

Draft for Public Comment, November 2022

Approved: **Month, Day, Year**  
AS-468

# Draft Implementation Plan for Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek

Assessment Units 0603A\_01 and 0603B\_01



By Stakeholders of the Sandy and Wolf Creeks Watershed  
and the Texas Water Resources Institute

---

Published by the Texas Commission on Environmental Quality  
Office of Water, Water Quality Planning Division

Prepared by the Sandy and Wolf Creeks I-Plan Coordination Committee  
and the Texas Water Resources Institute

Distributed by the  
Total Maximum Daily Load Team  
Texas Commission on Environmental Quality  
MC-203  
P.O. Box 13087  
Austin, Texas 78711-3087  
Email: [tmdl@tceq.texas.gov](mailto:tmdl@tceq.texas.gov)

Total maximum daily load implementation plans are also available on the  
Texas Commission on Environmental Quality website at:  
[www.tceq.texas.gov/waterquality/tmdl](http://www.tceq.texas.gov/waterquality/tmdl).

The preparation of this report was financed in part through grants from  
the United States Environmental Protection Agency.

This plan is based in part on technical reports prepared for the  
Texas Commission on Environmental Quality by  
The Texas Water Resources Institute  
and in large part on the recommendations of the  
Sandy and Wolf Creeks Implementation Plan Coordination Committee

Organizations that took part in the development of this document include:

Angelina-Neches River Authority  
City of Jasper Public Works Department  
Jasper Newton County Public Health District  
Jasper-Newton Soil and Water Conservation District  
Lower Neches Valley Authority  
Texas Commission on Environmental Quality  
Texas A&M AgriLife Extension Service  
Texas A&M AgriLife Research  
Texas State Soil and Water Conservation Board  
Texas Water Resources Institute  
U.S. Department of Agriculture Natural Resources Conservation Service  
U.S. Army Corps of Engineers

The maps in this report were created by the Total Maximum Daily Load Team of the  
Texas Commission on Environmental Quality. These maps are for informational purposes and  
may not have been prepared for or be suitable for legal, engineering, or surveying purposes. They  
do not represent an on-the-ground survey and represent only the approximate relative location of  
property boundaries. For more information concerning these maps, call the  
Water Quality Planning Division at 512-239-6284 or email [tmdl@tceq.texas.gov](mailto:tmdl@tceq.texas.gov).

The Texas Commission on Environmental Quality is an equal opportunity employer. The agency  
does not allow discrimination on the basis of race, color, religion, national origin, sex, disability,  
age, sexual orientation, or veteran status. In compliance with the Americans with Disabilities Act,  
this document may be requested in alternate formats by contacting TCEQ at 512-239-0010, or  
800-RELAY-TX (TDD), or by writing PO Box 13087, Austin TX 78711-3087. We authorize you to use  
or reproduce any original material contained in this publication—that is, any material we did not  
obtain from other sources. Please acknowledge TCEQ as your source. For more information on  
TCEQ publications, visit our website at: [tceq.texas.gov/publications](http://tceq.texas.gov/publications).  
How is our customer service? [tceq.texas.gov/customersurvey](http://tceq.texas.gov/customersurvey).

# Contents

Executive Summary .....	1
Management Measures .....	1
Introduction .....	2
Watershed Overview .....	3
Summary of TMDLs.....	4
Implementation Strategy .....	5
Adaptive Implementation.....	5
Activities and Milestones.....	5
Management Measures .....	6
Management Measure 1.....	6
Education Component.....	8
Priority Areas.....	8
Responsible Parties and Funding.....	10
Measurable Milestones .....	12
Estimated Load Reductions.....	14
Management Measure 2.....	17
Education Component.....	17
Priority Areas.....	17
Responsible Parties and Funding.....	19
Measurable Milestones .....	20
Estimated Load Reductions.....	21
Management Measure 3.....	23
Education Component.....	23
Priority Areas.....	23
Responsible Parties and Funding.....	25
Measurable Milestones .....	26
Estimated Load Reductions.....	26
Management Measure 4.....	30
Education Component.....	30
Priority Areas.....	31
Responsible Parties and Funding.....	33
Measurable Milestones .....	34
Estimated Load Reductions.....	35
Management Measure 5.....	38
Education Component.....	38
Priority Areas.....	38
Responsible Parties and Funding.....	39
Measurable Milestones .....	40
Estimated Load Reductions.....	40
Management Measure 6.....	43
Education Component.....	43

Priority Areas.....	43
Responsible Parties and Funding.....	46
Measurable Milestones .....	47
Estimated Load Reductions.....	48
Management Measure 7.....	51
Education Component.....	51
Priority Areas.....	51
Responsible Parties and Funding.....	51
Measurable Milestones .....	52
Estimated Load Reductions.....	53
Management Measure 8.....	55
Education Component.....	56
Responsible Parties and Funding.....	56
Measurable Milestones .....	57
Estimated Load Reductions.....	58
Sustainability .....	60
Water Quality Indicators .....	60
Implementation Milestones.....	60
Communication Strategy .....	60
References.....	61

## Figures

Figure 1.	Overview map of the Sandy Creek and Wolf Creek TMDL watersheds .....	4
Figure 2.	Subwatershed priorities based on <i>E. coli</i> loading potential from cattle in the Sandy Creek and Wolf Creek watersheds .....	9
Figure 3.	Subwatershed priorities based on <i>E. coli</i> loading potential from hogs in the Sandy Creek and Wolf Creek watersheds.....	18
Figure 4.	Subwatershed priorities based on <i>E. coli</i> loading potential from dogs across the Sandy Creek and Wolf Creek watersheds .....	24
Figure 5.	Subwatershed priorities based on <i>E. coli</i> loading potential from OSSFs in the Sandy Creek and Wolf Creek watersheds .....	32
Figure 6.	Estimated density of SSO events in the Sandy Creek watershed.....	39
Figure 7.	Subwatershed priorities for Management Measure 6 based on TFS Forest Action Plan water resources priority areas.....	45
Figure 8.	Existing TCEQ SWQM stations on Segments 0603A and 0603B .....	55

## Tables

Table 1.	TMDL Allocation Summary for Sandy Creek AU 0603A_01 and Wolf Creek AU 0603B_01.....	5
Table 2.	NRCS conservation practices for producers that can improve water quality .....	7
Table 3.	Estimates of <i>E. coli</i> loads from livestock.....	8
Table 4.	Estimated funding needed for implementing Management Measure 1 .....	11
Table 5.	Summary of literature reported values for conservation practice effectiveness in reducing indicator bacteria loads.....	15
Table 6.	Management Measure 1: Promote and implement NRCS conservation plans and TSSWCB Water Quality Management Plans .....	16
Table 7.	Estimated funding needed for implementing Management Measure 2 .....	20
Table 8.	Management Measure 2: Promote feral hog management .....	22
Table 9.	Estimated funding needed for implementing Management Measure 3 .....	25
Table 10.	Management Measure 3: Develop and implement pet waste programs throughout the TMDL watersheds.....	29
Table 11.	Estimated funding needed for implementing Management Measure 4 .....	34
Table 12.	Management Measure 3: Promote OSSF management.....	37
Table 13.	Estimated funding needed for implementing Management Measure 5 .....	40
Table 14.	Management Measure 5: Reduce SSOs and unauthorized discharges .....	42
Table 15.	Estimated funding needed for implementing Management Measure 6 .....	46

Table 16. Management Measure 6: Promote sustainable forest practices..... 50  
Table 17. Estimated funding needed for implementing Management Measure 7 ..... 52  
Table 18. Management Measure 7: Promote volunteer water quality monitoring..... 54  
Table 19. Estimated funding needed for implementing Management Measure 8 ..... 57  
Table 20. Management Measure 8: Implement water quality monitoring ..... 59

## Abbreviations

ANRA	Angelina and Neches River Authority
AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
cfu	colony forming units
CIG	Conservation Innovation Grants
CMS	Coordinated Monitoring Schedule
CRP	Clean Rivers Program
CSP	Conservation Stewardship Program
<i>E. coli</i>	<i>Escherichia coli</i>
EPA	Environmental Protection Agency (United States)
EQIP	Environmental Quality Incentives Program
FG	future growth
I-Plan	implementation plan
LA	load allocation
LNVA	Lower Neches Valley Authority
mL	milliliter
MOS	margin of safety
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
OSSF	on-site sewage facility
QAPP	Quality Assurance Protection Plan
RCPP	Regional Conservation Partnership Program
SARE	Sustainable Agriculture Research and Education
SEP	Supplemental Environmental Projects
SSO	sanitary sewer overflow
SWCD	Soil and Water Conservation District
SWQM	surface water quality monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TFS	Texas A&M Forest Service
TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board

TST	Texas Stream Team
TWRI	Texas Water Resources Institute
U.S.	United States
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
WLA	wasteload allocation
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

# Implementation Plan for Two TMDLs for Indicator Bacteria in Sandy Creek and Wolf Creek

---

## Executive Summary

In 2022, the Texas Commission on Environmental Quality (TCEQ) adopted *Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek* (Waterbodies 0603A and 0603B).

This implementation plan, or I-Plan:

- Describes the steps that watershed stakeholders and TCEQ will take toward achieving the pollutant reductions identified in the total maximum daily load (TMDL) report.
- Outlines the schedule for implementation activities.

The goal of this I-Plan is to restore the primary contact recreation 1 uses in assessment units (AUs) 0603A\_01 and 0603B\_02 by reducing concentrations of indicator bacteria to levels established in the TMDL. *Escherichia coli* (*E. coli*) are widely used as indicator bacteria to assess attainment of the contact recreation use in freshwater. The criteria for assessing attainment of the contact recreation use are expressed as the number (or “counts”) of *E. coli* bacteria, typically given as colony forming units (cfu). The primary contact recreation 1 use is not attained when the geometric mean of *E. coli* samples exceeds the geometric mean criterion of 126 cfu per 100 milliliters (mL) for *E. coli* in freshwater streams.

This I-Plan includes eight management measures that stakeholders will use to reduce indicator bacteria in the Sandy Creek and Wolf Creek watersheds. Management measures are related to nonpoint sources (mostly unregulated), such as working to identify on-site sewage facilities (OSSFs) in the TMDL watersheds. Control actions are related to point sources (regulated discharges), such as implementing industrial or domestic wastewater treatment facilities (WWTFs) permits or municipal separate storm sewer systems and their associated storm-water management programs. No control actions are included in this plan.

## Management Measures

For each of the measures chosen, this plan names the responsible parties, technical and financial needs, monitoring and outreach efforts, and a schedule of activities. Implementation of management measures will be dependent upon the availability of funding. The management measures in this plan are:



- 1) Promote and implement Natural Resources Conservation Service conservation plans and Texas State Soil and Water Conservation Board Water Quality Management Plans.
- 2) Promote feral hog management.
- 3) Develop and implement pet waste programs throughout the TMDL watersheds.
- 4) Promote OSSF management.
- 5) Reduce sanitary sewer overflows and unauthorized discharges.
- 6) Promote sustainable forest practices.
- 7) Promote volunteer water quality monitoring.
- 8) Implement water quality monitoring.

The stakeholders and TCEQ will review progress under TCEQ's adaptive management approach. Stakeholders may adjust the plan periodically as a result of progress reviews.

## Introduction

To keep Texas' commitment to restore and maintain water quality in impaired rivers, lakes, and bays, TCEQ works with stakeholders to develop an I-Plan for each adopted TMDL. A TMDL is a technical analysis that:

- Determines the amount of a particular pollutant that a water body can receive and still meet applicable water quality standards.
- Sets limits on categories of sources that will result in achieving standards.

This I-Plan is designed to guide activities that will achieve the water quality goals for the Sandy Creek and Wolf Creek watersheds as defined in the TMDL report. It is a flexible tool that governmental and non-governmental organizations involved in implementation use to guide their activities to improve water quality. The participating partners may accomplish the activities described in the plan through rule, order, guidance, or other formal or informal action.

This I-Plan includes the following components:

- Description of management measures that will be implemented to achieve the water quality target.
- Schedule for implementing activities.
- A follow-up tracking and monitoring plan to determine the effectiveness of the management measures undertaken.
- Measurable outcomes and other considerations TCEQ and stakeholders will use to decide whether the I-Plan has been properly executed, water quality standards are being achieved, or the plan needs to be modified.

- Communication strategies TCEQ will use to share information with stakeholders.
- Review strategy that stakeholders will use to periodically review and revise the plan to ensure progress in improving water quality.

## Watershed Overview

Sandy Creek (0603A) and Wolf Creek (0603B) are in southeast Texas (Figure 1). Sandy Creek is located entirely in Jasper County and consists of two AUs (0603A\_01 and 0603A\_02). Sandy Creek flows approximately 27 miles from its headwaters near Recreational Road 255 and south through the City of Jasper to its confluence with B. A. Steinhagen Lake. The total watershed area for Sandy Creek is 56.54 square miles (36,184.36 acres).

Wolf Creek is located entirely in Tyler County. Wolf Creek consists of two AUs (0603B\_01 and 0603B\_02). Wolf Creek flows approximately 23 miles from its headwaters upstream of Lake Amanda to the confluence with B. A. Steinhagen Lake. The total watershed area for Wolf Creek is 83.14 square miles (53,207.52 acres).

The 2020 Texas Integrated Report (TCEQ, 2020) provides the following AU descriptions for the water bodies considered in this document:

- 0603A (Sandy Creek) - From the confluence with B. A. Steinhagen Lake southwest of the City of Jasper in Jasper County upstream to the headwaters at Recreational Road 255 north of Jasper in Jasper County.
  - 0603A\_01 - From the confluence with B. A. Steinhagen Lake upstream to 0.5 kilometers below FM 776 east of the City of Jasper, per Appendix D of the Texas Surface Water Quality Standards.
  - 0603A\_02 - From 0.5 kilometers below FM 776 east of the City of Jasper upstream to headwaters at Recreational Road 255 north of the City of Jasper.
- 0603B (Wolf Creek) - From the confluence of B. A. Steinhagen Lake southeast of Colmesneil in Tyler County to the upstream perennial portion of the stream south of Colmesneil in Tyler County.
  - 0603B\_01 - From the confluence of B. A. Steinhagen Lake upstream to Lake Amanda Dam.
  - 0603B\_02 - From the confluence with Lake Amanda upstream to the headwaters.

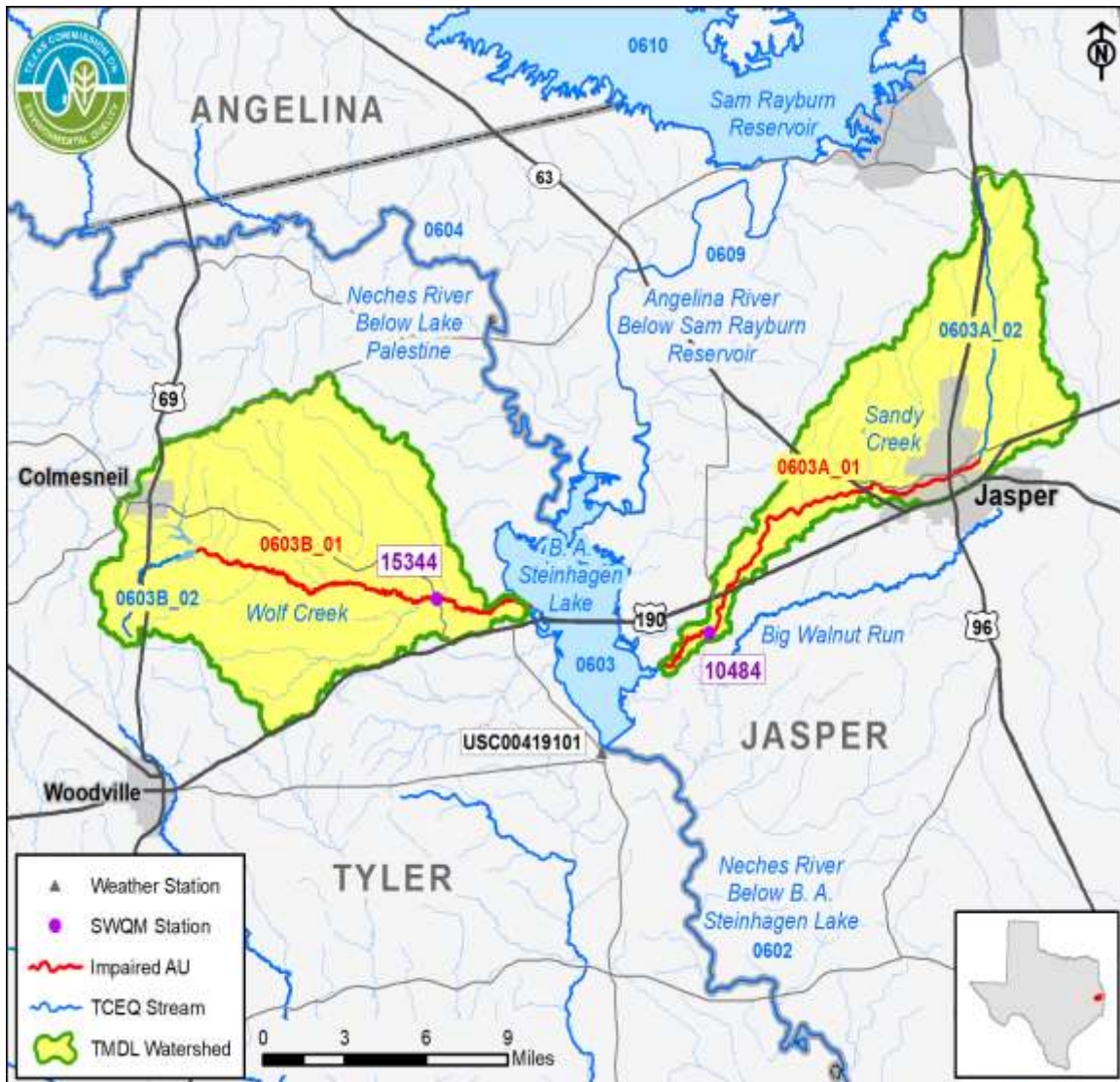


Figure 1. Overview map of the Sandy Creek and Wolf Creek TMDL watersheds

The Sandy Creek watershed is primarily rural, with large swaths of pine forests contributing to the local forest and paper industries. The City of Jasper is the only municipality in the Sandy Creek watershed. The Wolf Creek watershed is also primarily rural, with many pine forests. The town of Colmesneil is the only municipality in the watershed. Both TMDL watersheds have relatively limited cattle grazing and agricultural production.

## Summary of TMDLs

Table 1 summarizes the allocations developed for *Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek*. See the TMDL report for additional background information, including the problem definition,

endpoint identification, source analysis, linkages between sources and receiving waters, and pollutant load allocations.

**Table 1. TMDL Allocation Summary for Sandy Creek AU 0603A\_01 and Wolf Creek AU 0603B\_01**

AU	Segment Name	TMDL	MOS <sup>a</sup>	WLA <sub>WWTF</sub> <sup>b</sup>	WLA <sub>SW</sub> <sup>c</sup>	LA <sup>d</sup>	FG <sup>e</sup>
0603A_01	Sandy Creek	634.579	31.729	15.501	2.465	584.481	0.403
0603B_01	Wolf Creek	729.923	36.496	0	0.069	692.643	0.715

All loads are expressed in billion cfu/day

<sup>a</sup>MOS: margin of safety

<sup>b</sup>WLA<sub>WWTF</sub>: wasteload allocation for WWTFs

<sup>c</sup>WLA<sub>SW</sub>: wasteload allocation for stormwater

<sup>d</sup>LA: load allocation

<sup>e</sup>FG: future growth

## Implementation Strategy

This I-Plan documents eight management measures to reduce bacteria loads. Stakeholders selected management measures based on feasibility, costs, support, and timing. Activities may be phased in based on the needs of the stakeholders, availability of funding, and the progress made in improving water quality.

### Adaptive Implementation

All I-Plans use an adaptive management approach in which stakeholders periodically assess measures for efficiency and effectiveness. This adaptive management approach is one of the crucial elements of the I-Plan. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals and expresses stakeholder commitment to the process.

The stakeholders will periodically assess progress using the schedule of implementation, interim measurable milestones, water quality data, and the communication strategy included in this plan. If stakeholders find that there has been insufficient progress or that implementation activities have improved water quality, the implementation strategy can be adjusted.

### Activities and Milestones

The Texas Water Resources Institute (TWRI), in coordination with TCEQ, facilitated stakeholder participation in the development of this I-Plan. With guidance from TWRI and TCEQ, the Sandy Creek and Wolf Creek stakeholders formed a

Coordination Committee to determine management measures along with activities and schedules to accomplish them. Collectively, the Sandy Creek and Wolf Creek Coordination Committee held six meetings to develop this I-Plan.

The Coordination Committee developed detailed, consensus-based measures. The following sections describe the planned implementation activities.

## Management Measures

This I-Plan includes eight management measures.

- 1) Promote and implement Natural Resources Conservation Service conservation plans and Texas State Soil and Water Conservation Board Water Quality Management Plans.
- 2) Promote feral hog management.
- 3) Develop and implement pet waste programs throughout the TMDL watersheds.
- 4) Promote OSSF management.
- 5) Reduce sanitary sewer overflows and unauthorized discharges.
- 6) Promote sustainable forest practices.
- 7) Promote volunteer water quality monitoring.
- 8) Implement water quality monitoring.

### Management Measure 1

*Promote and implement Natural Resources Conservation Service conservation plans and Texas State Soil and Water Conservation Board Water Quality Management Plans.*

Grazed pastures and rangeland can contribute to bacteria loadings across the watersheds. Wagner (2013) found that *E. coli* concentrations in runoff from grazed lands were up to 70% higher compared to ungrazed sites. While the fate and transport of fecal bacteria deposited on upland surfaces is not always certain, practices that manage livestock behavior and time spent grazing, particularly in riparian pastures, can reduce potential bacteria loads reaching nearby water bodies.

Promoting and implementing Water Quality Management Plans (WQMPs) and conservation plans is anticipated to provide direct benefits to water quality and can provide benefits to producers. Several best management practices (BMPs) are available to achieve goals of improving forage quality, distributing livestock across a property, and making water available to livestock. Table 2 provides a list of common practices available to producers. Note that available BMPs are not limited to those in the table and the scope and type of BMPs implemented

will vary by operation. In addition to reducing bacteria loads reaching waterways, these practices can reduce erosion, sediment loads, and nutrient loads.

The United States (U.S.) Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and the Texas State Soil and Water Conservation Board (TSSWCB) give technical and financial assistance to producers for planning and implementing BMPs that protect and improve water quality. NRCS offers a variety of programs to implement operation-specific conservation plans that will meet producer goals and outline how BMPs will be implemented. TSSWCB, through local Soil and Water Conservation Districts (SWCDs), gives technical and financial assistance to develop and implement WQMPs through planning, implementation, and maintenance of each practice.

**Table 2. NRCS conservation practices for producers that can improve water quality**

Practice	NRCS code	Focus area or benefit
Brush management	314	Livestock, water quality, water quantity, wildlife
Fencing	382	Livestock, water quality
Filter strips	393	Livestock, water quality, wildlife
Grade stabilization structures	410	Water quality
Grazing land mechanical treatment	548	Livestock, water quality, wildlife
Heavy use area protection	562	Livestock, water quantity, water quality
Pond	378	Livestock, water quantity, water quality, wildlife
Prescribed burning	338	Livestock, water quality, wildlife
Prescribed grazing	528	Livestock, water quality, wildlife
Range/pasture planting	550/512	Livestock, water quality, wildlife
Shade structure	NA	Livestock, water quality, wildlife
Stream crossing	578	Livestock, water quality
Supplemental feed location	NA	Livestock, water quality
Water well	642	Livestock, water quality, wildlife
Watering facility	614	Livestock, water quality

The goal of this management measure is to promote BMP implementation in about 50% of the cattle farms in either TMDL watershed. Of all livestock, cattle were found to be the major contributors of bacteria loading in the two segments (Table 3). Based on USDA (2019) agricultural census data, there are approximately 42 and 52 cattle farms in the Sandy Creek and Wolf Creek watersheds, respectively. The I-Plan, therefore, targets implementing 20 conservation plans

or WQMPs in the Sandy Creek watershed and 25 plans in the Wolf Creek watershed.

**Table 3. Estimates of *E. coli* loads from livestock**

Livestock	Population estimates	Annual <i>E. coli</i> loading (billion cfu/year)	% of Total
<b>Sandy Creek Watershed</b>			
Cattle	856	1,680,000	91%
Goats and Sheep	72	71,500	4%
Hogs and Pigs	16	89,500	5%
Horses	68	5,690	0%
<b>Total</b>		<b>1,850,000</b>	
<b>Wolf Creek Watershed</b>			
Cattle	1827	3,590,000	88%
Goats and Sheep	201	200,000	5%
Hogs and Pigs	46	257,000	6%
Horses	111	9,280	0%
<b>Total</b>		<b>4,060,000</b>	

## Education Component

Education is one of the most important components of this management measure. An intensive education and outreach program is needed to broadly promote the adoption of management practices. Awareness of the TSSWCB and NRCS programs, management practices, and their benefits is often one of the largest factors affecting the adoption of BMPs. Existing educational programs specific to landowner interests should be used in the education and outreach campaign to further promote the adoption of BMPs. These educational resources include the Lone Star Healthy Streams Program and the Texas Riparian and Stream Ecosystem Education Program. Local AgriLife Extension offices and SWCDs work to locally promote and deliver these programs.

## Priority Areas

The greatest impact of this measure will be limiting the direct disposal of fecal waste in or near water bodies. Figure 2 shows *E. coli* loading potential from cattle per subwatershed in both Sandy Creek and Wolf Creek, respectively. Responsible parties for this measure will prioritize voluntary practices that limit



livestock access to streams by supplying alternative watering systems and excluding livestock from streamside buffers.

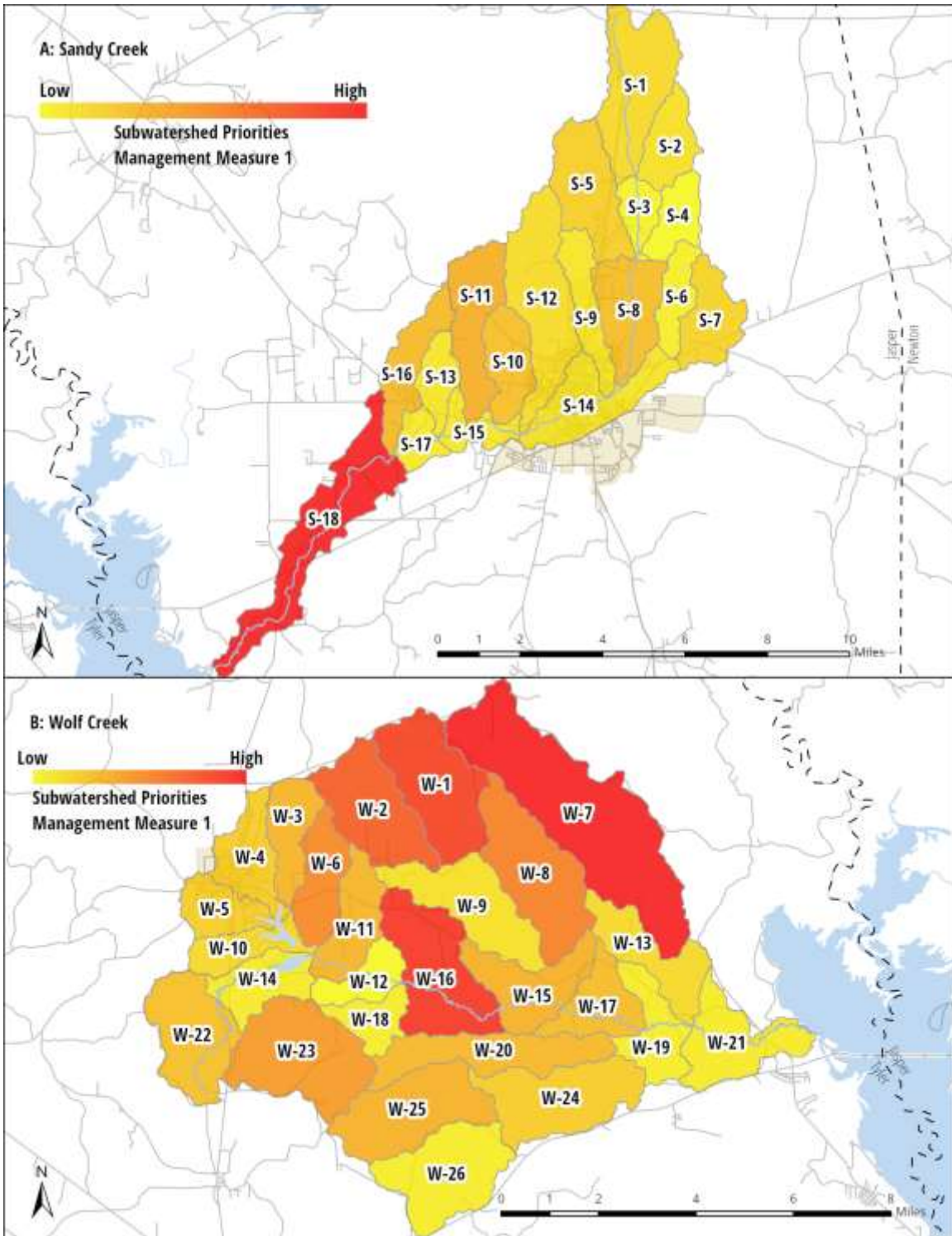


Figure 2. Subwatershed priorities based on *E. coli* loading potential from cattle in the Sandy Creek and Wolf Creek watersheds



## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **Landowners and producers:** Landowners and producers will work with the NRCS and SWCDs as appropriate to develop conservation plans or WQMPs and obtain funding to implement BMPs according to the site-specific plans.
- **Texas A&M AgriLife Extension Service:** The Texas A&M AgriLife Extension Service (AgriLife Extension) will work with NRCS, SWCDs, and TSSWCB to deliver outreach, education, and extension materials, workshops, and field days.
- **TSSWCB:** TSSWCB will work with NRCS and SWCDs to fund and hire a field technician to facilitate the development and implementation of conservation plans and WQMPs. TSSWCB is also responsible for oversight of the WQMP program.
- **SWCDs:** A SWCD, like a county or school district, is a subdivision of state government. SWCDs are administered by boards of directors who are elected by their fellow landowners. There are 216 individual SWCDs organized in Texas. The Sandy Creek and Wolf Creek watersheds are covered by the Jasper-Newton and Tyler SWCDs, respectively. The SWCDs will work with TSSWCB and NRCS to develop and implement conservation plans or WQMPs. The districts will also work with other entities in the delivery of outreach and extension materials, workshops, and field days.
- **USDA NRCS:** NRCS will work with landowners/producers and SWCDs to develop and implement conservation plans or WQMPs. NRCS will also work with entities in the delivery of outreach and extension materials, workshops, and field days.

## Technical Assistance

Developing and implementing practices to reduce runoff from agricultural lands requires substantial technical expertise. Producers can obtain technical assistance from local SWCDs, local NRCS offices, and local AgriLife Extension offices. Producers that request planning assistance will work with their local SWCD and NRCS office to define operation-specific management goals and objectives and develop a management plan that prescribes effective practices that will achieve stated goals while also improving water quality.

## Financial Assistance

This I-Plan targets the adoption and implementation of a total of 45 conservation plans and three education programs over five years. Table 4 shows the funding requirements for implementing Management Measure 1. The estimated funding needed for education programs is based on an average cost of \$50,000

per program. The annual salary, benefits and additional costs associated with a field technician is estimated at approximately \$75,000 per year. The cost of on-farm practices can vary substantially, depending on the specific suite of practices adopted by the producer. For this plan, TWRI estimates the cost associated with each plan at \$15,000. Several cost-share programs are available to producers that incentivize the planning and implementation of these practices.

**Table 4. Estimated funding needed for implementing Management Measure 1**

Description	Item	Unit	Rate	Amount
Field technician for developing WQMPs	5	Years	\$75,000	\$375,000
Educational programs	3	No.	\$50,000	\$150,000
WQMP implementation	45	No.	\$15,000	\$675,000
<b>Total:</b>				<b>\$1,200,000</b>

Potential funding sources include:

- **WQMP Program** - WQMPs are property-specific plans that outline the BMPs most appropriate to improve the quality of land and water on the property. The TSSWCB may provide financial assistance to private property owners in implementing individual WQMPs, as funding allows.
- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This U.S. Environmental Protection Agency (EPA) grant program, administered by TCEQ and TSSWCB, provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to support education programs, watershed implementation, and technicians.
- **Sustainable Agriculture Research and Education** - Sustainable Agriculture Research and Education (SARE) provides grants and educational programs to advance agricultural innovation which promotes profitability, stewardship of the land, air, and water, and quality of life for farmers, ranchers, and their communities. Southern SARE is the regional component that includes Texas and grants go towards land, crop, and livestock management.
- **USDA Conservation Innovation Grants:** The USDA Conservation Innovation Grants (CIG) is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, Environmental Quality Incentives Program (EQIP) funds are used to award competitive grants to non-federal governmental or non-governmental organizations, tribes, or individuals.

- **NRCS Agricultural Management Assistance** - The Agriculture Management Assistance program of the NRCS helps agriculture producers use conservation to manage risk and solve natural resource issues through natural resources conservation.
- **NRCS Conservation Stewardship Program:** The Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Participants earn CSP payments for conservation performance — the higher the performance, the higher the payment.
- **NRCS EQIP:** EQIP is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. An additional purpose of EQIP is to help producers meet federal, state, tribal, and local environmental regulations.
- **NRCS Regional Conservation Partnership Program:** The Regional Conservation Partnership Program (RCPP) is a new, comprehensive, and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Through RCPP, NRCS and state, local, and regional partners coordinate resources to help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved.
- **EPA Environmental Education Grants:** Under the Environmental Education Grant Program, EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program provides financial support for projects that design, show, or teach environmental education practices, methods, or techniques as described in their Requests for Proposals.

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Number of WQMPs and conservation plans developed.
- Number of acres in conservation plans developed.
- Number of AgriLife Extension, outreach, or education programs delivered.

## **Monitoring Component**

NRCS, TSSCWB, and AgriLife Extension, working with local stakeholders, will monitor and track the implementation of BMPs, workshops, field days, and extension programs delivered, and document the implementation status annually.

## **Implementation Schedule**

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

### **Years 1:**

- Secure funding for a field technician to develop WQMPs.
- Deliver a Lone Star Healthy Streams workshop, or related workshop or field day event.
- Develop four WQMPs or conservation plans in the Sandy Creek watershed and five WQMPs or conservation plans in the Wolf Creek watershed.

### **Year 2:**

- Maintain funding for the field technician developing WQMPs.
- Develop four WQMPs or conservation plans in the Sandy Creek watershed and five WQMPs or conservation plans in the Wolf Creek watershed.

### **Year 3:**

- Maintain funding for the field technician developing WQMPs.
- Deliver a Lone Star Healthy Streams workshop, or related workshop or field day event.
- Develop four WQMPs or conservation plans in the Sandy Creek watershed and five WQMPs or conservation plans in the Wolf Creek watershed.

### **Year 4:**

- Maintain funding for the field technician developing WQMPs.
- Develop four WQMPs or conservation plans in Sandy Creek watershed and five WQMPs or conservation plans in Wolf Creek watershed each year.

### **Year 5:**

- Maintain funding for the field technician developing WQMPs.
- Deliver a Lone Star Healthy Streams workshop, or related workshop or field day event.
- Develop four WQMPs or conservation plans in Sandy Creek watershed and five WQMPs or conservation plans in Wolf Creek watershed.

## Estimated Load Reductions

The following equation was used to estimate the potential annual load reduction of *E. coli* (billion cfu/year) from implementation of conservation plans and WQMPs:

$$Load_{cattle} = N_{plans} \times Head/Operation \times Animal\ Unit\ Conversion \times FC_{cattle} \times Conversion_{bac} \times Median\ Efficacy \times Prox \times 365\ days/year.$$

Where:

$Load_{cattle}$  = Potential annual load reduction of *E. coli* attributed to cattle

$N_{plans}$  = Number of conservation plans or WQMPs developed and implemented

$Head/Operation$  = Average number of head of cattle per operation in Tyler and Jasper counties (approximately 42 and 52 operations in Sandy Creek and Wolf Creek watersheds, respectively)

$Animal\ Unit\ Conversion$  = Cattle to animal unit conversion factor, assumed to be one (Wagner and Moench, 2009)

$FC_{cattle}$  = Fecal coliform produced per animal unit per day; 8.55 billion cfu/day (Wagner and Moench, 2009)

$Conversion_{bac}$  = Conversion rate of .63 from fecal coliform to *E. coli* (Wagner and Moench, 2009)

$Median\ Efficacy$  = Median efficacy of selected conservation practices at reducing bacteria loads (.58 used, see Table 5)

$Prox$  = Approximate proximate factor to account for distance of management practices from riparian areas (.15 used, see below)

The effectiveness of WQMPs and conservation plans at reducing bacteria loads is highly dependent on the specific conservation practices installed by the rancher or farmer. To estimate expected *E. coli* reductions, efficacy values of likely BMPs were calculated from median literature reported values. Because the actual BMPs implemented per WQMP or conservation plan are unknown, an overall median efficacy value of 58% was used to calculate load reductions (Table 5). The proximity of implemented BMPs to water bodies will influence the effectiveness of reducing loads. Typically, a proximity factor of 5% is used for BMPs in upland areas and 25% is used in riparian areas (Escamilla et al. 2019). Since there is uncertainty in both the selection of specific BMPs and the locations where plans are implemented, an average proximity factor of 15% was used.

**Table 5. Summary of literature reported values for conservation practice effectiveness in reducing indicator bacteria loads**

<b>Management practice</b>	<b>Median <i>E. coli</i> removal efficacy</b>
Exclusionary fencing	62%
Prescribed grazing	54%
Stream crossing	48%
Watering facility	73%
<b>Overall median</b>	<b>58%</b>

Potential load reductions of about 143,680 and 222,362 billion cfu of *E. coli* per year in Sandy Creek and Wolf Creek watersheds, respectively, are estimated.

**Table 6. Management Measure 1: Promote and implement NRCS conservation plans and TSSWCB Water Quality Management Plans**

**Causes and Sources:** Fecal deposition from livestock in pastures, rangeland, and in streams, and runoff from manure applied to cropland

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p>0603A_01 143,680 billion cfu/year of <i>E. coli</i></p> <p>and</p> <p>0603B_01 222,362 billion cfu/year of <i>E. coli</i></p>	<p><b>Technical:</b></p> <ul style="list-style-type: none"> <li>Assistance for producers and landowners is available through local SWCDs, NRCS, and county AgriLife Extension offices.</li> </ul> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>Funding for the field technician at approximately \$75,000 per year.</li> <li>About \$50,000 per education or outreach program per year.</li> <li>Funding for each WQMP at approximately \$15,000.</li> <li>Funding requirements for conservation plans vary substantially based on landowner production goals.</li> </ul>	<p>An intensive education and outreach program is needed to broadly promote the adoption of BMPs through appropriate programs such as Lone Star Healthy Streams and the Texas Riparian and Stream Ecosystem Education Program.</p>	<p><b>Year 1</b></p> <ul style="list-style-type: none"> <li>Secure funding for a field technician to develop conservation plans and WQMPs.</li> <li>Deliver an education, outreach, or extension event.</li> <li>Develop four WQMPs in the Sandy Creek watershed and five WQMPs in the Wolf Creek watershed.</li> </ul> <p><b>Year 2</b></p> <ul style="list-style-type: none"> <li>Maintain funding for the field technician developing WQMPs.</li> <li>Develop four WQMPs in the Sandy Creek watershed and five WQMPs in the Wolf Creek watershed.</li> </ul> <p><b>Year 3</b></p> <ul style="list-style-type: none"> <li>Maintain funding for the field technician developing WQMPs.</li> <li>Deliver an education, outreach, or extension event.</li> <li>Develop four WQMPs in the Sandy Creek watershed and five WQMPs in the Wolf Creek watershed.</li> </ul> <p><b>Year 4</b></p> <ul style="list-style-type: none"> <li>Maintain funding for the field technician developing WQMPs.</li> <li>Develop four WQMPs in the Sandy Creek watershed and five WQMPs in the Wolf Creek watershed.</li> </ul> <p><b>Year 5</b></p> <ul style="list-style-type: none"> <li>Maintain funding for the field technician developing WQMPs.</li> <li>Deliver an education, outreach, or extension event.</li> <li>Develop four WQMPs in the Sandy Creek watershed and five WQMPs in the Wolf Creek watershed.</li> </ul>	<ul style="list-style-type: none"> <li>Number of WQMPs and conservation plans developed.</li> <li>Number of acres in the conservation plans developed.</li> <li>Number of educational programs delivered.</li> </ul>	<p><b>Years 1-5</b></p> <ul style="list-style-type: none"> <li>Four WQMPs or conservation plans in Sandy Creek watershed and five WQMPs or conservation plans in Wolf Creek watershed developed annually.</li> </ul> <p><b>Years 1,3,5</b></p> <ul style="list-style-type: none"> <li>Educational events held in Years 1, 3, and 5 for each watershed.</li> </ul>	<ul style="list-style-type: none"> <li>NRCS, TSSWCB, and AgriLife Extension working with local stakeholders, will monitor and track the implementation of BMPs and document the implementation status annually.</li> </ul>	<ul style="list-style-type: none"> <li>Local Stakeholders</li> <li>AgriLife Extension</li> <li>TSSWCB</li> <li>NRCS</li> <li>SWCDs</li> </ul>

## Management Measure 2

### *Promote feral hog management.*

Fecal matter deposited directly in streams by feral hogs contributes bacteria and nutrients to the state's water bodies. In addition, extensive rooting activities of feral hogs can cause erosion and soil loss.

While the complete eradication of feral hogs from the TMDL watersheds is not feasible, a variety of methods are available to manage populations. Stakeholders have recommended that governmental agencies and others undertake efforts to control feral hogs to reduce their population, limit their spread, and minimize the effects on water quality. AgriLife Extension (2012) estimated that 66% of feral hogs need to be managed annually to keep the population stable with no increase.

Currently, feral hog trapping is the responsibility of individual landowners. Given resource constraints, reliance on landowners to conduct the majority of feral hog trapping is likely to remain. As resources allow, professional trapping services and equipment programs can be provided to local stakeholders.

The promotion and implementation of BMPs focused on managing the feral hog populations within priority subwatersheds can lead to instream water quality improvements by minimizing fecal deposition.

The goal of this management measure is to manage 60% of the feral hog population in the TMDL watersheds.

### **Education Component**

Education is one of the most important components of this management measure. An intensive education and outreach program is needed to broadly promote the adoption of management practices. A targeted education and outreach campaign will provide multiple educational opportunities to stakeholders.

Educational materials will be developed and tailored to local conditions and broadcasted throughout the TMDL watersheds. Existing feral hog management workshops will also be used in the education and outreach campaign.

### **Priority Areas**

Feral hogs occupy and exploit a wide variety of habitats, and as shown in Figure 3, their loading potential is widespread. However, hogs will often congregate in high concentrations in areas where food is readily available, such as crop fields or forested areas with mast-producing trees. Feral hogs also congregate in riparian areas and muddy wetland habitats where they like to wallow around to keep cool.



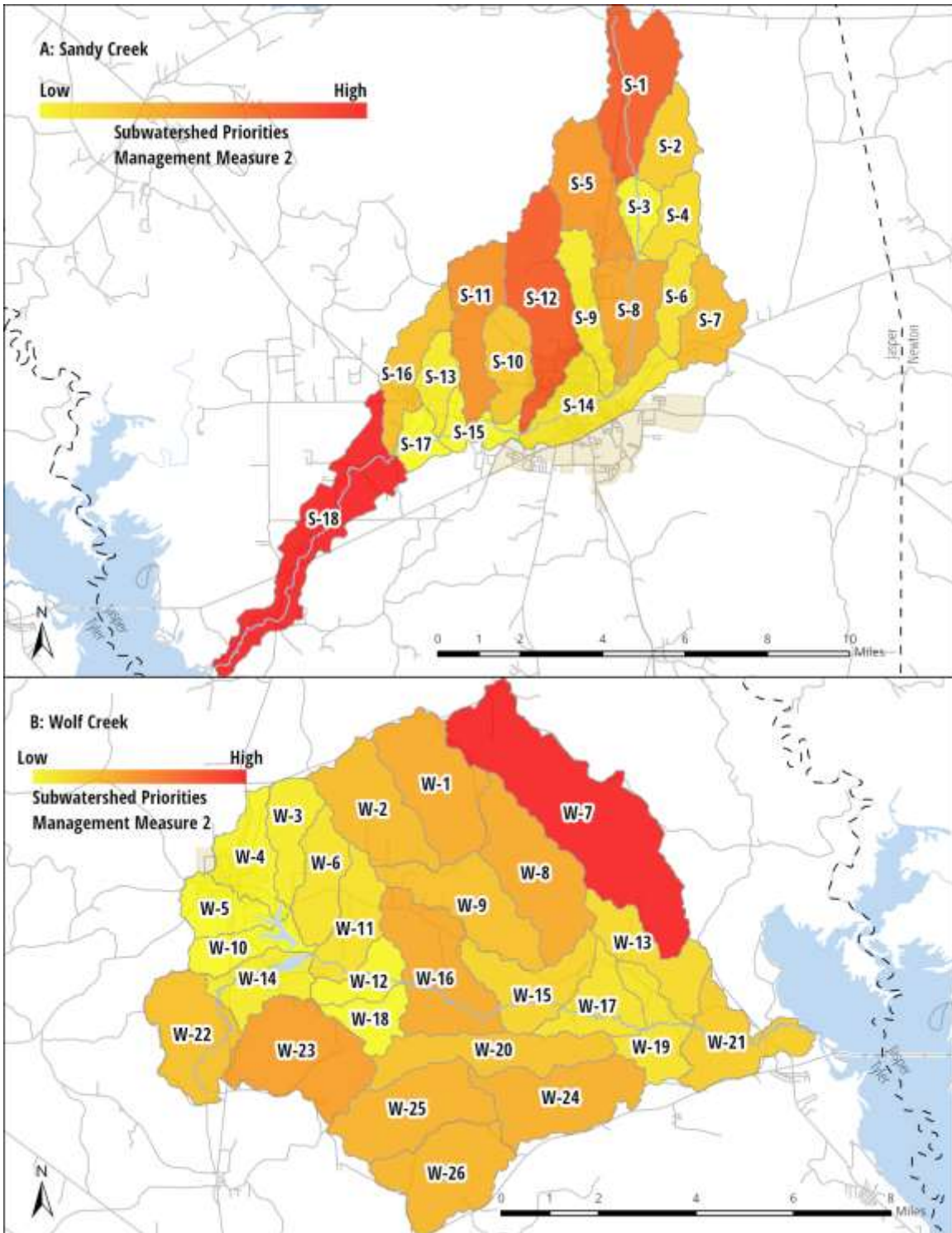


Figure 3. Subwatershed priorities based on *E. coli* loading potential from hogs in the Sandy Creek and Wolf Creek watersheds

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **Stakeholders:** Landowners are responsible for trapping feral hogs on private property. Stakeholders are able to take advantage of services provided by AgriLife Extension by requesting feral hog management workshops. As resources allow, regional or county trapping services may be made available for local landowners to trap feral hogs and track feral hogs removed more efficiently.
- **Jasper and Tyler County Extension Offices:** The extension offices will work with other stakeholders or entities to deliver feral hog management education and outreach workshops.
- **AgriLife Extension:** AgriLife Extension will work with local stakeholders to deliver feral hog management workshops.

## Technical Assistance

Numerous resources are available to assist landowners and managers control feral hog populations. AgriLife Extension offers technical materials and workshops on feral hog identification, impacts, and control methods. Similar resources are available through the USDA Animal and Plant Health Inspection Services. Texas Parks and Wildlife Department (TPWD) offers general information about identification, trapping, hunting, and regulations regarding removal of feral hogs.

## Financial Assistance

Table 7 shows the estimated costs of activities to implement for managing feral hog populations in the TMDL watersheds. Feral hog management workshops are estimated to cost approximately \$2,500 per workshop. The cost will vary depending on anticipated attendance, speaker and travel costs, and venue fees.

Annual costs associated with funding a feral hog trapper and associated equipment is estimated at \$95,000 per year. These costs may vary depending on whether a full or part-time trapper is employed.

Currently, funding for feral hog management activities is limited primarily to non-federal and non-state funding sources. Therefore, funding for trapper activities will rely primarily on local funds.

**Table 7. Estimated funding needed for implementing Management Measure 2**

Description	Item	Unit	Rate	Amount
Funding for a feral hog trapper and associated equipment	5	Years	\$95,000	\$475,000
Feral hog workshops	10	No.	\$2,500	\$25,000
			Total:	<b>\$500,000</b>

Potential funding sources include:

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This EPA grant program, administered by TCEQ and TSSWCB, provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to fund feral hog education workshops and outreach programs.
- **Local Funds:** Local funds include funds or eligible in-kind resources provided by local entities, such as county and municipal governments, local agencies, non-governmental organizations, volunteer groups, or individuals. While financial resources are typically considered, volunteer or staff time can be leveraged as eligible cost-share for many state and federal grant programs that require some type of cost-share. Local funds are anticipated to be the primary avenue of funding trappers.

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Estimated number of feral hogs removed on an annual basis.
- Number of education programs delivered.
- Estimated number of individuals reached.

## Monitoring Component

Local stakeholders are primarily responsible for removal of feral hogs. However, no mechanisms exist for tracking watershed-wide removal of feral hogs at this time. Although some efforts in the past have attempted to track these numbers, they have failed to gain traction. As funds allow, trapping programs will be used to track feral hogs removed. AgriLife Extension will track delivery of feral hog programs.

## Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

**Years 1-4:**

- Deliver one feral hog management workshop per year in each TMDL watershed.
- Promote the removal of feral hogs by voluntary hunting or trapping.
- Explore funding for feral hog trappers and equipment as needed.

**Year 5:**

- Deliver one feral hog management workshop per TMDL watershed.
- Promote the removal of feral hogs by voluntary hunting or trapping.
- Explore funding for feral hog trappers and equipment as needed.

## **Estimated Load Reductions**

Load reductions resulting from feral hog management are highly uncertain. According to AgriLife Extension (2012), approximately 60% of the population must be culled just to maintain current population levels. Therefore, the I-Plan targets annual removal of about 95 feral hogs from the Sandy Creek watershed and 155 from the Wolf Creek watershed over a period of five years.

Populations are highly mobile and will travel in and out of the watershed, making estimating changes in local populations nearly impossible. Therefore, overall load reductions resulting from feral hog management are not calculated in the plan. The plan estimates that a single feral hog has a loading potential of approximately 34.8 billion cfu/year of *E. coli*. Therefore, any efforts to maintain or reduce local feral hog populations will either reduce future increases in bacteria loadings or decrease existing loads by the loading potential indicated above.

The following equation was used to estimate the loading potential of a feral hog, and the assumed potential avoided load from removing a single feral hog:

$$Load_{fh} = N_{fh} \times Animal\ Unit\ Conversion \times FC_{fh} \times Conversion \times 365\ days/year$$

Where:

$Load_{fh}$  = Potential annual load reduction of *E. coli* attributed to removal of one feral hog (in units of billion cfu/year)

$N_{fh}$  = Number of feral hogs removed

*Animal Unit Conversion* = Feral hog to animal unit conversion factor, assumed to be .125 (Wagner & Moench, 2009)

$FC_{fh}$  = Fecal coliform produced per animal unit per day; 1.21 billion cfu/day (Wagner & Moench, 2009)

*Conversion* = Conversion rate of .63 from fecal coliform to *E. coli* (Wagner and Moench, 2009)

**Table 8. Management Measure 2: Promote feral hog management**

**Causes and Sources:** Fecal deposition from feral hogs directly into streams and in riparian habitats.

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p>34.8 billion cfu/year of <i>E. coli</i> per feral hog removed.</p>	<p><b>Technical:</b> Resources for land-owners about feral hog management techniques are available through AgriLife Extension, USDA Animal and Plant Health Inspection Services, and TPWD.</p> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>• Feral hog workshops are estimated at \$2,500 per program.</li> <li>• Salary and costs associated with a trapper are estimated at \$95,000 per year.</li> </ul>	<p>Responsible parties will deliver 10 feral hog management educational events or extension programs.</p>	<p><b>Years 1-4</b></p> <ul style="list-style-type: none"> <li>• Deliver one feral hog management workshop per year in each TMDL watershed.</li> <li>• Promote the removal of feral hogs by voluntary hunting or trapping.</li> <li>• Explore funding for feral hog trappers and equipment as needed.</li> </ul> <p><b>Year 5</b></p> <ul style="list-style-type: none"> <li>• Deliver one feral hog management workshop per TMDL watershed.</li> <li>• Promote the removal of feral hogs by voluntary hunting or trapping.,</li> <li>• Explore funding for feral hog trappers and equipment as needed.</li> </ul>	<ul style="list-style-type: none"> <li>• Estimated Number of feral hogs removed.</li> <li>• Number of educational programs delivered.</li> <li>• Estimated number of individuals reached.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of education programs delivered.</li> <li>• Estimated number of feral hogs removed.</li> <li>• Estimated number of individuals reached.</li> </ul>	<ul style="list-style-type: none"> <li>• AgriLife Extension will track programs delivered</li> <li>• As funds allow, trapping programs will be used to track feral hogs removed.</li> </ul>	<ul style="list-style-type: none"> <li>• Local Stakeholders</li> <li>• Jasper and Tyler County Extension Offices</li> <li>• AgriLife Extension</li> </ul>

## Management Measure 3

*Develop and implement pet waste management programs throughout the TMDL watersheds.*

Bacteria loading from domestic pets was determined to be a potential bacteria contributor in the TMDL watersheds. Recognizing that enforcement of ordinances in primarily rural watersheds is problematic, reducing bacteria loads from domestic pets hinges on education and outreach to increase knowledge and the desired behavior. Management strategies emphasize reducing the amount of pet waste that can be transferred to streams via overland transport. Strategies for carrying out this measure include:

- Educating the public about the harmful effects of uncollected animal waste, including human health hazards and the sullyng of public parks.
- Providing the public with improved means of animal waste collection, including bag dispensers and disposal containers at public parks (in the Sandy Creek watershed).

This I-Plan assumes that about 60% of the current pet owners already pick up after their pets. The goal of this management measure is to reduce the estimated percentage of people who do not pick up after their pets from 40% to 20%.

### Education Component

AgriLife Extension and the Lower Neches Valley Authority (LNVA) will work with the City of Jasper and Colmesneil neighborhoods to provide education and outreach materials to pet owners about bacteria pollution and the health risks posed by improperly disposed waste that could lead to an increase in the number of residents that pick up and dispose of their pets' waste.

### Priority Areas

It is important that pet waste be managed throughout the TMDL watersheds, although the emphasis will be on areas where pets and humans are likely to congregate, such as public parks. Most of the dogs will likely be in the more urbanized areas and as such, higher rates of bacteria loading are from the City of Jasper and its suburbs (priority area S-14) and the Colmesneil neighborhoods (priority area W-4 and W-5) (Figure 4).

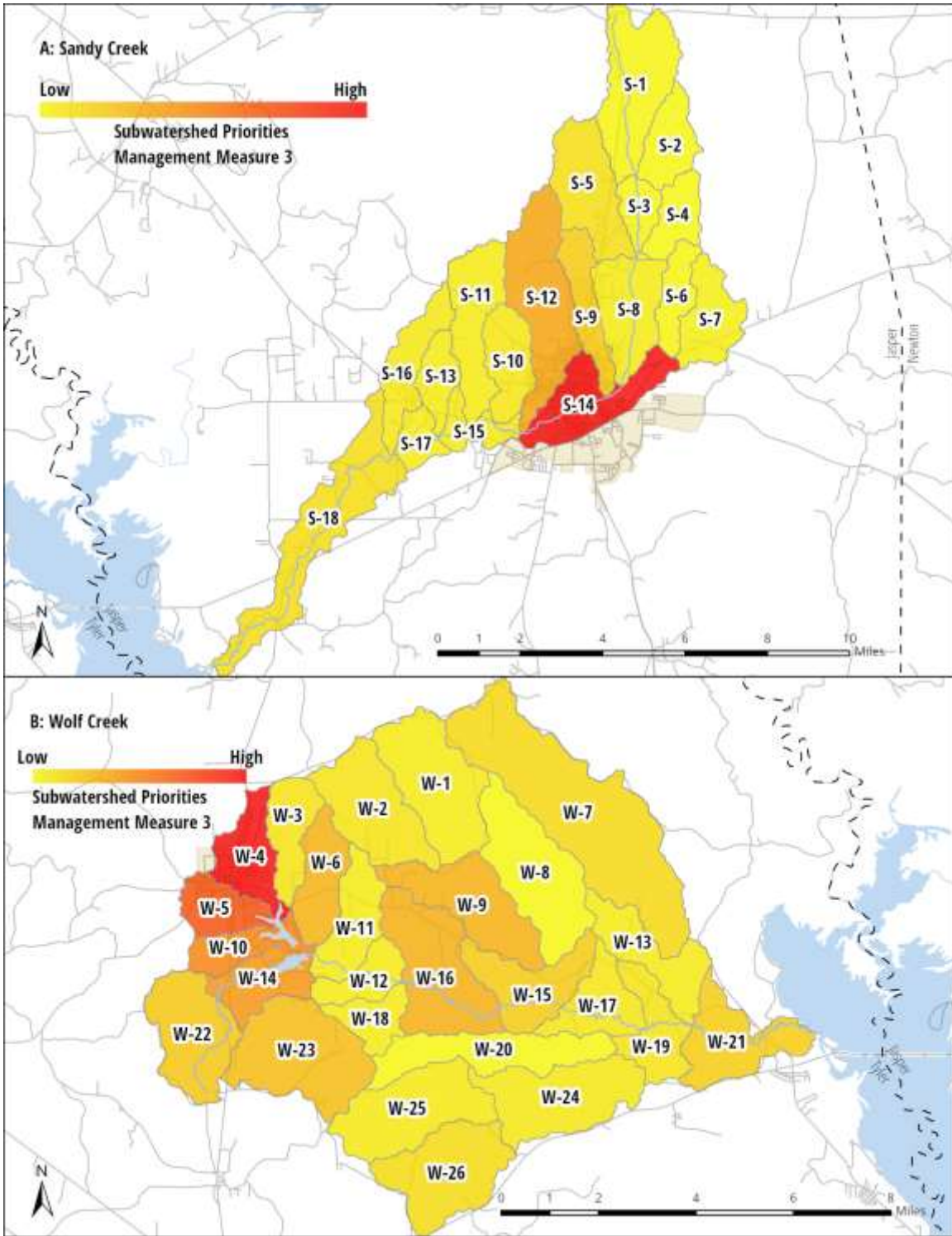


Figure 4. Subwatershed priorities based on *E. coli* loading potential from dogs across the Sandy Creek and Wolf Creek watersheds

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **Pet owners:** Pet owners will be encouraged to take part in educational programs and any other activity related to this measure. Buy-in and engagement by pet owners are paramount for the successful implementation of this measure.
- **City of Jasper:** The City of Jasper maintains local public spaces and will work with AgriLife Extension and LNVA to provide educational materials to pet owners.
- **AgriLife Extension:** AgriLife Extension will work with the City of Jasper, the Colmesneil neighborhoods, and other stakeholders to deliver relevant education programs or material pertinent to this measure.
- **LNVA:** LNVA will work with the City of Jasper, the Colmesneil neighborhoods, and other stakeholders to deliver relevant education programs or material pertinent to this measure.

### Technical Assistance

Minimal technical assistance is needed to develop education and outreach materials. Sample source materials are available from EPA and other sources. City and county staff may be needed, as appropriate, for installation and maintenance activities and enforcement of ordinances.

### Financial Assistance

The estimated costs for implementing pet BMPs (Table 9) are based on the installation of ten pet waste stations at \$3,500 each and providing outreach and education materials to watershed residents on pet waste and water quality for the duration of this plan. Annual maintenance costs will vary by usage and location and are not included in the financial estimate.

**Table 9. Estimated funding needed for implementing Management Measure 3**

Description	Item	Unit	Rate	Amount
Pet waste management outreach materials	NA	NA	NA	\$10,000
Pet waste stations and supplies	10	No.	\$3,500	\$35,000
Annual maintenance costs	NA	NA	NA	NA
			<b>Total</b>	<b>\$45,000</b>

Funding sources are detailed below.

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This EPA grant program, administered by TCEQ and TSSWCB, provides



funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to fund pet waste management programs.

- **Environmental Education Grants:** Under the Environmental Education Grants Program, EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program supplies financial support for projects that design, show, or teach environmental education practices, methods, or techniques as described in the Environmental Education Grant Program solicitation notices.
- **Urban Water Small Grants:** The objective of the Urban Waters Small Grants Program, administered by EPA, is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. The Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of local urban waterways.

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Number of extension, outreach, or education materials delivered.
- Number of pet waste stations installed.

## Monitoring Component

AgriLife Extension and LNVA will work with the City of Jasper, the Colmesneil neighborhoods, and local stakeholders to track this management measure.

## Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

### Years 1-5:

- Install and maintain at least 10 pet waste collection stations (eight in the Sandy Creek watershed and two in the Wolf Creek watershed).
- Develop and deliver education and outreach materials to pet owners.

## Estimated Load Reductions

The potential load reductions for this measure depend on how many dog owners will implement BMPs that eradicate or minimize the disposal of pet waste in

the environment. Load reduction was calculated based on the number of dogs, thus dog owners that will implement pet waste BMPs under this I-Plan. The American Veterinary Medical Association (AVMA) estimates there are 0.614 dogs and 0.457 cats per American household (AVMA, 2018). The number of domestic cats and dogs in the watersheds was estimated by applying the AVMA estimates to the number of households in the watersheds. The number of dogs were estimated to be 2,116 and 662, in the Sandy Creek and Wolf Creek watersheds, respectively.

Pet waste management measures will be most effective in public areas and places with higher concentrations of dogs. A proximity factor of 0.5 was included to account for the fact that the majority of these areas in the Sandy Creek and Wolf Creek watersheds are upland or further away from riparian areas.

The following equation was used to estimate the potential annual load reduction of *E. coli* (billion cfu/year) from pet waste:

$$Load_{pets} = Pets_{pop} \times Pets_{managed} \times FC_{pets} \times Conversion \times Median Efficacy \times Prox \times 365 \text{ days/year}$$

Where:

$Load_{pets}$  = Potential annual load reduction of *E. coli* attributed to pet waste

$Pets_{pop}$  = Pet population contributing to *E. coli* load reduction (40% of existing dog owners; 846 and 264 dogs in the Sandy Creek and Wolf Creek watersheds, respectively)

$Pets_{managed}$  = Percentage of pets from which waste is to be managed under a BMP per year

$FC_{pets}$  = Fecal coliform produced per dog per day; 5 billion cfu/day (USEPA, 2001)

$Conversion$  = Conversion rate of .63 from fecal coliform to *E. coli* (Wagner and Moench, 2009)

$Median Efficacy$  = BMP efficacy, assumed to be .75

$Prox$  = Proximity factor, assumed to be .5

Management Measure 3 does not recommend the removal of pets. Rather, Management Measure 3 is seeking to change pet owner actions that result in the proper disposal of pet waste through active pet waste collection and the installation of pet waste stations. The goal of the pet waste management measure is to reduce the number of pets currently contributing to *E. coli* loading by 50% in

five years by properly disposing the pet waste. Consequently, this I-Plan set a target of managing 10% of the pet population contributing to *E. coli* loading per year.

Based on these assumptions, for each additional dog whose waste is picked up by its owner, *E. coli* loading will be reduced by about 47,858 billion cfu/year. A program that seeks to change pet owner actions that result in the proper disposal of pet waste by 50% will lead to annual load reductions of 36,475 billion cfu/year from the Sandy Creek watershed and 11,382 billion cfu/year from the Wolf Creek watershed.

**Table 10. Management Measure 3: Develop and implement pet waste programs throughout the TMDL watersheds**

**Causes and Sources:** *E. coli* loading from pet waste not properly disposed of.

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
47,858 billion cfu/year of <i>E. coli</i> per pet	<p><b>Technical:</b> City and county staff may be needed, as appropriate, for installation and maintenance activities and enforcement of ordinances.</p> <p><b>Financial:</b> Costs incurred for installation of pet waste stations and maintenance estimated at \$3,500 per station.</p>	Providing education and outreach materials to pet owners about bacteria pollution and the several health risks posed by improperly disposed waste could lead to an increase in the number of residents that pick up and dispose of their pets' waste.	<p><b>Years 1-5:</b></p> <ul style="list-style-type: none"> <li>• Install and maintain at least a total of 10 pet waste collection stations (eight in Sandy Creek and two in Wolf Creek).</li> <li>• Develop and deliver education and outreach materials to pet owners annually.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of pet waste collection stations installed.</li> <li>• The number of pet waste management education materials developed and delivered.</li> </ul>	<ul style="list-style-type: none"> <li>• Pet waste collection stations installed.</li> <li>• Pet waste management and education materials delivered.</li> </ul>	<ul style="list-style-type: none"> <li>• AgriLife Extension and LNVA will work with local stakeholders to track education materials developed and provided.</li> </ul>	<ul style="list-style-type: none"> <li>• Pet owners</li> <li>• AgriLife Extension</li> <li>• LNVA</li> <li>• City of Jasper</li> </ul>

## Management Measure 4

### *Promote OSSF management.*

Failing private residential OSSFs, commonly referred to as septic systems, have been known to contribute to bacteria impairments in surface water. Several pathways of the liquid waste in OSSFs afford opportunities for bacteria to enter ground and surface waters if the OSSF is malfunctioning. Lack of routine maintenance, aging of OSSFs, improper use of OSSFs, and inappropriate designs are some of the reasons that lead OSSFs to fail. When properly designed and operated, OSSFs would be expected to contribute virtually no fecal bacteria to surface waters (Weiskel et. al 1996).

The exact number of failing systems is unknown, but studies estimate that approximately 19% of systems in the TMDL watersheds are expected to be in failing condition (Reed, Stowe, and Yanke, 2001). Of an estimated 1,433 OSSFs in the Sandy Creek watershed and 936 in the Wolf Creek watershed (Schramm & Jha, 2020), an estimated 450 malfunctioning OSSFs need to be managed. While some systems can be treated and repaired, some may need to be redesigned or replaced. However, homeowners must have the awareness and resources to address OSSF problems when they arise.

The goal of this management measure is to promote OSSF management in the TMDL watersheds by delivering OSSF operation and maintenance (O&M) workshops and repair or replace 25 OSSFs in the Sandy Creek watershed and 20 OSSFs in the Wolf Creek watershed to minimize potential water quality impacts.

### **Education Component**

Education and outreach for OSSFs will be targeted to both homeowners and local officials. Local officials can set up mechanisms that will mitigate pollution problems from OSSFs at community, county, watershed, and regional scales. Responsible parties will aim to deliver educational materials on proper OSSF O&M to homeowners.

AgriLife Extension currently hosts education programs for homeowners about proper O&M requirements as well as providing an overview of general OSSFs, collection and storage, pretreatment (and advanced pretreatment) components, disinfection, final treatment and dispersal, selection, and permitting. See information about this program on AgriLife Extension's webpage [On-Site Sewage Facilities](https://ossf.tamu.edu).<sup>1</sup> As funding allows, this program will be delivered throughout the TMDL watersheds to help meet the educational requirements of this plan. One program will be provided in Years 1, 3, and 5 in each watershed.

---

<sup>1</sup> <https://ossf.tamu.edu>

## **Priority Areas**

Both TMDL watersheds are predominately rural and as such, many residences use OSSFs. Loading potentials are highest in priority areas S-5, S-16, and S-18 for the Sandy Creek watershed and, generally in the upstream part of the Wolf Creek watershed (Figure 5).

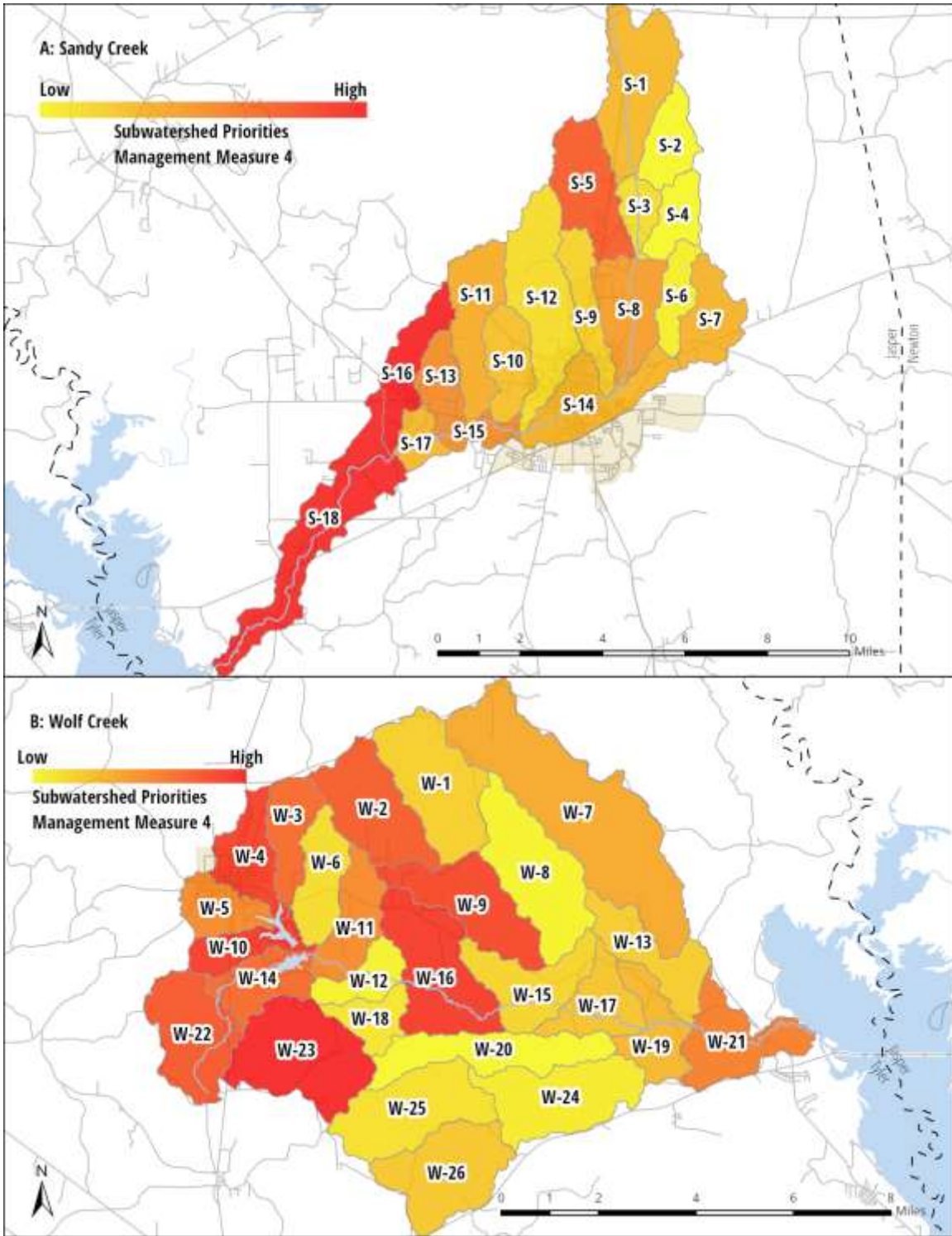


Figure 5. Subwatershed priorities based on *E. coli* loading potential from OSSFs in the Sandy Creek and Wolf Creek watersheds

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **OSSF owners:** OSSF owners will be responsible for coordinating repairs or replacements of malfunctioning OSSFs on their own property. Homeowners will be made aware of available resources or programs to assist with OSSF repair and replacement as funding becomes available.
- **AgriLife Extension:** AgriLife Extension will work with local stakeholders to develop the OSSF repair and replacement program and to provide OSSF O&M workshops.
- **County Staff or Designated Representatives:** TCEQ Region 10 is responsible for permitting OSSFs within Jasper County and Tyler County. Angelina and Neches River Authority (ANRA) is responsible for permitting OSSFs within 2,000 feet of Sam Rayburn Reservoir, which is in Jasper County. These entities will work with OSSF owners to permit new or replaced OSSFs.
- **LNVA:** LNVA can assist with coordination and delivery of AgriLife Extension based training programs.
- **ANRA:** ANRA is the Authorized Agent for regulating OSSFs in areas within 2,000 feet of Sam Rayburn Reservoir, which is just north of the TMDL watersheds. ANRA can assist with coordination and delivery of AgriLife Extension based training programs.

## Technical Assistance

The repair and replacement of OSSFs requires licensed personnel and permits through the appropriate offices. TCEQ Region 10 is responsible for OSSF permitting in Jasper County and Tyler County, except within 2,000 feet of Sam Rayburn Reservoir, which is in ANRA's permitting jurisdiction. Both TCEQ Region 10 and ANRA can direct homeowners towards appropriate technical experts as required. The design, construction, installation, and maintenance of new systems should be coordinated with local licensed service providers that can provide technical assistance to homeowners as needed.

AgriLife Extension offers educational opportunities through the Texas Well Owner Network, Installer and Maintenance Provider Workshops, and OSSF O&M workshops.

## Financial Assistance

The estimated cost for this management measure (Table 11) assumes that all of the malfunctioning OSSFs will be replaced, however, some may only need minor repairs. For proper identification and documentation of failing OSSFs and



follow-up after repairs or replacements, regional organizations are encouraged to hire a dedicated technician to oversee this process.

**Table 11. Estimated funding needed for implementing Management Measure 4**

Description	Item	Unit	Rate	Amount
Repair or replacement of OSSFs	45	No.	\$7,500	\$337,500
Employ technician to find and document failing OSSFs	5	Years	\$40,000	\$200,000
OSSFs O&M workshops	6	No.	\$1,000	\$6,000
			<b>Total:</b>	<b>\$543,000</b>

As resources are available, TCEQ’s Small Business and Local Government Assistance Program will provide technical support to local governments to find the best approach for addressing OSSF issues.

Funding sources are detailed below.

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This EPA grant program, administered by TCEQ and TSSWCB, provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to fund OSSF education, repairs, and replacements.
- **TCEQ Supplemental Environmental Projects:** The Supplemental Environmental Projects (SEP) program, administered by TCEQ, directs fines, fees, and penalties for 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. Program dollars may be directed to OSSF repair, trash dump clean up, and wildlife habitat restoration or improvement, among other things. Program dollars may be directed to entities for single, one-time projects that require special approval from TCEQ or directed entities (such as Resource Conservation and Development Councils) with pre-approved “umbrella” projects.

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Number of OSSF inspections made.
- Number of OSSFs repaired or replaced.
- Number of educational programs delivered.

## Monitoring Component

AgriLife Extension, LNVA, and ANRA will work with county staff and designated representatives to track the number of OSSFs repaired or replaced upon receipt of proposed project funding.

## Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

### Years 1-5:

- Secure funding and administer an OSSF repair or replacement program to address malfunctioning OSSFs found through inspections.
- Repair or replace approximately 45 OSSF systems within five years (contingent upon funding).
- Organize and deliver OSSF O&M workshops including any other related topics requested by local stakeholders in each watershed during Years 1, 3 and 5 of implementation.

## Estimated Load Reductions

The following equation was used to estimate annual bacteria load reductions from the repair and replacement of failing OSSFs:

$$Load_{ossf} = N_{ossf} \times N_{hh} \times Production \times FC_s \times Conversion \times 365 \text{ days/year}$$

Where:

$Load_{ossf}$  = Potential annual load reduction of *E. coli* attributed to OSSF repair/replacement (in units of billion cfu per year)

$N_{ossf}$  = Number of OSSFs repaired/replaced (25 in the Sandy Creek watershed and 20 in the Wolf Creek watershed)

$N_{hh}$  = Average number of people per household (2.67 for Jasper County and 2.66 for Tyler County, derived from U.S. Census Bureau Population and Household Data [2019a and 2019b])

$Production$  = Assumed sewage discharge rate; 264,979 mL per person per day (Horsley & Witten, 1996)

$FC_s$  = Fecal coliform concentration in sewage; 0.01 billion cfu/mL (USEPA, 2001)

$Conversion$  = Conversion rate of .63 from fecal coliform to *E. coli* (Wagner & Moench, 2009)

Based on the installation, repair, or replacement of 25 and 20 OSSFs in the Sandy Creek and Wolf Creek watersheds, respectively, the estimated total annual bacteria reduction from OSSF repair and replacement is about 40,672,057 billion cfu for Sandy Creek and 32,415,782 billion cfu in Wolf Creek.

**Table 12. Management Measure 3: Promote OSSF management**

**Causes and Sources:** *E. coli* loading from untreated or insufficiently treated household sewage discharged from malfunctioning OSSFs.

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p>40,672,057 billion cfu/year of <i>E. coli</i> in 0603A_01.</p> <p>and</p> <p>32,415,782 billion cfu/year of <i>E. coli</i> in 0603B_01.</p>	<p><b>Technical:</b> Resources and staff to identify and prioritize repair and replacement of failing OSSFs.</p> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>• Costs incurred for OSSF repair or replacement, estimated at \$7,500 per system.</li> <li>• Funds for hiring technical staff to undertake surveys and document status of OSSFs estimated at \$40,000 per year.</li> <li>• Workshop and training funds are estimated at \$1,000 per program.</li> </ul>	<p>Delivery of OSSF workshops for homeowners.</p>	<p><b>Years 1-5</b></p> <ul style="list-style-type: none"> <li>• Secure funding and administer an OSSF repair or replacement program to address malfunctioning OSSFs found through inspections.</li> <li>• Repair or replace approximately 45 OSSF systems within five years (contingent upon funding).</li> <li>• Organize and deliver six OSSF O&amp;M workshops (one in each watershed during Years 1, 3, and 5).</li> </ul>	<ul style="list-style-type: none"> <li>• Number of OSSF inspections made.</li> <li>• Number of OSSFs repaired or replaced.</li> <li>• Number of educational programs delivered.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of OSSF inspections made.</li> <li>• Number of education and outreach programs.</li> <li>• Number of failing OSSFs repaired or replaced.</li> </ul>	<ul style="list-style-type: none"> <li>• AgriLife Extension, LNVA, and ANRA will work with county staff and designated representatives to track number of OSSFs repaired or replaced upon receipt of proposed project funding.</li> </ul>	<ul style="list-style-type: none"> <li>• AgriLife Extension</li> <li>• County Staff or Designated Representatives</li> <li>• LNVA</li> <li>• ANRA</li> <li>• OSSF owners</li> </ul>

## Management Measure 5

### *Reduce sanitary sewer overflows and unauthorized discharges.*

Sanitary sewer overflows (SSOs) have the potential to occur in almost every sewer system. The causes of SSOs can vary from community to community but many avoidable SSOs are caused by inadequate O&M, inadequate system capacity, and/or improper system design and construction. The costs of rehabilitation and other measures to correct SSOs can vary widely by community size and sewer system type.

The SSO Initiative is a voluntary program that aims at addressing increases in SSOs due to aging collection systems throughout the state and encourages corrective action before there is harm to human health and safety or the environment. Municipalities choose to take part in the voluntary SSO Initiative Program by contacting TCEQ. Benefits of participation include (1) not being subject to formal enforcement by TCEQ for most continuing SSO violations, as long as the overflows are addressed by the SSO plan, and (2) participation allows the municipality to direct resources towards corrective actions rather than having to pay penalties associated with an enforcement order in addition to the corrective actions.

The goal of this management measure is to promote the continuing participation of the City of Jasper in TCEQ's SSO Initiative Program, thus minimizing the unauthorized discharge of untreated or partially treated wastewater and its impacts on receiving waters. The City of Jasper currently has an SSO initiative in place that stipulates activities that the City will implement in efforts to reduce the number of overflows that happen within its respective service area.

### **Education Component**

Public education involves informing developers and the public of how sewer overflows happen and what they can do to prevent them. The community can help prevent overflows by conserving water and flushing only appropriate items. Therefore, as part of this measure, responsible parties will deliver targeted education materials as resources allow.

### **Priority Areas**

Management Measure 5 prioritizes the City of Jasper's (priority area S-14) sewage service area. Figure 6 shows the estimated density of SSO events based on events report to TCEQ from 2005 to 2018.

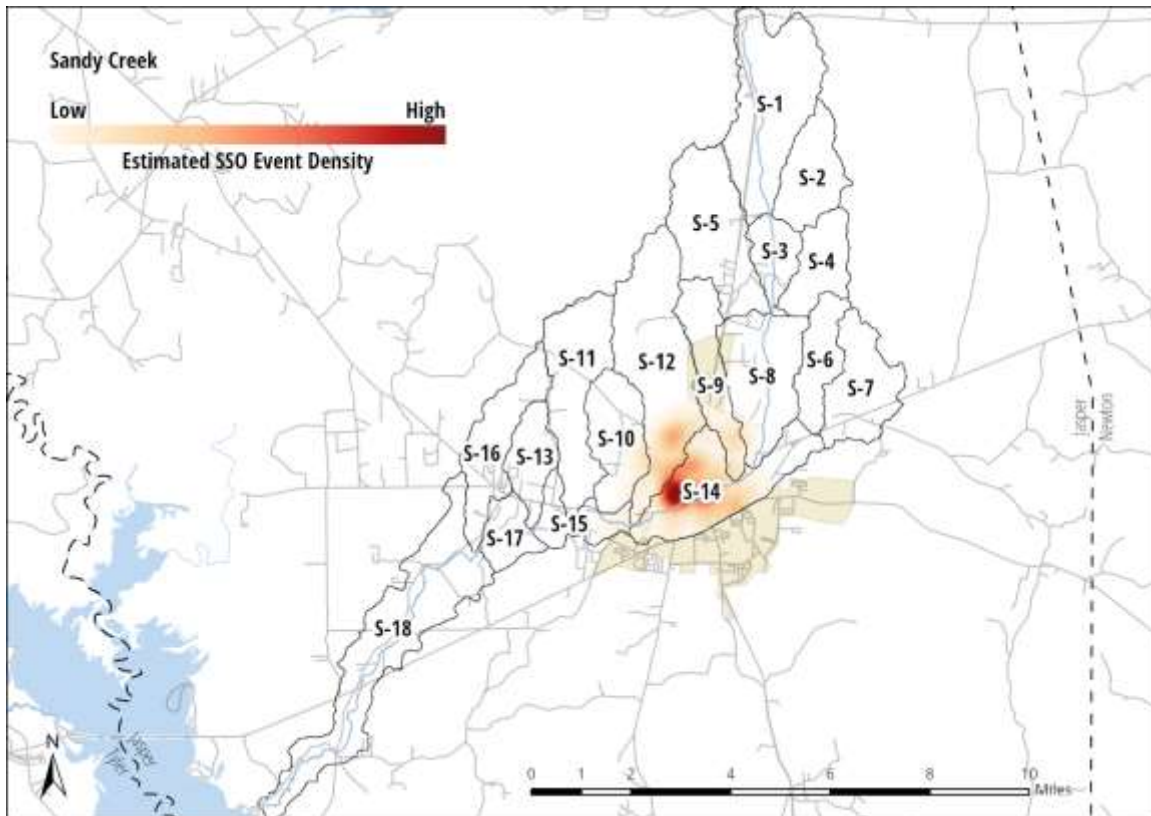


Figure 6. Estimated density of SSO events in the Sandy Creek watershed

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **City of Jasper:** Will continue taking part in the SSO Initiative, establishing funding for this initiative, and implementing SSO prevention overflow management strategies described in its SSO plan.
- **AgriLife Extension:** AgriLife Extension has worked with other small municipalities to develop and deliver stormwater and SSO education materials. AgriLife Extension will work with the City of Jasper as needed to provide educational materials for the general public related.

## Technical Assistance

TCEQ's Small Business and Local Government Assistance Program may provide technical support to find the best approach for addressing SSO issues, as resources are available.

## Financial Assistance

Expenses associated with this management measure are built into annual operating budgets (Table 13). Additional costs associated with educational material

development and delivery can be minimized by leveraging existing resources and projects in other watersheds that provide educational materials for residents. Participation in the initiative also allows the municipality to direct resources toward corrective actions, as opposed to having to pay penalties associated with an enforcement order in addition to the corrective actions.

**Table 13. Estimated funding needed for implementing Management Measure 5**

Description	Item	Unit	Rate	Amount
SSO Initiative participation	NA	NA	Varies based on local budgets	NA
Capital projects for sewer improvements	NA	NA	Varies based on local budgets	NA
Educational material development	NA	NA	\$10,000	\$10,000
<b>Total:</b>				<b>\$10,000</b>

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Approved SSO plan.
- Employee training on O&M.
- Community outreach events.

## Monitoring Component

The City of Jasper will continue to monitor and track the implementation of their SSO plan and the occurrence of SSOs to report to TCEQ as required.

## Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

### Years 1-5:

- Continue to implement the components of the City of Jasper’s SSO Initiative and track SSO events, repairs, and replacements.
- Deliver annual employee training on O&M and community outreach.

## Estimated Load Reductions

*E. coli* loading from overflow events will vary based on the discharge amount and the level of treatment of sewage. In total, wastewater facilities documented about 196 overflow events from 2005 to 2018 in the Sandy Creek watershed and only four in the Wolf Creek watershed.

The following equation was used to estimate bacteria load reductions from reductions in SSOs:

$$Load_{SSO} = Average Volume \times FC \times Conversion$$

Where:

$Load_{SSO}$  = Average potential *E. coli* load reduction per overflow incident (total cfu).

*Average Volume* = The average SSO volume (mL) for each watershed from 2005-2018 (4,989 gallons for Sandy Creek and 2,125 gallons for Wolf Creek) (Schramm & Jha, 2020). These values were multiplied by 3,785.41 mL/gallon to convert to mL.

$FC$  = Fecal coliform concentration in sewage; 0.01 billion cfu/mL (USEPA, 2001)

*Conversion* = Conversion rate of .63 from fecal coliform to *E. coli* (Wagner & Moench, 2009)

Since reductions in SSO events are uncertain, total annual reductions were not estimated. However, reductions per incident are estimated to be 118,978 billion cfu in the Sandy Creek watershed and 50,677 billion cfu in the Wolf Creek watershed.



**Table 14. Management Measure 5: Reduce SSOs and unauthorized discharges**

**Causes and Sources:** *E. coli* loading from SSO incidents.

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p>118,978 billion cfu of <i>E. coli</i> per SSO event avoided in 0603A_01.</p> <p>And</p> <p>50,677 billion cfu of <i>E. coli</i> per SSO event avoided in 0603B_01.</p>	<p><b>Technical:</b> TCEQ's Small Business and Local Government Assistance Program may provide technical support to find the best approach for addressing SSO issues, as resources are available.</p> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>• Financial support is currently set aside for these efforts through annually approved budgets by the City of Jasper.</li> <li>• Funds for educational development material estimated at \$10,000.</li> <li>• Extra funds for capital projects.</li> </ul>	<ul style="list-style-type: none"> <li>• Employee training</li> <li>• Public outreach</li> </ul>	<p>Years 1-5</p> <ul style="list-style-type: none"> <li>• The City of Jasper will continue to implement the components of its SSO initiative and track SSO events, repairs, and replacements.</li> <li>• Deliver employee training on O&amp;M and community outreach.</li> </ul>	<ul style="list-style-type: none"> <li>• Approved SSO plan.</li> <li>• Annual employee training on O&amp;M.</li> <li>• Annual community outreach.</li> </ul>	<ul style="list-style-type: none"> <li>• Reduction in number of SSO incidents</li> </ul>	<ul style="list-style-type: none"> <li>• Documentation of progress indicators achieved.</li> </ul>	<ul style="list-style-type: none"> <li>• City of Jasper</li> <li>• AgriLife Extension</li> <li>• TCEQ</li> </ul>

## Management Measure 6

### *Promote sustainable forest practices.*

In both the Sandy Creek and Wolf Creek watersheds, the predominant landcover is evergreen forests, which accounts for close to 50% of the total land area. Healthy forests are critical to supplying clean water. Forests support a multitude of functions, such as water flow regulation and soil erosion control, which have direct impacts on the quality of surface waters. By regulating flow and reducing the amount of sediment reaching the water body, forests can reduce bacteria loading into water bodies. Activities that remove or disturb forest vegetation or hydro-pollutant flow paths affect the quality of water bodies, including enhancing bacteria concentration. Therefore, forest operations such as harvesting, and road work can potentially degrade water quality if done improperly. Forestry BMPs are the principal means of protecting water resources during forestry activities.

The Texas A&M Forest Service (TFS) promotes several BMPs that can directly affect instream water quality, especially the establishment and maintenance of appropriately sized streamside management zones, stream crossings, and harvesting techniques. These practices target a wide range of stakeholders including loggers, landowners, and contractors. The goal of this management measure is to promote the implementation of forestry BMPs chosen by local stakeholders.

### Education Component

Because of the potential of forestry activities contributing to increased bacterial loading in the receiving water bodies, foresters, landowners with forestry interests, and other interested parties must be educated on the impact of forestry operations and the benefits of implementing BMPs on water quality.

### Priority Areas

Generally, priority areas will change based on the forestry operations ongoing. It is important, however, whether during harvesting, planting, or other forestry activities, that operators try to limit disturbances in streamside management zones. TFS guidelines stipulate that streamside management zones should be at least 50 feet wide on each side and above the head of perennial and intermittent streams, although streamside management zones can be wider depending on site conditions. More information on streamside management zones and how they can be demarcated, mapped, and protected in Texas is available on the [TFS website](https://tfsweb.tamu.edu).<sup>2</sup>

---

<sup>2</sup> <https://tfsweb.tamu.edu>

Management Measure 6 priority areas are based on water resource protection priority areas developed by TFS for the state's Forest Action Plan (TFS 2020a; TFS 2020b) (Figure 7). Loading potentials are high in almost all priority areas for both Sandy Creek and Wolf Creek watersheds, with the exception for the City of Jasper and its surrounding areas (priority area S-14) in the Sandy Creek watershed.

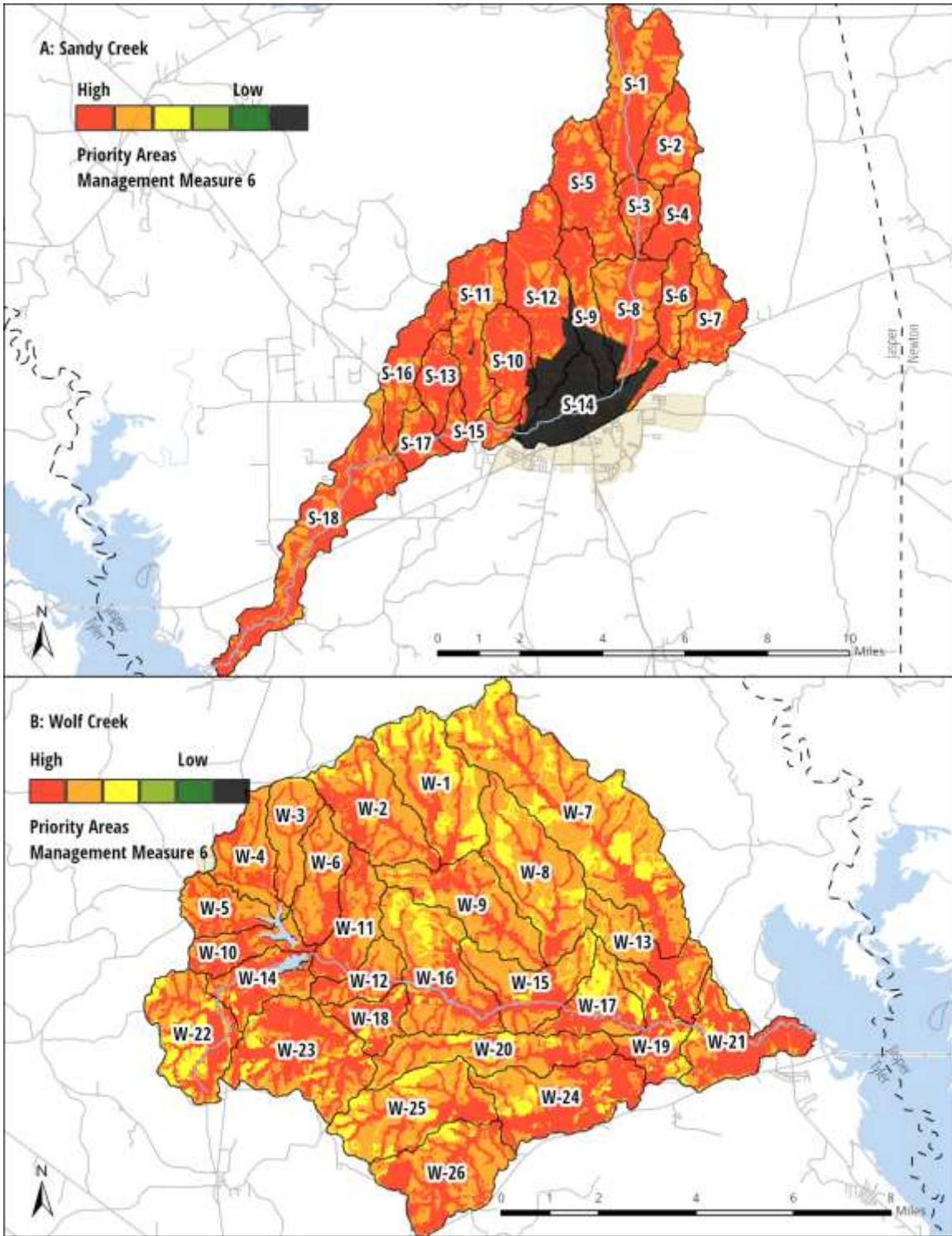


Figure 7. Subwatershed priorities for Management Measure 6 based on TFS Forest Action Plan water resources priority areas

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **TFS:** TFS will be responsible for providing technical assistance and helping landowners identify sources of financial assistance. TFS also tracks progress of local education and outreach efforts and BMP implementation. Landowners, loggers, and logging contractors will be responsible for voluntarily implementing these practices.
- **Landowners and managers:** Responsible for taking part in educational opportunities and applying what they learned to their lands.

### Technical Assistance

TFS, Texas Forestry Association, TSSWCB, and organizations such as the Texas Sustainability Forestry Initiative Committee administer training tailored to different stakeholders. TFS provides several resources for forest operational planning such as “Plan My Land Operation,” which is a free, publicly accessible, web-based forest operation planning tool. The application allows users to plan and layout a project based on the specific terrain, soil, and water resources found on an area of interest, locate and map their property, and identify and place custom buffers around sensitive areas, such as streams.

### Financial Assistance

When available, TFS will promote the availability of financial aid to forestry interests in the TMDL watersheds. Voluntary reforestation efforts are eligible for existing Farm Bill program funds. Financial assistance required per landowner will vary greatly depending on practices implemented and were not estimated (Table 15). The staff time for a full-time forester to provide education and outreach and track implementation is estimated at \$75,000 annually.

**Table 15. Estimated funding needed for implementing Management Measure 6**

Description	Item	Unit	Rate	Amount
Full-time regional forester	5	Years	\$75,000	\$375,000
BMP implementation	NA	NA	NA	NA
<b>Total:</b>				<b>\$375,000</b>

Funds may also be available through the following programs:

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This EPA grant program, administered by TCEQ and TSSWCB, provides funding for implementation of nonpoint source management measures. The

funds require a 40% match and may be used to support education programs, watershed implementation, and technicians.

- **CIG:** The USDA CIG is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to non-federal governmental or non-governmental organizations, tribes, or individuals.
- **CSP:** The CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Participants earn CSP payments for conservation performance — the higher the performance, the higher the payment.
- **EQIP:** EQIP is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. An additional purpose of EQIP is to help producers meet federal, state, tribal, and local environmental regulations.
- **RCPP:** The RCPP is a new, comprehensive, and flexible program that uses partnerships to stretch and multiply conservation investments and reach conservation goals on a regional or watershed scale. Through RCPP, the NRCS and state, local, and regional partners coordinate resources to help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved.

## Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Delivery of education and outreach programs to local stakeholders by TFS.
- Documentation of landowner and forestry personnel participation.
- Documentation of BMP implementation through survey feedback.

## Monitoring Component

TFS will play a leading role in tracking the implementation of BMPs.

## Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

### Years 1-5:

- Deliver education programs to landowners, loggers, and others or host outreach activities for them.
- Encourage landowners and forestry managers with no forestry management plans to develop such plans.
- Encourage landowners and forestry managers to voluntarily implement and maintain appropriate BMPs.

## Estimated Load Reductions

Although timber harvesting itself is not a direct source of *E. coli* loading and typically have only short-term impacts on post-harvest stream water quality, the altered hydrology from harvesting activities have been shown to be correlated with elevated fecal coliform loading after harvest (Ensign & Mallin 2001). It should be noted that despite widespread research on the impacts of forestry BMPs on sediment, nutrients, and fauna, little research has been conducted on the impacts of forestry BMPs on fecal indicator bacteria (Cristan, et al. 2016). However, it is generally established that the transport of fecal indicator bacteria, when correlated with stream discharge, is greatly influenced by suspended sediments (Yang, Lin & Falconer 2008), and, therefore, it is assumed that there is a correlative reduction in *E. coli* loads with reduced stream discharges and suspended sediment loads that are associated with implementing forestry BMPs.

Forestry BMP adoption rates are assumed to be high across East Texas, with an overall area weighted BMP adoption rate of 94% reported for non-industrial forestlands in East Texas (Thomas, Hazel & Work, 2018). Given high rates of BMP implementation, it is unlikely that additional load reductions will be seen from forestry BMPs relative to sources such as wildlife and livestock calculated earlier. However, BMP implementation will continue to be important to avoid additional *E. coli* loading to the watershed. Therefore, an estimate was calculated to approximate the avoided additional loads per year as a result from forestry BMP implementation from each TMDL watershed. Avoided loads associated with the application of forestry BMPs will vary based on numerous site-specific factors for which data is currently unavailable.

The following equation was used to estimate bacteria loads avoided from implementing forestry BMPS:

$$\text{Load} = (\text{Existing Median Load} \div \text{Watershed Acres}) \times \text{Annually Treated Area} \\ \times \text{Percent of forestland with BMPs} \times \text{Percent Increase without BMP implementation} \times 365 \text{ days/year}$$

Where:

*Load* = Average potential *E. coli* load avoided per day (total cfu).

*Existing Median Load* = The median daily *E. coli* load for the watershed (139.09 billion cfu/day in Sandy Creek and 167.02 billion cfu/day in Wolf Creek) (Schramm & Jha, 2020).

*Watershed Acres* = 36,184.36 acres in Sandy Creek and 53,207 acres in Wolf Creek.

*Annually Treated Area* = 502.3104 acres in Sandy Creek and 820.5186 acres in Wolf Creek.

*Percent of forestland with BMPs* = 94% (Thomas, Hazel & Work 2018)

*Percent Increase Without BMPs* = 108.92% (Sanders & McBroom 2012)

Avoided *E. coli* loading is uncertain considering the assumptions that are required to develop calculations. However, there is high certainty that forestry BMPs are widely adopted and beneficial to overall water quality. Based on current estimates of BMP adoption in East Texas and area of treated forests, *E. coli* loads avoided are estimated at 722 billion cfu and 963 billion cfu annually in the Sandy Creek and Wolf Creek watersheds, respectively.



**Table 16. Management Measure 6: Promote sustainable forest practices**

**Causes and Sources:** *E. coli* loading from runoff.

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p>722 billion cfu per year avoided based on current BMP estimates for 0603A_01.</p> <p>And</p> <p>963 billion cfu per year avoided based on current BMP estimates for 0603B_01.</p>	<p><b>Technical:</b></p> <ul style="list-style-type: none"> <li>• TFS will supply technical aid to landowners, foresters, loggers, logging contractors, and others, promoting sound forestry management practices that protect water quality.</li> <li>• Other entities including the Texas Forestry Association, TSSWCB, and the Texas Sustainability Forestry Initiative Committee all administer training tailored to different stakeholders.</li> </ul> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>• When they are available, TFS will inform forestry interests in the TMDL watersheds about financial assistance opportunities.</li> <li>• Voluntary reforestation efforts are eligible for existing Farm Bill program funds.</li> <li>• Funds for hiring a full-time regional forester estimated at \$75,000 per year.</li> </ul>	<ul style="list-style-type: none"> <li>• TFS will tailor training for foresters, landowners with forestry interests, and other interested parties about the impact of forestry operations and the benefits of implementing BMPs.</li> <li>• TFS will provide education and outreach opportunities to local stakeholders about the proper installation and maintenance of forestry BMPs.</li> </ul>	<p><b>Years 1-5:</b></p> <ul style="list-style-type: none"> <li>• TFS will deliver education programs to landowners, loggers, and others or host outreach activities for them.</li> <li>• TFS will encourage landowners and forestry managers with no forestry management plan to develop such plans.</li> <li>• TFS will encourage landowners and forestry managers to voluntarily implement and maintain chosen BMPs.</li> </ul>	<ul style="list-style-type: none"> <li>• Delivery of education and outreach programs to local stakeholders by TFS.</li> <li>• Documentation of landowner and forestry personnel participation.</li> <li>• Documentation of BMP implementation through survey feedback.</li> </ul>	<ul style="list-style-type: none"> <li>• Number and type of BMPs implemented in the TMDL watersheds.</li> <li>• Number of landowners and managers taking part in voluntary BMP adoption.</li> <li>• Number of education and outreach programs delivered in or near the TMDL watersheds.</li> </ul>	<ul style="list-style-type: none"> <li>• TFS will track BMP implementation and education and outreach events.</li> </ul>	<ul style="list-style-type: none"> <li>• TFS</li> <li>• Landowners</li> <li>• Forest managers</li> </ul>

## Management Measure 7

### *Promote volunteer water quality monitoring.*

To encourage environmental stewardship by empowering a statewide network of concerned volunteers, partners, and institutions, the Texas Stream Team (TST) program trains volunteers to monitor water and environmental quality across Texas. Along with training, the program offers a wide variety of engagement programs focused on taking volunteer monitoring to the next step through community involvement, awareness, and additional data collection.

The goal of this management measure is to promote water quality monitoring activities for volunteers. Stakeholders can use the collected data to evaluate water quality changes due to the implementation of the measures in this I-Plan. Data collected by volunteers are quality assured and the TST program maintains a database of the collected information.

### Education Component

Under the TST program, volunteers participate in educational workshops, outreach events, and receive educational resources. Activities include educating the public on citizen science, water quality, environmental stewardship, water quality sampling, and more.

### Priority Areas

Volunteers will be recruited from either or both watersheds. Recruitment of environmental stewards, schools, and other organizations near the creeks will be prioritized.

### Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **Local Stakeholders:** Local stakeholders will be encouraged to enroll and participate in the TST program. Before beginning voluntary data collection activities, volunteers will participate in the appropriate training provided by the Meadows Center for Water and the Environment or the local TST partner.
- **Meadows Center for Water and the Environment:** The Meadows Center oversees the TST volunteer monitoring program and is responsible for providing supplies, trainings, and data management services associated with the program.
- **LNVA:** LNVA supports a dedicated group of volunteer monitors in the basin. As a TST partner, LNVA supplies water quality testing kits, supplies, and reagents to trained volunteers.

- **ANRA:** ANRA offers support to volunteer environmental monitoring in the basin. ANRA provides TST monitoring kits, training, and replacement supplies and reagents to trained volunteers.

**Technical Assistance**

LNVA, ANRA, and the Meadows Center can train volunteers and implement “train the trainers” programs to help start and support a local chapter of citizen scientists. The Meadows Center also provides data storage and quality assurance services.

**Financial Assistance**

The water quality monitoring kits used by TST are about \$580 each (Table 17). The number of kits bought will depend on the number of local volunteers who take part in the TST program. Costs associated with personnel and travel will vary based on the party that conducts the monitoring within the TMDL watersheds.

**Table 17. Estimated funding needed for implementing Management Measure 7**

Description	Item	Unit	Rate	Amount
Water quality kits	10	Number	\$580	\$5,800
Personnel and travel	NA	NA	NA	NA
<b>Total:</b>				<b>\$5,800</b>

Possible sources of funds include the following:

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This EPA grant program, administered by TCEQ and TSSWCB, provides funding for the implementation of nonpoint source management measures. The funds require a 40% match and may be used to support volunteer water quality monitoring.
- **Local Funds:** Local funds include funds or eligible in-kind resources provided by local entities, such as county and municipal governments, local agencies, river authorities, non-governmental organizations, volunteer groups, or individuals.

While financial resources are typically considered, volunteer or staff time may be eligible to meet cost-share requirements for many state and federal cost-sharing grant programs.

**Measurable Milestones**

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.

- Number of water quality sampling events.
- Number of water quality training events for volunteers.
- Number of volunteers enrolled as citizen scientists.

### **Monitoring Component**

TST coordinates a network of citizen scientists who conduct water quality monitoring at assigned sites on their local water bodies. Citizen scientists may identify water quality issues, possible nonpoint pollution sources, monitor water quality, or collect and analyze data. Information collected by citizen scientists is submitted to a database containing data from sites across the state that is maintained by The Meadows Center for Water and the Environment.

Like other citizen scientists, volunteers from the two TMDL watersheds, working with the LNVA steering committee, will track the number of sampling events held, number of trainings organized, and number of volunteers enrolled in addition to undertaking water quality monitoring.

### **Implementation Schedule**

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

#### **Years 1-5:**

- Recruit local environmental stewards or citizen scientists.
- Provide one annual volunteer water quality training event.
- Secure funding for buying water quality monitoring kits.

### **Estimated Load Reductions**

No load reduction was calculated for the measure.

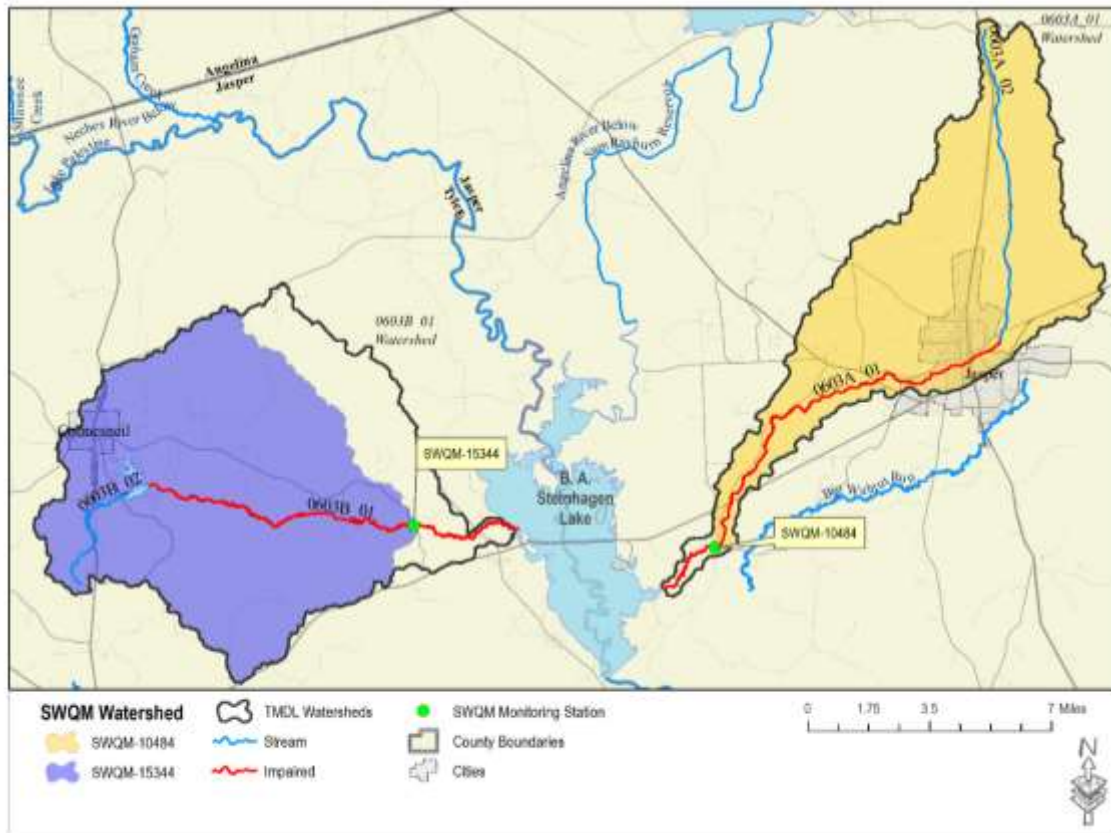
**Table 18. Management Measure 7: Promote volunteer water quality monitoring**

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<p><i>Not estimated</i></p>	<p><b>Technical:</b></p> <ul style="list-style-type: none"> <li>• Training opportunities are provided by LNVA, ANRA, and the Meadows Center.</li> <li>• The Meadows Center supplies data storage and quality assurance services.</li> </ul> <p><b>Financial:</b></p> <ul style="list-style-type: none"> <li>• Procurement of water quality monitoring kits. The retail price is about \$580 each (in 2020). The number to be bought will depend on the number of volunteers who take part in the TST program.</li> <li>• Training or workshop costs.</li> </ul>	<ul style="list-style-type: none"> <li>• Volunteers will participate in educational workshops and outreach activities about citizen science, water quality, environmental stewardship, water quality sampling, and more.</li> </ul>	<p><b>Years 1-5:</b></p> <ul style="list-style-type: none"> <li>• Recruit local environmental stewards or citizen scientists.</li> <li>• Provide one annual volunteer training event.</li> <li>• Secure funding for buying water quality monitoring kits.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of water quality sampling events.</li> <li>• Number of water quality monitoring training events for volunteers.</li> <li>• Number of volunteers enrolled as citizen scientists.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of training events held.</li> <li>• Number of citizen scientists enrolled in the TST program.</li> <li>• Number of water quality monitoring events undertaken.</li> </ul>	<ul style="list-style-type: none"> <li>• Volunteers will participate in educational workshops and outreach activities about citizen science, water quality, environmental stewardship, water quality sampling, and more.</li> </ul>	<ul style="list-style-type: none"> <li>• Volunteers</li> <li>• LNVA</li> <li>• ANRA</li> <li>• Meadows Center</li> </ul>

## Management Measure 8

### *Implement Water Quality Monitoring.*

Water quality monitoring has historically been collected at a single downstream surface water quality monitoring (SWQM) station on each of the TMDL segments (Figure 8). The water quality of the upstream AUs (AU 0603A\_02 and AU 0603B\_02) of segments 0603A and 0603B are not routinely monitored. Some stakeholders highlighted the need to monitor the quality of waters flowing into the downstream TMDL AUs, since these flows have a direct bearing on the water quality of the AUs considered in this I-Plan. Also, to track the progress and effectiveness of management measures proposed in this plan, routine monitoring on the existing TCEQ stations should be maintained. Monitoring efforts could also include bacteria source tracking analysis to find the sources of *E. coli* in the water bodies so that future management measures can be tailored to the main source of contamination.



**Figure 8. Existing TCEQ SWQM stations on Segments 0603A and 0603B**

Through the Texas Clean Rivers Program (CRP), TCEQ partners with regional water authorities to coordinate and conduct water quality monitoring, assessment, and stakeholder participation across the state. LNVA is the CRP partner for the

Lower Neches River, which is a subwatershed of the larger Neches River Basin, including the TMDL watersheds of Sandy Creek and Wolf Creek. LNVA provides public participation on water quality issues through its Basin Steering Committee, which includes stakeholders who represent local industry and municipalities, state and federal agencies, tribal groups, environmental groups, and residents. Stakeholders in both TMDL watersheds are encouraged to take part at Basin Steering Committee meetings and highlight any local concerns, including additional monitoring needs.

The goal of this management measure is to continue routine monitoring at the existing SWQM stations, engage TCEQ and LNVA to routinely monitor the upstream AUs (AU 0603A\_02 and AU 0603B\_02) of segments 0603A and 0603B and to perform a bacteria source tracking study.

## Education Component

LNVA's website provides an overview of the CRP statewide water quality program and includes basin reports, quality assurance documents, and links to other websites such as the TCEQ Surface Water Quality Data Viewer and Statewide Coordinated Monitoring Schedule (CMS). LNVA also holds an annual Steering Committee meeting in coordination with CRP to share updates on water quality monitoring and relevant watershed issues that includes information on the Sandy Creek and Wolf Creek watersheds, among others. Updates on I-Plan progress can be presented during this annual meeting. Local stakeholders are encouraged to engage with LNVA to publish information like water quality analysis reports and other resources specific to the TMDL watersheds on LNVA's website. LNVA carries out educational and informational events in areas under its jurisdiction. Stakeholders are encouraged to coordinate with LNVA to participate in such training.

## Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available.

- **Local Stakeholders:** Local stakeholders aid in determining and refining data and data quality objectives for future monitoring programs.
- **LNVA:** LNVA is the CRP partner in this area. LNVA conducts routine monitoring on segments 0603A and 0603B.

## Technical Assistance

LNVA and TCEQ oversee several water quality projects. These organizations have considerable expertise to design and carry out monitoring programs. LNVA and TCEQ should continue providing monitoring services as funding allows. CRP

can also supply further technical assistance in determining monitoring frequency and locations.

### Financial Assistance

Costs associated with water quality monitoring can vary based on the suite of parameters monitored, personnel costs, vehicle and mileage costs, and lab costs. TWRI and LNVA estimate approximately \$2,500 for lab analysis and supply costs per station per year for full routine water quality monitoring (Table 19). Costs associated with personnel and travel will vary substantially based on the party that conducts the monitoring.

**Table 19. Estimated funding needed for implementing Management Measure 8**

Description	Item	Unit	Rate	Amount
Lab analysis and supply costs for four stations per year	5	Year	\$10,000	\$50,000
Personnel and travel	NA	NA	NA	NA
<b>Total:</b>				<b>\$50,000</b>

Possible sources of funds are detailed below:

- Texas CRP:** The Texas CRP is a state fee-funded, non-regulatory program. CRP funds can be used for routine monitoring as well as special projects. Responsible parties and local stakeholders can request water quality monitoring through the Texas CRP during the development of the coordinated monitoring schedule.
- Clean Water Act Section 319(h) Nonpoint Source Grant Program:** This U.S. Environmental Protection Agency (EPA) grant program, administered by TCEQ and TSSWCB, provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to support education programs, watershed implementation, and technicians.
- Local Funds:** Local funds include funds or eligible in-kind resources provided by local entities, such as county and municipal governments, local agencies, non-governmental organizations, volunteer groups, or individuals. While financial resources are typically considered, volunteer or staff time can be leveraged as eligible cost-share for many state and federal grant programs that require some type of cost-share.

### Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are as follows.



- Updating CMS for the Lower Neches River watershed.
- Conducting water quality monitoring in each of the TMDL watersheds according to the TCEQ-approved CRP quality assurance protection plan (QAPP).
- Submitting routine water quality data to the TCEQ Surface Water Quality Monitoring Information System (SWQMIS).
- Developing additional water quality monitoring sites, projects, and funding sources as needed.

### **Monitoring Component**

LNVA will report water quality monitoring and water quality analyses in the annual Basins Highlights Report delivered as part of the CRP program.

Water quality monitoring will continue at existing TCEQ SWQM stations. Additional monitoring projects may be developed under this management measure as needed.

### **Implementation Schedule**

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

#### **Years 1-5:**

- Conduct water quality monitoring and submit data according to the TCEQ-approved CRP QAPP.
- Develop QAPPs for additional projects as needed.
- Provide water quality monitoring and I-Plan implementation updates at annual CRP Steering Committee meetings.

### **Estimated Load Reductions**

No load reduction was calculated for this measure.

**Table 20. Management Measure 8: Implement water quality monitoring**

Potential Load Reduction	Technical and Financial Assistance	Education Component	Schedule of Implementation	Interim, Measurable Milestones	Indicators of Progress	Monitoring Component	Responsible Parties
<i>Not estimated</i>	<p><b>Technical:</b> LNVA and TCEQ provide technical expertise associated with monitoring and data management activities for coordinated water quality monitoring.</p> <p><b>Financial:</b> Local and state funds can be used for water quality monitoring activities. Costs per site are about \$2,500 annually.</p>	LNVA will hold annual stakeholder meetings in conjunction with CRP Basin Steering Committee meetings.	<p><b>Years 1-5:</b></p> <ul style="list-style-type: none"> <li>• Conduct water quality monitoring and submit data according to established QAPPs.</li> <li>• Develop QAPPs for additional projects as needed.</li> <li>• Water quality and I-Plan updates will be reported at annual CRP Steering Committee meetings.</li> </ul>	<ul style="list-style-type: none"> <li>• Updated CMS.</li> <li>• Water quality monitoring programs implemented.</li> <li>• Routine data submitted and published in the SWQMIS.</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement in water quality.</li> </ul>	<ul style="list-style-type: none"> <li>• Monitoring will continue at existing TCEQ SWQM stations.</li> <li>• Additional monitoring projects may be developed under this management measure as needed.</li> </ul>	<ul style="list-style-type: none"> <li>• LNVA</li> <li>• Local stakeholders</li> </ul>

## Sustainability

TCEQ, responsible parties, and other stakeholders in TMDL implementation projects periodically assess the results of the planned activities, along with other information, to evaluate the effectiveness of the I-Plan. Responsible parties and other stakeholders evaluate several factors, such as the pace of implementation, the effectiveness of BMPs, load reductions, and progress toward meeting water quality standards.

The responsible parties and other stakeholders will track progress using both implementation milestones and water quality indicators. These terms are defined as:

- **Water Quality Indicator** – A measure of water quality conditions for comparison to pre-existing conditions, constituent loadings, and water quality standards.
- **Implementation Milestone** – A measure of administrative actions undertaken to affect an improvement in water quality.

## Water Quality Indicators

Water quality monitoring staff from LNVA and TCEQ will continue to monitor the status of water quality during implementation as funding and resources allow. Additional funding will be sought to conduct supplemental monitoring in the TMDL watersheds. The indicator that will be used to measure improvement in water quality is *E. coli*.

## Implementation Milestones

Implementation tracking provides information that can be used to determine if progress is being made toward meeting the goals of the TMDL. Tracking also allows stakeholders to evaluate actions taken, identify those that may not be working, and make any changes that may be necessary to get the plan back on target.

## Communication Strategy

TCEQ will work with responsible parties and other stakeholders to hold meetings or obtain annual I-Plan updates for up to five years so stakeholders may evaluate their progress. Responsible parties and stakeholders will continue to provide annual updates and/or take part in any meetings over the five-year period to evaluate implementation efforts. At the completion of the scheduled I-Plan activities, stakeholders will assemble and evaluate the actions, overall impacts, and results of their implementation efforts.

## References

- AgriLife Extension 2012. Feral Hog Population Growth, Density and Harvest in Texas. SP-472. College Station. [wildpigs.nri.tamu.edu/media/1155/sp-472-feral-hog-population-growth-density-and-harvest-in-texas-edited.pdf](http://wildpigs.nri.tamu.edu/media/1155/sp-472-feral-hog-population-growth-density-and-harvest-in-texas-edited.pdf).
- AVMA [American Veterinary Medical Association] 2018. In: AVMA Pet Ownership and Demographic Sourcebook (2017-2018). [www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx](http://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx)
- Cristan, R., Aust, M., Bolding, M., Barrett, S., Munsell, J., and Schilling, E. 2016. Effectiveness of forestry best management practices in the United States: Literature review. *Forest Ecology and Management*. 360: 133-151. [doi.org/10.1016/j.foreco.2015.10.025](https://doi.org/10.1016/j.foreco.2015.10.025).
- Ensign, S. and Mallin, M. 2001. Stream water quality changes following timber harvest in a coastal plain swamp forest. *Water Research*. 35:14, 3381-3390. [doi.org/10.1016/S0043-1354\(01\)00060-4](https://doi.org/10.1016/S0043-1354(01)00060-4).
- Escamilla, C., Shen, X., Schramm, M., Gregory, L. 2019. Mid and Lower Cibolo Creek Watershed Protection Plan. Texas Water Resources Institute. TR-512. [twri.tamu.edu/publications/technical-reports/2019-technical-reports/tr-512/](http://twri.tamu.edu/publications/technical-reports/2019-technical-reports/tr-512/)
- Horsley and Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, New Brunswick and Freeport, Maine. Barnstable, MA: Horsley and Witten, Inc. Environmental Services. Final Report. Submitted to Casco Bay Estuary Project, Portland, ME. [www.cascobayestuary.org/wp-content/uploads/2014/07/1996\\_nutrient\\_loading\\_maquiot\\_bay.pdf](http://www.cascobayestuary.org/wp-content/uploads/2014/07/1996_nutrient_loading_maquiot_bay.pdf)
- Reed, Stowe, and Yanke, LLC. 2001. Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. [www.tceq.texas.gov/assets/public/compliance/compliance\\_support/regulatory/ossf/StudyToDetermine.pdf](http://www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf).
- Sanders, L., McBroom, M. 2013. Stream water quality and quantity effects from select timber harvesting of a streamside management zone. *Southern Journal of Applied Forestry*. 37:1, 45-52. [doi.org/10.5849/sjaf.11-015](https://doi.org/10.5849/sjaf.11-015).
- Schramm, M and Jha, A. 2020. Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in Sandy Creek and Wolf Creek. Texas Water Resources Institute for the Texas Commission on Environmental Quality. [www.tceq.texas.gov/downloads/water-quality/tmdl/sandy-wolf-creeks-recreational-118/118-sandy-wolf-tsd-2020-june.pdf](http://www.tceq.texas.gov/downloads/water-quality/tmdl/sandy-wolf-creeks-recreational-118/118-sandy-wolf-tsd-2020-june.pdf).
- TCEQ 2020. 2020 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d). [www.tceq.texas.gov/waterquality/assessment/20twqi/20txir](http://www.tceq.texas.gov/waterquality/assessment/20twqi/20txir).
- TFS 2020a. Draft Forest Action Plan. Texas A&M Forest Service. College Station, TX. [texasforestinfo.tamu.edu/ForestActionPlan/docs/Texas%20Forest%20Action%20Plan--for%20USFS%20Review--14Oct2020.pdf](http://texasforestinfo.tamu.edu/ForestActionPlan/docs/Texas%20Forest%20Action%20Plan--for%20USFS%20Review--14Oct2020.pdf)

- TFS 2020b. State Assessment – Forest Action Plan (GIS Data). [tfs.tamu.edu/arcgis/rest/services/Forest\\_Action/State\\_assessment\\_FAP/MapServer](https://tfs.tamu.edu/arcgis/rest/services/Forest_Action/State_assessment_FAP/MapServer).
- Thomas, T., Hazel, L., and Work, D. 2018. Voluntary Implementation of Forestry Best Management Practices in East Texas. Texas A&M Forest Service for the Texas State Soil and Water Conservation Board. [tfsweb.tamu.edu/BMPMonitoring/](https://tfsweb.tamu.edu/BMPMonitoring/).
- USCB [United States Census Bureau] 2019a. Population Estimates, July 1, 2019 (V2019) – Jasper County, TX. Quick Facts. <https://www.census.gov/quickfacts/jaspercountytexas>.
- USCB 2019b. Population Estimates, July 1, 2019 (V2019) – Tyler County, TX. Quick Facts. <https://www.census.gov/quickfacts/tylercountytexas>
- USEPA [United States Environmental Protection Agency] 2001. Protocol for Developing Pathogen TMDLs. EPA-841-R-00-002. [www.epa.gov/tmdl/tmdl-support-documents](http://www.epa.gov/tmdl/tmdl-support-documents)
- Wagner, K., and Moench, E. 2009. Education Program for Improved Water Quality in Copano Bay Task Two Report. Texas Water Resources Institute. [oaktrust.library.tamu.edu/handle/1969.1/93181](http://oaktrust.library.tamu.edu/handle/1969.1/93181)
- Wagner, K., Redmon, L., Gentry, T., and Clary C. 2013. Evaluation and Demonstration of BMPs for Cattle on Grazing Lands for the Lone Star Healthy Streams Program. Texas Water Resources Institute. <http://oaktrust.library.tamu.edu/handle/1969.1/149192>
- Weiskel, P.K., B.L. Howes, and G.R. Heufelder. 1996. Coliform Contamination of Coastal Embayment: Sources and Transport Pathways. *Environmental Science and Technology*, 30, 1872-1881.
- Yang, L., Lin, B., and Falconer, R. 2008. Modelling enteric bacteria level in coastal and estuarine waters. *Proceedings of the Institution of Civil Engineers - Engineering and Computational Mechanics*. 161:4, 179-186. [doi.org/10.1680/eacm.2008.161.4.179](https://doi.org/10.1680/eacm.2008.161.4.179).