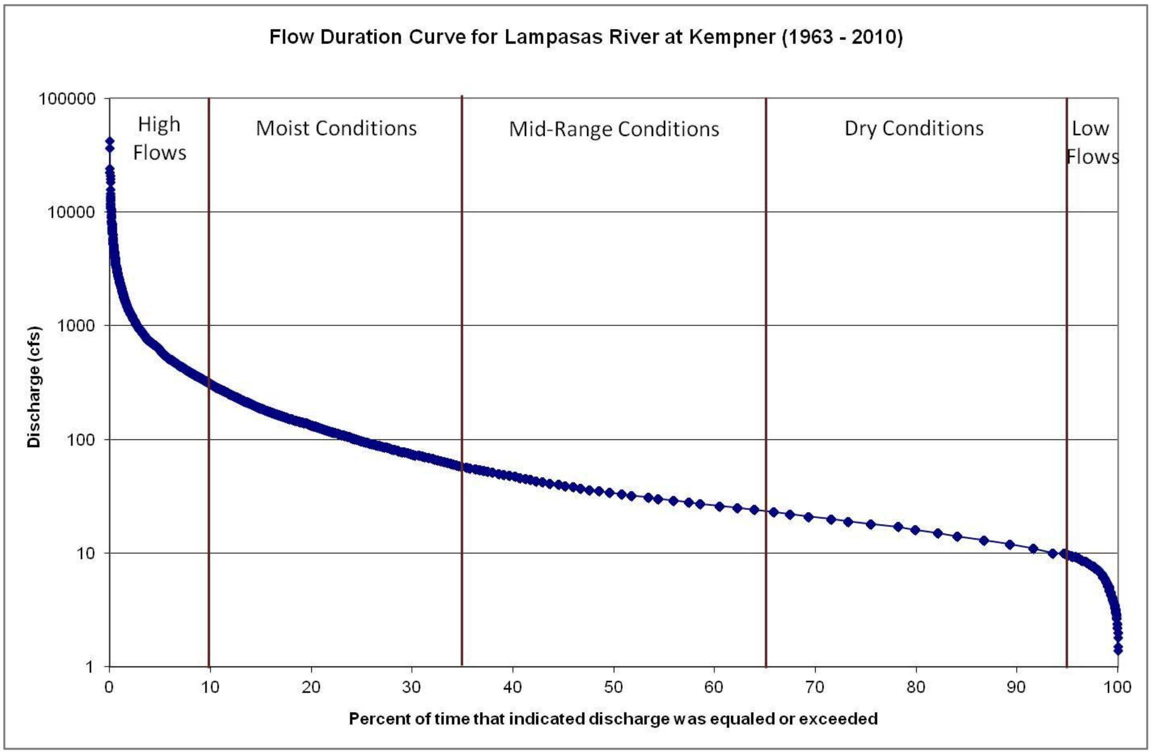

Figure C.1 Flow Duration Curve (FDC) for streamflow conditions at site 11897 on the Lampasas River, near Kempner, Texas.

Using the relative percent exceedance from the FDC that corresponds to the stream discharge at the time the water quality sample was taken, the computed load is plotted in a duration curve format (Figure C.2). Graphing loads calculated from water quality data and the average daily flow on the date of the sample, characteristic patterns can develop which help describe the nature of the water quality impairment. As indicated in Figure C.2, loads that plot above the curve indicate an exceedance of the water quality criterion, while those below the LDC show compliance.

Examining the pattern for occurrence across all flow conditions, high flow events only, or low flows only, helps identify whether the impairment is due to a point or nonpoint source. Impairments observed in the low flow area generally indicate the influence of point sources, while those further left in high flow and moist conditions tend to reflect potential nonpoint source contributions.

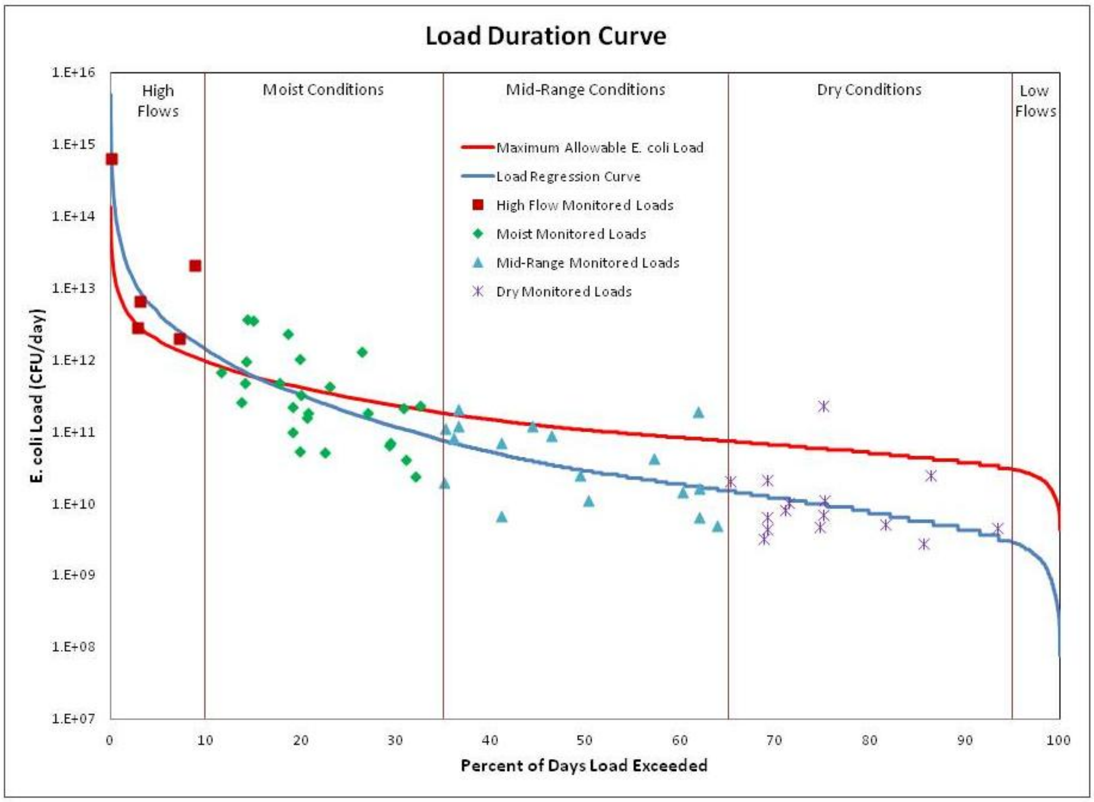

Figure C.2 Example of a Load Duration Curve. The red line indicates the maximum allowable pollutant load.

The foundation underlying the duration curve approach is that water quality impairments are correlated with flow conditions. In its technical guidance on using LDCs the EPA states LDCs are appropriate in cases where flow is a primary driver in pollutant delivery mechanisms, and other processes are a relatively insignificant part of the total loading.

Flow, in many cases, is the principal force behind habitat modification, stream bank erosion, and other concerns preventing attainment of designated uses. Use of a duration curve in flow-induced nonpoint source situations more generally reflects actual loadings than in cases where flow is only one of many components influencing the overall loading.

According to the EPA, the duration curve method, by itself, is limited in the ability to track individual source loadings or relative source contributions within a watershed and does not provide the means to distinguish point source loads and nonpoint source loads for individual sources. Furthermore, duration curves do not identify specific fate and transport mechanisms moving contaminants from the land surface into the water.

LDC METHODOLOGY FOR THE LAMPASAS WATERSHED PROTECTION PLAN

The LDC approach and methods described by the EPA were used in this project to analyze water quality data collected in the Lampasas River watershed.

Historic water quality data gathered through the State of Texas Surface Water Quality Monitoring Program (SWQM) were provided by the Texas Commission on Environmental Quality (TCEQ) via Surface Water Quality Monitoring Information System. The provided data include over 28,000 unique observations including many observations of various water quality parameters collected at 38 locations beginning in the early 1970s and continuing through the present.

Long-term records of daily stream flow exist for three locations in the Lampasas River watershed (Table C.1). Daily average flow data for the sites were downloaded from the USGS National Web site (http://waterdata.usgs.gov/nwis/sw). Two sites, Kempner and the South Fork Rocky Creek (S. Rocky Creek) have been active continuously since 1963 and 1964, respectively. The gage at Youngsport was active between 1924 and 1980. Both Kempner and Youngsport are located on the main stem of the river about 20 miles apart while the S. Rock Creek site is an intermittent tributary in the lower watershed. The Kempner site drains approximately 818 square miles, the Youngsport site drains 1240 square miles and the South Rocky Creek site drains about 33 square miles.

Table C.1 Drainage basin characteristics associated with the USGS gages used to develop flow estimates for the Lampasas River.

General Characteristics and Flow Statistics	**Kempner (08103800)**	**Youngsport (08104000)**	**S Rocky Creek (08103900)**
Period of Record	1936 - Current	1924 - 1980	1964 - Current
Drainage area (miles^2)	818	1,240	33
Mean basin slope (ft per mi)	13.46	10.49	36.15
Main channel length (miles)	61.9	89.3	11.7
Average daily streamflow (cfs)	156.4	273.4	10.8
Maximum daily flow (cfs)	42,500	49,600	1,510
Minimum daily flow (cfs)	1.4	0	0
Std Dev of daily flows	771.311	1,090.307	45.379

Surface runoff (base and storm flows) from precipitation events comprise one of the two main components of streamflow in the watershed. Because of the nature of the watershed, long and narrow shape bisected by the Balcones Escarpment and bordered by the Llano Uplift, as well as the complex climate associated with the central Texas region, weather patterns and precipitation are often unpredictable. Precipitation events are highly stochastic and vary greatly both temporally and spatially. Rainfall intensities vary drastically over short distances. An intense storm may be concentrated over a particular subwatershed while neighboring subwatersheds receive little or no rainfall.

Groundwater is the second component of streamflow. Groundwater from two major aquifers (Edwards and Trinity) and perhaps as many as four minor aquifers outcrop in the watershed. Outcrops occur mainly in the middle and lower watershed. Springs in the Sulphur Creek subwatershed are a significant source of water inputs to streamflow. In the lower watershed interactions between ground and surface waters are complex. At times groundwater seems to contribute water to the stream while in periods of drought surface waters appear to flow to the underlying aquifer. Inflows from the aquifer to the stream and opposite outflows may be occurring simultaneously within a narrow spatial extent.

Streamflow in the Lampasas River is complex. Streamflow originates from two sources: surface runoff from precipitations and groundwater inputs. An additional complexity is that surface water is lost to groundwater in the lower watershed, particularly during drought conditions. Estimated daily flow values for water quality monitoring sites without USGS gage sites were using simple equations to mimic the functioning of the watershed (Table C.2). Estimation technique was checked using estimates at 11897 and the Youngsport gate for years 1963 -1980. Correlation of daily flows had an r^2 of 0.75 and a 2-day moving average of daily flows had an r^2 of 0.94 (Figure C.3 and Figure C.4).

Table C.2 Daily flow estimation functions for LDC analyses at water quality monitoring sites without historical flow data.

Monitoring Site	Daily Flow Estimation
15250	$= 1.2931\ Q_k^{0.7683}$
16404	$= Q_k - 1.2931\ Q_k^{0.7683}$
15762	$=$ IF $Q_k - 1.2931\ Q_k^{0.7683} * 0.0865 > 0.1$ then flow $= Q_{04} * 0.0885$ else flow $= 0$
15770	$=$ IF $Q_k - 1.2931\ k^{0.7683} * 0.0359 > 0.1$ then flow $= Q_{04} * 0.0368$ else flow $= 0$
11724	$= 3.378\ Q_r + 1.2$
11897	$= 10.78\ Q_r + Q_k - 5$

Q_k = Daily flow at USGS Gage at Kempner, TX
Q_r = Daily flow USGS Gage at S. Rocky Creek
Q_{04} = Estimated Daily flow at 16404

LDCs are based on FDCs, with the additional display of historical pollutant load observations at the same location, and the associated water quality criteria. Rather than flow, the y-axis is expressed in terms of contaminant loads. The curve represents the single sample water quality criteria through multiplication by the continuum of flows historically observed at the site and a unit conversion factor. Points represent individual paired historical observations of concentration and flow. Loads (or the y-value of each point) are calculated by multiplying the contaminant concentration by the daily flow (cfs) from the same site and time, with appropriate volumetric and time unit conversions. Because this analysis was for a voluntary watershed protection plan rather than a regulatory TMDL, no margin of safety was used.

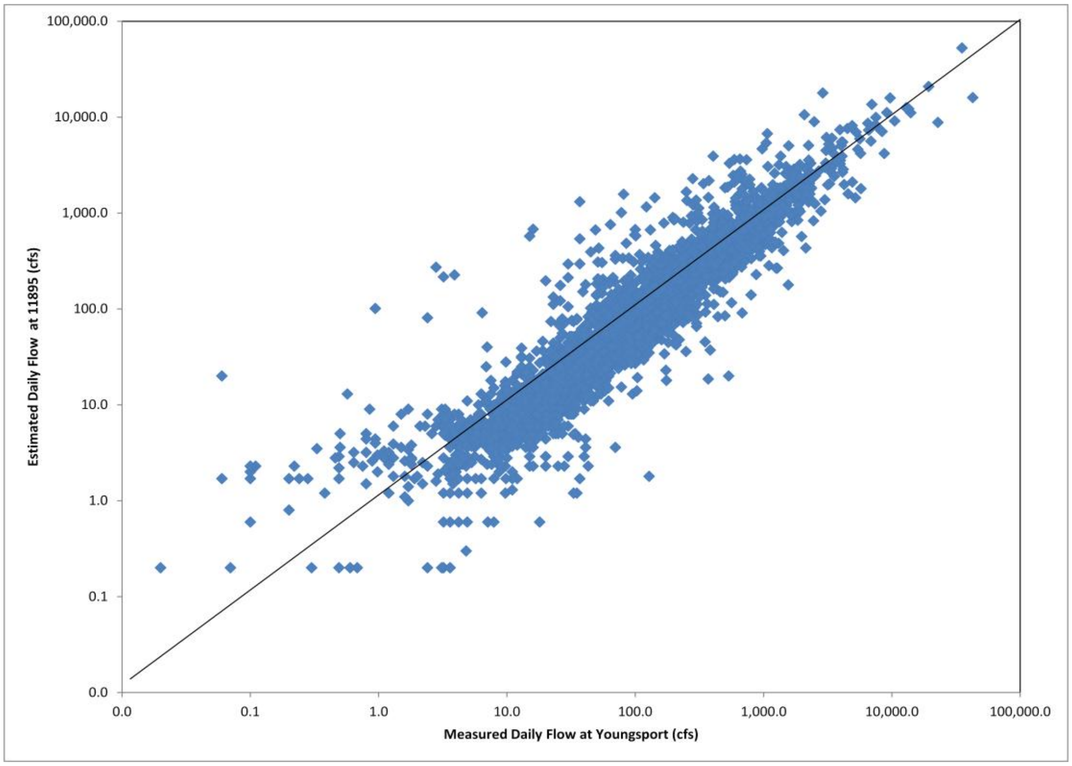

Figure C.3 Estimated daily flows at monitoring site 11895 vs measured daily flows at USGS Gage 0804000 near Youngsport, TX (1963 - 1980).

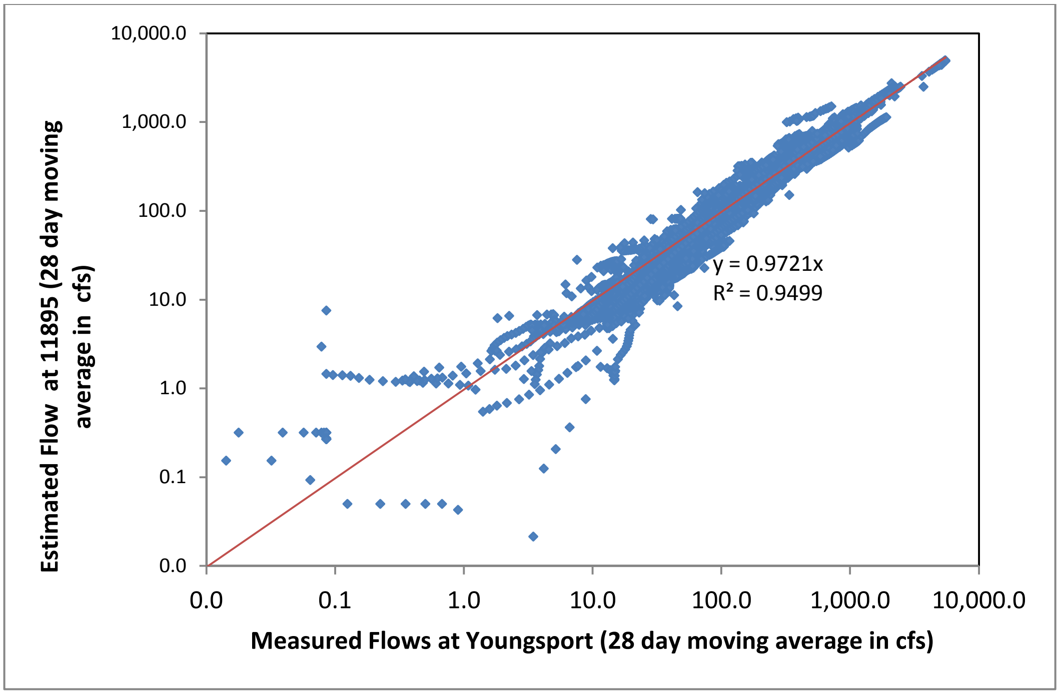

Figure C.4 Estimated 28-day moving average of daily flows at monitoring site 11895 vs measured daily flows at USGS Gage 0804000 near Youngsport, TX (1963 - 1980).

D. Spatially Explicit Load Enrichment Calculation Tool Rationale

The Spatially Explicit Load Enrichment Calculation Tool (SELECT) is an analytical approach for developing an inventory of potential pollutant sources, particularly nonpoint source contributors, and distributing their potential loads based on land use and geographical location. A custom land use classification was developed by the Texas A&M University Spatial Sciences Laboratory using 2008 National Agriculture Imagery Program (NAIP) imagery and other datasets (Appendix B). The watershed was divided into 14 subwatersheds based on elevation changes along tributaries and the main segment of the water body. Since SELECT divides the watershed into a raster grid with a 30-meter cell size, the potential load is calculated over the entire watershed at a 30-meter cell size. The individual raster files for each source are then added together spatially to create a total load raster for the watershed that is divided into 30-meter grid cells.

Stakeholders determined the sources potentially contributing to the watershed bacterial loading. The analysis was conducted at a 30-meter-by-30-meter spatial resolution. First, each source was distributed to suitable areas in the watershed and then the *E. coli* load was calculated using the equations in (Table D.1). The fecal production rates for the sources were calculated using the highest in the range of values in EPA guidance (EPA 2001) for all of the *E. coli* sources. Doyle and Erikson (2006) estimate that 50% of fecal coliform are *E. coli*. Therefore, a conversion factor of 0.5 was applied to convert the fecal production rates from fecal coliform to *E. coli*. After the potential *E. coli* loads were calculated, the results were aggregated at the subwatershed level to distinguish areas of concern.

Table D.1 Calculations utilized in the SELECT model to estimate potential loads from sources within the Lampasas River watershed.

Source	*E. coli* Load Calculation
Cattle	
Sheep	
Goats	
Horses	
CAFOs	
Whitetail Deer	
Feral Hogs	
OSSFs	
WWTFs	
Domestic Dogs	

([a]) Fecal coliform to *E. coli* conversion factor using Doyle and Erikson (2006) rule of thumb estimating 50% of fecal coliform is *E. coli*.
([b]) An 80% treatment efficiency was assumed for CAFOs, so 20% of the *E. coli* in the raw waste was assumed in the calculation of the potential *E. coli* load.

Cattle

The Agriculture and Wildlife Work Group utilized the 2007 USDA National Agricultural Statistics Service (NASS) for an estimate of the number of cattle within the watershed (USDA 2007). An estimated 34,388 cattle were equally distributed across the three different land uses in each subwatershed deemed appropriate by the stakeholders;

rangeland, forest and managed pasture (Figure D.1). The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

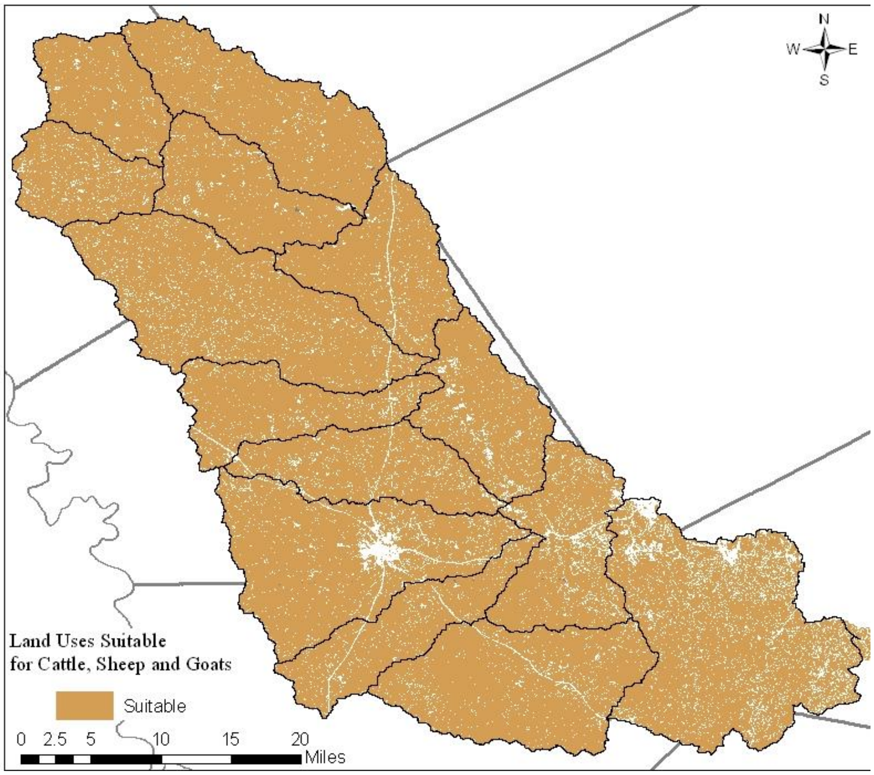

Figure D.1 Cattle, sheep and goat populations were distributed evenly across suitable land uses.

Sheep

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of sheep within the watershed. An estimated 7,311 sheep were equally distributed across the three different land uses in each subwatershed as deemed appropriate by stakeholders; rangeland, forest and managed pasture (Figure D.1). The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

Goats

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of goats within the watershed. An estimated 11,162 goats were equally distributed across the three different land uses in each subwatershed as deemed appropriate by stakeholders; rangeland, forest and managed pasture (Figure D.1). The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

Horses

The Agriculture and Wildlife Work Group utilized the 2007 USDA NASS (USDA 2007) for an estimate of the number of horses within the watershed. An estimated 1,288 horses were distributed across rangeland (Figure D.2). The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

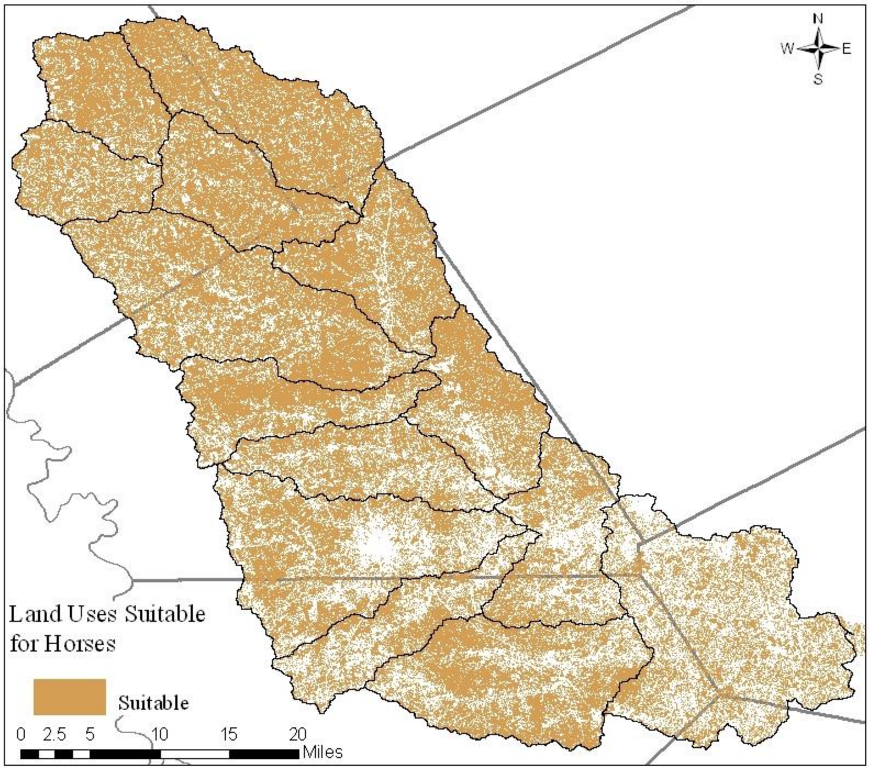

Figure D.2 The horse population was distributed evenly across suitable land uses.

CAFOs

There are three confined animal feeding operations that are permitted with TCEQ within the Lampasas River watershed, all in the northern part of the watershed. Lawrence Clowdus Dairy and PX Feeders are located in the Lampasas River 1 subwatershed, while DSM Dairy is located in the Bennett Creek subwatershed (Figure D.3).

All three CAFOs located within the watershed operate under a general permit with the TCEQ through the TPDES. As part of the permit, all facilities must operate under a nutrient management plan filed with the TCEQ. Because of the nature of the CAFO operation and because the manure undergoes treatment in the form of lagoons and sludge and land application, the SELECT analysis assumed and that all materials were treated to remove 80% of bacteria with no direct discharge into nearby streams. The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

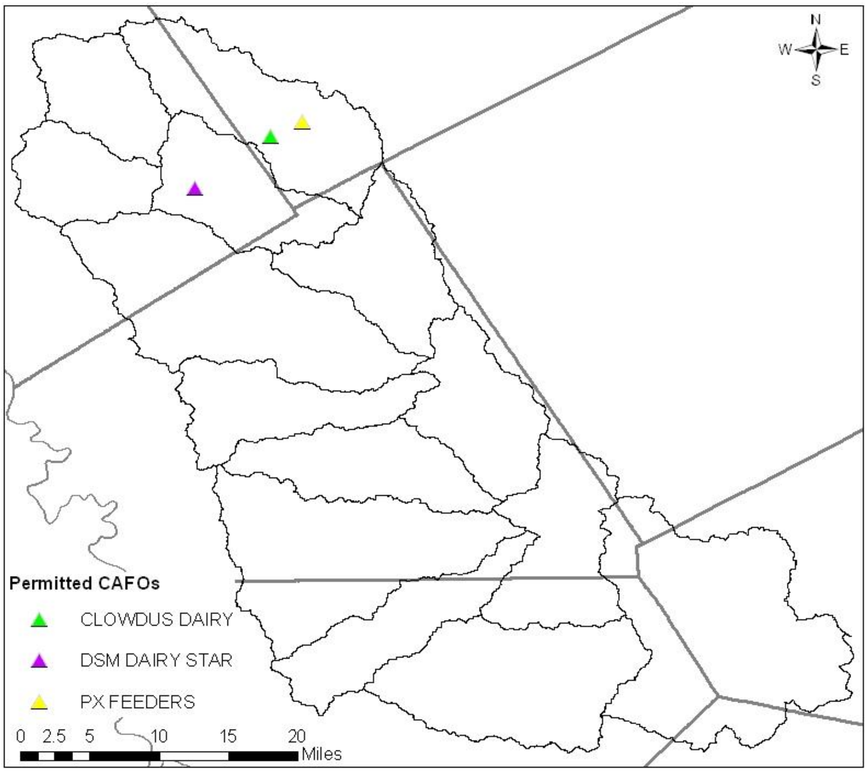

Figure D.3 There are three permitted CAFOs within the Lampasas River watershed.

Whitetail Deer

The Agriculture and Wildlife Work Group used several different data sources from TPWD to estimate whitetail deer populations within the watershed.

Multiple Wildlife Management Associations (WMA) are operated in conjunction with TPWD throughout the watershed (Figure D.4). Each of the WMAs complete annual deer surveys to monitor changes in the deer populations. Averages of the 2005 – 2009 surveys (Table D.2) were distributed equally across all land uses in each of the individual boundaries of the WMAs.

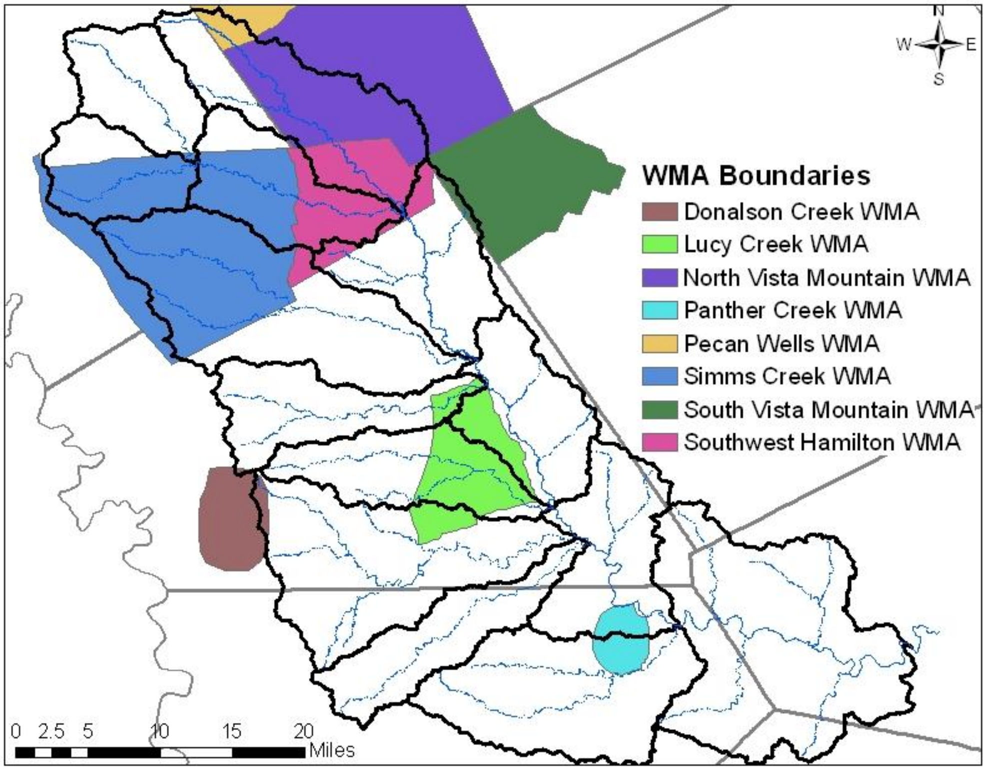

Figure D.4 Boundaries of the seven WMAs located in the Lampasas River watershed.

Table D.2 WMAs within the Lampasas River watershed with their respective acreage and average number of deer per 1,000 acres.

WMA	Acreage Represented in Watershed	Average Deer/ 1,000 acres (2005 - 2009)
Donalson	69,947	182
Lucy Creek	1,321,193	99
North Vista Mountain	1,272,039	155
Panther Creek	337,827	76
Pecan Wells	131,638	104
Simms Creek	3,588,846	216
Southwest Hamilton	1,436,391	421
Vista Mountain South	55,647	102

The Work Group utilized a deer density study by TPWD (Lockwood 2007) for population estimates throughout portions of the watershed that were not included in the boundaries of WMAs. The 2007 deer density study divided the state of Texas into 33 resource management units (RMU) based on similar soils, vegetation types and land uses to more accurately capture the deer population dynamics (Figure D.5). The Lampasas River watershed is located in two different RMUs, the Cross Timbers RMU and the Edwards Plateau RMU. Based on the densities for both of the RMUs and personal knowledge of the area, stakeholders recommended using the density of 100 deer per 1000 acres across the watershed outside of WMAs, regardless of land use. The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

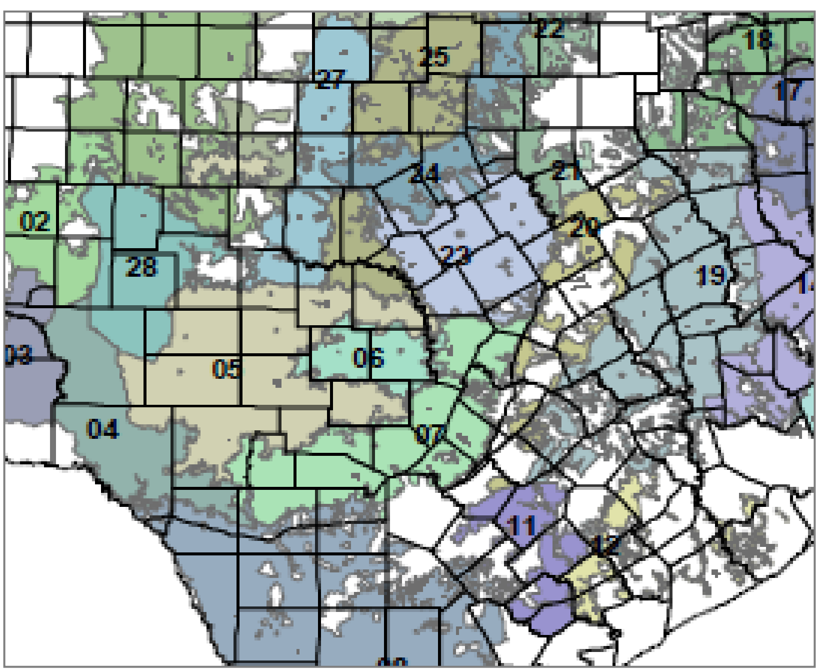

Figure D.5 TPWD RMU boundaries.

Feral Hogs

For feral hogs, the densities used for the Plum Creek (54 acres per hog) and Geronimo Creek (24 acres per hog) watesheds along with a 1997 study by Hellgren were presented to the stakeholders (Berg et al. 2008; Hellgren 1997; Ling and McFarland 2011) to determine reasonable estimates of feral hog populations. Stakeholders decided a density of 32 acres per hog should be applied uniformly across forest, rangeland, barren land, cultivated land, and managed pasture within a 100-meter buffer around the stream network of the watershed. An estimated total population of 24,263 feral hogs was used with the equation from Table D.1 to estimate the daily potential *E. coli* load from feral hogs.

Septic Systems

The SELECT analysis utilized a series of steps to determine the potential contribution from OSSFs (Figure D.6). Spatially distributed point data of each household were collected from residential 911 address data gathered from the Central Texas Council of Governments, and Williamson and Burnet Counties. Households within Certificate of Convenience and Necessity (CCN) areas were removed to exclude households being serviced by a WWTF. The number of people per home was determined by the average household size from the 2000 census blocks. A constant sewage discharge of 70 gallons per person per day was used in the calculations. A failure rate was determined for the OSSFs using SSURGO soil limitation classe was also utilized in the analysis. The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

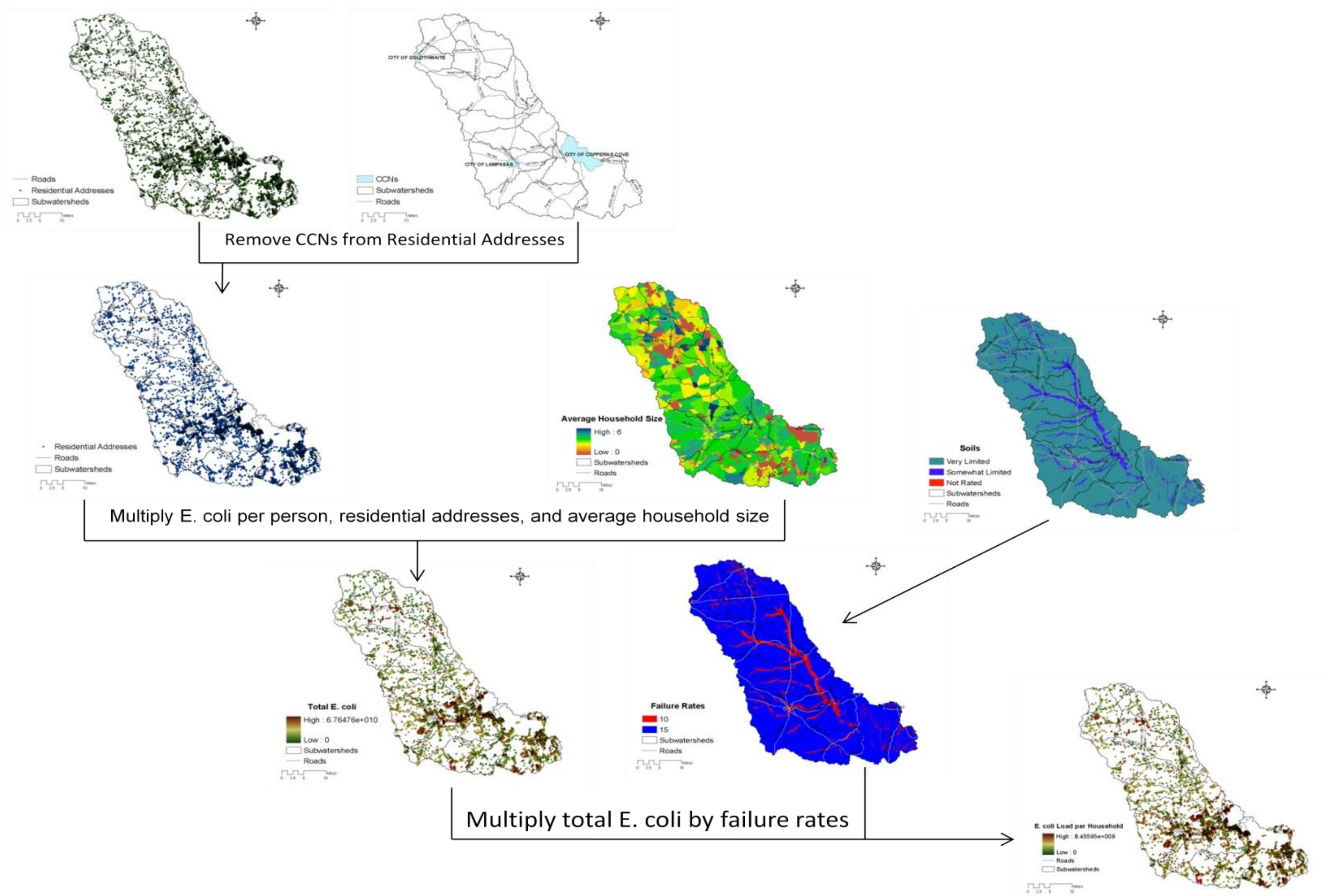

Figure D.6 The potential *E. coli* contribution from OSSFs was estimated through a series of steps and calculations.

Wastewater Treatment Facilities

The Lampasas River watershed contains two WWTFs located in separate subwatersheds. For WWTFs, the maximum permitted discharge and the *E. coli* concentration of 126 colony forming units per milliliters was applied to the subwatershed in which the WWTFs are located. The average potential daily *E. coli* load for each subwatershed was estimated using the calculation in Table D.1.

Domestic Dogs

The potential *E. coli* load from dogs was calculated using the equation from Table D.1. A dog density was determined by presenting the density of 0.8 dogs per household (AVMA 2002) to stakeholders. Stakeholders determined that a dog density of 1 dog per household would be more accurate for this area. The density was applied to the residential 911 addresses, resulting in an estimated dog population of 10,775.

E. Management Practice Efficiencies

For use in determining optimal management practices for implementation in urban and agricultural areas, the following reduction efficiencies were assumed. All values are load reductions unless otherwise stated.

URBAN MANAGEMENT PRACTICES

Table E.1 Load reductions for Media Filters.

TSS[1]	TN[2]	TP[3]	Metals	Bacteria		
89%	17%	59%	72-86%	65%	Glick et al., 1998	Calif Handbook
95%	-[4]	41%	61-88%	-	Stewart 1992	
85%	-	4%	44-75%	-	Leif 1999	
85%	-	80%	65-90%	-	Pitt et al. 1997	
83%	-	-	9-100%		Pitt 1996	
98%	-	84%	83-89%	-	Greb et al. 1998	
70%	21%	33%	45%	76%(FC)	Galli, 1990	EPA Fact Sheet 1999
99%	38%	97%	94-99%	-	Hatt et al. 2008	
85%	35%	45%	-	-	NCDENR 2007	
82%	42%	49%	-	31%	N.P.R.D. 2007[5]	
70-90%	30-50%	43-70%	-	-	Bell et al. 1995; Horner & Horner 1995; Young et al. 1996	StormWater BMPs FHWA
75-92%	27-71%	27-80%	-	-	City of Austin 1990; Welborn & Veenhuis 1987	
90-95%	55%	49%	48-90%	90%	Claytor & Schueler 1996; Stewart 1992; Stormwater Management 1994	

TSS[1]	TN[2]	TP[3]	Metals	Bacteria		
66-95%	44-47%	4-51%	34-88%	-	USEPA 2004	

[1]Total suspended solids
[2]Total nitrogen
[3]Total phosphorous
[4] No data.
[5] Reductions based on an average of multiple studies.

Table E.2 Load reductions for Wetlands.

Volume	TSS	TN	TP	Bacteria	Metals	BOD		
10%	45%	27%*	28%	31%[2]	-[5]	28%	Newman & Clausen 1997	
-	83%	26%,	43%	76%**[2]	36-85%	-	Winer 2000	EPA NPDES 2006
-	69%	56%	39%	-	80-63%	-		
-	71%	19%	56%	-	0-57%	-		
-	83%	19%	64%	78%[2]	21-83%	-		
-	-	37%	2%	-	-	-	Kovacic et al. 2000	
-	-	11%	17%	-	-	-	Raisin et al. 1997	
-	-	-	-	-	-	80%	Huddleston et al. 1999	
-	85%	85-90%	47%[4]	-	84%(Fe)	-	Lake Tahoe	EPA National Management Measures 2005
-	70%	-	-	-	-	-	Shop Creek	
-	94%	76%	90%	-	-	-	Lake Jackson	
-	55%	36%	43%	-	83%(Pb), 70%(Zn)	-	Orange County	
-	55-83%	36%	43%	-	55-83% (Pb, Zn)	-	Orlando	
-	50%	-	62%	-	-	-	Palm Beach	
-	71%	-	47%	-	-	-	Tampa	
-	86-90%	61-92%	65-78%	-	-	-	Des Plaines	
-	95-97%	-	82-91%	-	-	-	Long Lake	
-	95%	-	92%	-	-	-	St. Agatha	

Volume	TSS	TN	TP	Bacteria	Metals	BOD		
-	96%	74%	78%	-	90%(Pb)	-	Spring Creek	
-	55%	24%	44%	76%[3]	-	-	N.P.R.D. 2007***	
-	65%	20%	25%	-	35-65%		USEPA 1993	StormWater BMPs FHWA
				99%[1]			Stenstrom and Carlander	
				93%[2]			de J. Quinonez-Diaz et al., Gerba et al., Khatiwada et al., Neralla et al, Rifai 2006	

* Total Kjeldahl-N Reduction.
** Based on fewer than 5 data points.
*** Reductions based on an average of multiple studies.
[1] *E. coli.*
[2] Fecal coliform.
[3] Indicator species not specified.
[4] Particulate phosphorus reduction only.
[5] No data.

Table E.3 Load reductions for Bioretention.

Volume	TSS	TP	TN	Cu	Pb	Zn	Oil & Grease	Bacteria	
-[3]	97%	35-65%	33-66%	36-93%	24-99%	31-99%	99%	70%[2]	MD Envir. Service 2007
96.5%	60%	31%[2]	32%	54%	31%	77%	-	69%(FC) 71%(EC)	Hunt et al. 2008
-	-	-	40%	99%	81%	98%	-	-	Hunt et al. 2006
-	-	58-63%	47-88%	-	-	-	-	-	Passeport et al. 2009
-	-	65-87%	49%	43-97%	70-95%	64-95%	-	-	EPA BMP Menu
40%	-	35-50%	70-80%	-	-	-	-	97%(FC)*	Smith & Hunt
51%	-	16%	43%	-	-	-	-	-	Sharkey 2006
48%	-	-39%[2]	38%	-	-	-	-	-	

Volume	TSS	TP	TN	Cu	Pb	Zn	Oil & Grease	Bacteria	
-	-	65-87%	49%	43-97%	70-95%	64-95%	-	-	Davis et al. 1997 ; EPA NPDES 2005
-	29%	-11%	44%	68%	-	23%	-	-	N.P.R.D. 2007**
-	75%	50%	50%	75-80%	75-80%	75-80%	-	-	StormWater BMP FHWA; Prince George's County 1993
-	80%	65-87%	49%	-	-	-	-	-	USEPA 2004
								97%(EC) 44%(FC)	Peterson et al. 2011

* Values based on only 6 collected samples, not a statistically significant finding.
** Reductions based on an average of multiple studies.
[1] Negative value represents an increase in pollutant concentration.
[2] Indicator species not specified.
[3] No data.

Table E.4 Load reductions for infiltration trench/basin.

TSS	TN	TP	Metals	Bacteria		
50%	-[2]	51%	52-93%	96%(FC)	Birch et al. 2005	
99%	60-70%	65-75%	95-99%	98%[1]	Schueler, 1987	Wisconsin Manual 2000
90%	60%	60%	90%	90%[1]	Schueler, 1992	EPA Fact Sheet
85%	-	85%	-	-	PA Stormwater Manual 2006	
75-99%	45-70%	50-75%	75-99%	75-98%[3]	Young et al. 1996	StormWater BMPs FHWA
75%	55-60%	60-70%	85-90%	90%[1]	USEPA 2004	

[1] Indicator species not specified.
[2] No data.

Table E.5 Load reductions for dry ponds.

TSS	TN	TP	Metals	Bacteria		
61%	31%	19%	26-54%	-[3]	Schueler 1997	EPA BMP Menu
71%	-	-	26-55%	-	Stanley 1996	
47%	19%	21%	-	88%[2]	N.P.R.D. 2007**	
61%	19%	31%	26-54%	-	USEPA 2004	
-	-	-	-	90%[1]	BMP Database Project 3	

** Reductions based on an average of multiple studies.
[1] Fecal coliform.
[2] Indicator species not specified.
[3]No data.

Table E.6 Load reductions for wet ponds.

TSS	TN	TP	Metals	Bacteria		
67%	31%	48%	24.73%	65%[1]	Schueler 1997	EPA BMP Menu
76%	31%	54%	-[2]	68%[1]	N.P.R.D. 2007**	
68%	55%	32%	36-65%	-	USEPA 2004	
-	-	-	-	47%(FC)	Rifai (2006),Gerba et al., Mallin	

** Reductions based on an average of multiple studies.
[1] Indicator species not specified.
[2] No data.

Table E.7 Load reductions for swales.

TSS	TN	TP	Cu	Pb	Zn	Bacteria		
60-85%	10-90%	15-90%	45-80%	-[1]	68-88%	-	CRWA 2008	
81%	38% *	9%	51%	67%	71%	-	U.S. EPA Fact Sheet 1999	
-	51%, 41%	63%, 42%	70%, 49%	56%, 76%	93%, 77%	-	Yousef et al. 1987**	
30-90%	0-50%	20-85%	0-90%	0-90%	0-90%	-	City of Austin (1995)	StormWater

						-	Claytor & Schueler (1996); Kahn et al. (1992); Yousef et al. (1985); Yu & Kaighn (1995); Yu et al. (1993 & 1994)	BMPs FHWA
-	-	-	-	-	-	-388[2]	Randafi (2006), Dayton Ave Project [3]	

* Value reduction of nitrate only.
** Observations from two sites respectively.
[1] No data.
[2] Fecal coliform.
[3] MS Dept. of Marine Resources – http://www.dmr.state.ms.us/CMP/Storm/APPENDIX-C/Dayton%20Biofilter%20Grass%20Swale.pdf.

Table E.8 Load reductions for street sweeping.

TSS	TP	TN	Metals	Bacteria		
55-93%	40-74%	42-77%	35-85%	-[1]	NVPDC 1992	StormWater BMPs FHWA

[1] No data.

Table E.9 Load reductions for porous pavement.

Volume	TSS	TP	TN	Metals	Bacteria		
-[1]	82-95%	60-71%	80-85%	33-99%	-	MWCOG 1983 Hogland et al. 1987 Young et al. 1996	StormWater BMPs FHWA
-	82-95%	65%	80-85%	98-99%	-	USEPA 2004	
31-100%*	-	-	-	-	-	Smith et al. 2006	
66%**	-	-	-	-	-		

75%**	-	-	-	-	-	
81%**	-	-	-	-	-	
53%**	-	-	-	-	-	

* Represents the range of reduction for 4 types of porous pavement from 17 rainfall events.

** Represents an average reduction for one of the 4 types of porous pavement tested from 17 rainfall events.

[1] No data.

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Table E.10 Load reductions for filter strips.

Sediment/Solids	N	P	Fecal Coliform*	Length of Strip		
97.6%	95.3%	93.6%	-[1]	18.3m	Load(kg/ha)	Lim et al. 1998
91.9%	90.1%	83.8%	-	18.3m	Conc.(mg/L)	
77.3%	86.9%	92.6%	-	21m	Load(kg/ha)	Chaubey et al. 1994
92.1%	94.6%	96.9%	86.8%	21m	Conc.(mg/L)	
95%	80%	80%	-	9.1m	Load(kg/ha)	Dillaha et al. 1988
99%	-	-	74%	9m	Load(kg/ha)	Coyne et al. 1995
79%	84%	83%	69%		Conc.(cfu/mL)	Young et al. 1980
-	-	-	95%	1.37m	Conc.(cfu/mL)	Larsen et al. 1994
-	-	-	FC-54% EC-13%	-	-	Rifai (2006),Goel, et al.
-	-	-	FC-30-100% EC-58-99%	-	-	Peterson et al. 2011

* Concentration reductions are for fecal coliform unless otherwise labeled.
[1] No data.

Table E.11 Load reductions for riparian herbaceous buffers.

Sediment/Solids	N	P	Fecal Coliform*	Width	
79%	84%	83%	69%	27m	Young et al. 1980
84%	73%	79%	-[1]	9.1m	Lee et al. 1999
66%	0%	27%	-	4.6m	Magette et al. 1999
70%	50%	26%	-	4.3 & 5.3m	Parsons et al. 1991
99%	-	-	-	5-61m	Dosskey et al. 2002
67%	-	-	-	5-61m	Dosskey et al. 2002
59%	-	-	-	5-61m	Dosskey et al. 2002
41%	-	-	-	5-61m	Dosskey et al. 2002
-	-	-	95%	1.37m	Larsen et al. 1994

* Concentration reductions in cfu/mL.
[1] No data.

Table E.12 Load reductions for field borders.

Sediment/Solids	N	P		
57%	55%	50%	Load(kg/ha)	Arabi 2005
45%	35%	30%	Load(kg/ha)	Arabi 2005
50%	45%	25%	Load(kg/ha)	Arabi et al. 2006
48%	45%	24%	Load(kg/ha)	Arabi et al. 2006
81%	32%	-[1]	Load(kg/ha)	Tate et al. 2000

[1] No data.

Table E.13 Load reductions for grassed waterways.

Sediment/Solids	N	P	Fecal Coliform		
97%	-[1]	-	-	Load(kg/ha)	Fiener & Auerswald 2003
77%	-	-	-	Load(kg/ha)	Fiener & Auerswald 2003
95%	-	-	-	Load(t/ha)	Chow et al. 1999
-	-	-	95%	Conc.(cfu/mL)	Larsen et al. 1994
-	-	-	16%	Conc.(cfu/mL)	Dickey and Vanderholm, 1981

[1] No data.

Table E.14 Load reductions for riparian forest buffers.

Sediment/Solids	N	P		
97.2%	93.9%	91.3%	Load(kg/ha)	Lee et al. 2003
76%	-[1]	-	Mass(g/event)	Schoonover et al. 2005
61.3%	-	-	Conc.(mg/L)	Schoonover et al. 2005
90%	-	-	Conc.(mg/L)	Peterjohn & Correll 1984
-	89%	80%	Load(kg/ha)	Peterjohn & Correll 1984

[1] No data.

Table E.15 Load reductions for alternative watering facilities.

Sediment/ Solids	N	P	Bacteria	Reduction in Time Spent in Stream	Reduction in Time Spent Near Stream	Reduction in Time Spent Drinking From Stream		
96.2%	55.6%	97.5%	-[3]	-	-	92%	Load (kg/ha)[1]	Sheffield et al. 1997
90%	54%	81%	FC-51%	-	-	92%	Conc. (mg/L)[2]	Sheffield et al. 1997
-	-	-	-	85%	53%	73.5%	-	Clawson 1993
-	-	-	-	-	75%	-	-	Godwin & Miner et al. 1996
-	-	-	-	90%	-	-	-	Miner et al. 1992
77%*	-	-	EC-85% FC-51-94%	-	-	-	-	Peterson et al. 2011

* Estimated reduction in stream bank erosion.
[1] Load Reductions based on measurements taken only from the watershed outlet.
[2] Concentration reduction based on measurements averaged from all 5 sample sites in the studied watershed.
[3] No data.

Nutrient Management

Table E.16 Load reductions for nutrient management.

N*	NO_3-N**	P*	Management Practice	
-[1]	47%	-	Variable Rate Application	Delgado & Bausch 2005
-	59%	-	Nitrification Inhibitor	Di & Cameron 2002
-	-	12-41%	Variable Rate Application	Wittry & Mallarino 2004

* Reductions in nutrient applied to crop and continuing to maintain yield.
** Reduction in residual soil NO3-N and NO3-N leaching potential.
[1] No data.

Table E.17 Load reductions for conservation cover.

Sediment/Solids	N	P	Bacteria	
71%	-[1]	-	-	USEPA 2009 STEPL BMP Efficiency Rates
90%	-	-	-	Grace 2000
99%	-	-	-	Robichaud et al. 2006
89%	-	-	-	Robichaud et al. 2006

[1] No data.

Table E.18 Load reductions for prescribed grazing.

Consumption of Weed Species	Reduction of Weed Population	Reduction of Stem Density	Increase in Population of Preferred Veg.	Weed Species	Livestock Species	
40-90%	-[1]	-	-	Tall larkspur	Sheep	Ralphs et al. 1991
-	-	98%*	-	Leafy Spurge	Goats	Lym et al. 1997
-	93%	-	13%	Leafy Spurge	Sheep	Johnston & Peake 1960
-	90%	-	-	Barley	Sheep	Hartley et al. 1978
-	100%	-	-	Bull Thistle	Goats	Rolston et al. 1981
-	90%	-	-	Leafy Spurge	Sheep	Olson & Lacey 1994

* Reduction achieved in combination with herbicide application.
[1] No data.

Table E.19 Load reductions for prescribed grazing.

Sediments / Solids	N	Bacteria	Runoff Volume*	Livestock Species	
8%	34%	EC – 66-72% FC – 90-96%	[1]Mod. Grazed—29% [2]Lightly Grazed—89%	Cattle	Peterson et al. 2011

* Reduction as compared to heavily grazed (1.35 AUM/acre).
[1] (2.42 AUM/acre)
[2] (3.25 AUM/acre)

Table E.20 Load reductions for stream crossings.

Sediments / Solids	N	P	Bacteria*	
18-25%	18-25%	18-25%	EC—46% FC—44%-52%	Peterson et al. 2011
-[3]	35%[1]*	78%[2]*		

* Concentration reductions.
[1] Nitrate nitrogen.
[2] Particulate phosphorus.
[3] No data.

Table E.21 Load reductions for alternative shade.

Sediments / Solids	N	Bacteria	
-[1]	-	EC – 85%*	Peterson et al. 2011

* When combined with an off-stream water source.
[1] No data.

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Also see Lone Star Healthy Streams Program *Research Bibliography* at http://lshs.tamu.edu/research/.

F. Phase II MS4 Storm Water Program Overview

Minimum Control Measures and Compliance Strategies

Control Measures	What is Required	Best Management Practices
Public Education and Outreach	Implement a public education program to distribute educational materials to the community about the impacts of stormwater discharges on local water bodies and the steps that can be taken to reduce stormwater pollution.	Brochures or fact sheets
		Recreational guides
		Alternative information sources
		A library of educational materials
		Volunteer citizen educators
		Event participation
		Educational programs
		Storm drain stenciling
		Storm water hotlines
		Economic incentives
		Public Service Announcements
		Tributary signage
Public Participation and Involvement	Provide opportunities for citizens to participate in program development and implementation.	Public meetings/citizen panels
		Volunteer water quality monitoring
		Volunteer educators/speakers
		Storm drain stenciling
		Community clean-ups
		Citizen watch groups
		"Adopt A Storm Drain" programs
		Legally prohibit non-storm water discharges into the MS4.
		Implement a plan to detect and address non-storm water discharges into the MS4.
		Educate public employees, businesses, and the general public about the hazards of illegal discharges and improper disposal of waste.

Control Measures	What is Required	Best Management Practices
Construction Site Runoff Control	Develop, implement, and enforce an erosion and sediment control program for construction activities that disturb 1 or more acres of land.	Have procedures for site plan review of construction plans that include requirements for the implementation of BMPs to control erosion and sediment and other waste at the site.
		Have procedures for site inspection and enforcement of control measures.
		Have sanctions to ensure compliance (established in the ordinance or other regulatory mechanism).
		Establish procedures for the receipt and consideration of information submitted by the public.
Post-Construction Runoff Control	Develop, implement, and enforce a program to reduce pollutants in post-construction runoff to their MS4 from new development and redevelopment projects that result in the land disturbance of greater than or equal to 1 acre.	Planning procedures
		Site-based BMPs
		Stormwater Retention/Detention BMPs
		Infiltration BMPs
		Vegetative BMPs
Pollution Prevention/Good Housekeeping	Develop and implement an operation and maintenance program with the ultimate goal of preventing or reducing pollutant runoff from municipal operations into the storm sewer system.	Employee training on how to incorporate pollution prevention/good housekeeping techniques into municipal operations.
		Maintenance procedures for structural and non-structural controls.
		Controls for reducing or eliminating the discharge of pollutants from areas such as roads and parking lots, maintenance and storage yards.
		Procedures for the proper disposal of waste removed from separate storm sewer systems.
		Ensure that new flood management projects assess the impacts on water quality and examine existing projects for incorporation of additional water quality protection devices or practices.