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Revised Implementation Plan
for One Total Maximum Daily
Load
for Bacteria in Guadalupe River
Above Canyon Lake
Segment 1806

Prepared by the Upper Guadalupe River Authority and the Bacteria Reduction Plan
Stakeholder Committee

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by the Upper Guadalupe River Authority and the Bacteria Reduction Plan Stakeholder Committee.

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Acronyms and Abbreviations

AU	assessment unit
BMP	best management practice
BST	bacterial source tracking
cfu	colony-forming units
<i>E. coli</i>	Escherichia coli
EPA	U.S. Environmental Protection Agency
ft	feet
I-Plan	implementation plan
KCAD	Kerr Central Appraisal District
KCEHD	Kerr County Environmental Health Department
mL	milliliter
OSSF	on-site sewage facility
QAPP	quality assurance project plan
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TxDOT	Texas Department of Transportation
UGRA	Upper Guadalupe River Authority
WWTF	wastewater treatment facility



Implementation Plan for One TMDL for Bacteria in Guadalupe River Above Canyon Lake

Executive Summary

One Total Maximum Daily Load (TMDL) for Bacteria in Guadalupe River Above Canyon Lake (Segment 1806) was adopted by the Texas Commission on Environmental Quality (TCEQ) on July 25, 2007 and approved by the U.S. Environmental Protection Agency (EPA) on September 25, 2007. The TMDL addressed bacteria in two assessment units (AUs) within the City of Kerrville (AUs 1806_04 and 1806_06 based on the 2008 Texas Integrated Report of Surface Water Quality). The AUs are from the confluence of Camp Meeting Creek to one mile upstream of Flat Rock Dam inclusive of Kerrville-Schreiner Park and from Francisco Lemos Street inclusive of Louise Hays Park to one mile downstream. Primarily, the TMDL established the maximum amount of bacteria the waterway could accept and still meet the state's standards.

The second part of the TMDL process is an Implementation Plan (I-Plan) which describes the strategy and activities the TCEQ and watershed partners will carry out to improve water quality in the affected watershed. The Implementation Plan for One TMDL for Bacteria in Guadalupe River Above Canyon Lake was approved by TCEQ in 2011. The I-Plan focused on the impaired AUs of the Guadalupe River Above Canyon Lake identified in the TMDL and the main tributaries of these AUs.

The I-Plan was implemented by the TCEQ and the Upper Guadalupe River Authority (UGRA) in partnership with the City of Kerrville, Kerr County, and the Texas Department of Transportation. To address the bacteria impairment, the I-Plan includes waste deterrent best management practices (BMPs), infrastructure improvements, and education and outreach in the watershed. As a result of the collaborative effort of individuals and organizations, the water quality in the river has improved and the previously impaired AUs of Segment 1806 are no longer on the state's list of impaired waters as of the 2012 and 2014 Texas Integrated Report of Surface Water Quality. Additionally, the improvements to water quality in the Upper Guadalupe River were highlighted by the EPA as a success story in 2016 (EPA 2016).

The goal of this revised I-Plan is the continued reduction of bacteria concentrations in the Upper Guadalupe River to continue to meet the contact recreation criterion defined in the Texas Surface Water Quality Standards. The stakeholders in the watershed implement the I-Plan through voluntary management measures and/or mandatory, regulatory control actions. This plan documents the stakeholder-developed management measures and control actions that are being employed to mitigate bacteria contributions. The management measures and control actions are being implemented by the stakeholders under an adaptive management approach that assesses the efficiency and effectiveness of the actions and allows for changing conditions.

Included in this revised I-Plan is a summary of the TMDL, details of the plan's implementation and progress, and a summary of the implementation strategy for each of the management measures and the one control action.

Introduction

Section 303(d) of the Federal Clean Water Act and EPA regulation 40 CFR 130.7 require states to identify waterbodies that do not meet or are not expected to meet applicable water quality standards. The compilation of subject waterbodies is known as the 303(d) list. Each state must assign priorities to waterbodies on the list, in order to schedule development of TMDLs. The TMDL is an allocation of point and nonpoint source pollutant loadings that will enable the waterbody to meet water quality standards.

The TCEQ is responsible for the assessment of water quality data to evaluate compliance with State water quality standards. The assessment results are included in the Texas Integrated Report of Surface Water Quality every two years. Pursuant to the Clean Water Act, one of the areas of TCEQ responsibility is the development of the 303(d) list for Texas and subsequent development of TMDLs. The Guadalupe River above Canyon Lake, Segment 1806, was first included on the Texas 303(d) List in 2002. This segment was listed for elevated levels of bacterial indicators, resulting in nonsupport of contact recreation use. According to the 2018 Texas Surface Water Quality Standards, the freshwater indicator bacteria for recreation is *Escherichia coli* (*E. coli*). The geometric mean criterion for *E. coli* is 126/100 milliliters (mL). In addition, the single sample criterion for *E. coli* is 399/100 mL.

The TCEQ, with assistance from James Miertschin & Associates, Inc, completed a TMDL study of the Upper Guadalupe River in 2006. The TMDL assessed the magnitude of existing in-stream bacteria loads and quantified the loading reductions required to achieve compliance with the water quality standards for contact recreation (TCEQ 2007).

The TMDL was officially adopted by TCEQ in July 2007, entitled "One Total Maximum Daily Load for Bacteria in the Guadalupe River above Canyon Lake" (TCEQ 2007).

As the lead water resource planning agency in Kerr County, the UGRA worked with TCEQ to develop the "Implementation Plan for One Total Maximum Daily Load for Bacteria in the Guadalupe River above Canyon Lake" to address the load reduction prescribed in the TMDL. UGRA received funding from TCEQ through the CWA 319(h) program to develop the I-Plan and it was finalized in 2011 (TCEQ 2011).

UGRA received funding from TCEQ through the CWA 319(h) program from FY12-FY14 to implement the activities described in the I-Plan. The implementation project was called the "Bacteria Reduction Plan for the Upper Guadalupe River" and was supported with matching funds from the UGRA, City of Kerrville, Kerr County, and the Texas Department of Transportation. The projects included in the "Bacteria Reduction Plan" were designed to implement BMPs and demonstrate their effectiveness (UGRA 2014).

Summary of the TMDL

Detailed information about the Upper Guadalupe River (Segment 1806) and the bacteria impairment can be found in the TMDL (TCEQ 2007) and the initial Upper Guadalupe River I-Plan (TCEQ 2011). This section summarizes sections of the Guadalupe River Above Canyon Lake TMDL. The Guadalupe River Above Canyon Lake is identified as Segment 1806 by the TCEQ. The upstream end of this segment is the confluence of the North and South Forks of the Guadalupe River in Kerr County. The downstream end of this segment is Canyon Reservoir, which begins 1.7 miles downstream of Rebecca Creek Road in Comal County. This project includes only a small reach of Segment 1806, located within the City of Kerrville, which was impaired for contact recreation. The reach is defined as the Guadalupe River from its confluence with Town Creek downstream to Flat Rock Lake, as illustrated in Figure 1 and consists of two assessment units (AUs): 1806_04 and 1806_06 (based on the 2008 Texas Integrated Report of Surface Water Quality). This I-Plan addresses the impaired AUs and the watershed of the main tributaries into those AUs.

Segment 1806 was first identified as not supporting the contact recreation use on the *2002 Texas Water Quality Inventory and List*. The 2002 Inventory and List identified AU 1806_04 and AU 1806_06 as exceeding the contact recreation standard (126 colony forming units (cfu)/100 mL) with values of 231 and 193 cfu/100 mL respectively.



Figure 1. Map of the impaired reach of the Upper Guadalupe River above Canyon Lake
 The TMDL identified possible regulated and unregulated sources of bacteria, and quantified appropriate reductions necessary to comply with established water quality standards. Possible sources and/or causes of contamination identified in the TMDL include:

- Wildlife and feral animals (nesting birds, including domestic waterfowl, at bridge crossings in particular)
- Leaking collection lines in sanitary sewer infrastructure
- Failing septic systems
- Direct human deposition
- Livestock
- Urban storm water runoff

TMDL Addendum

In the 2010 Texas Integrated Report of Surface Water Quality, bacteria impairments were identified within both Quinlan Creek (Segment 1806D) and Town Creek (Segment 1806E) (Figure 2). Bacteria values not meeting contact recreation standards have been identified in each AU during all subsequent versions of the Integrated Report. Both impaired tributary AUs join the Guadalupe River within the original study area of the TMDL. Therefore, a TMDL Addendum for Quinlan Creek and Town Creek was prepared in 2018 (TCEQ 2018) to evaluate the bacteria load contributions of the tributaries. The addendum presents the new information associated with the two additional AUs and the details related to developing the TMDL allocations for these additional AUs, which were not specifically addressed in the original TMDL document. The two TMDLs were added by Addendum by TCEQ in January 2018 and approved by EPA on May 8, 2018. Many of the implementation measures outlined in the original I-Plan and this revised I-Plan include Town Creek and Quinlan Creek in the area of emphasis.

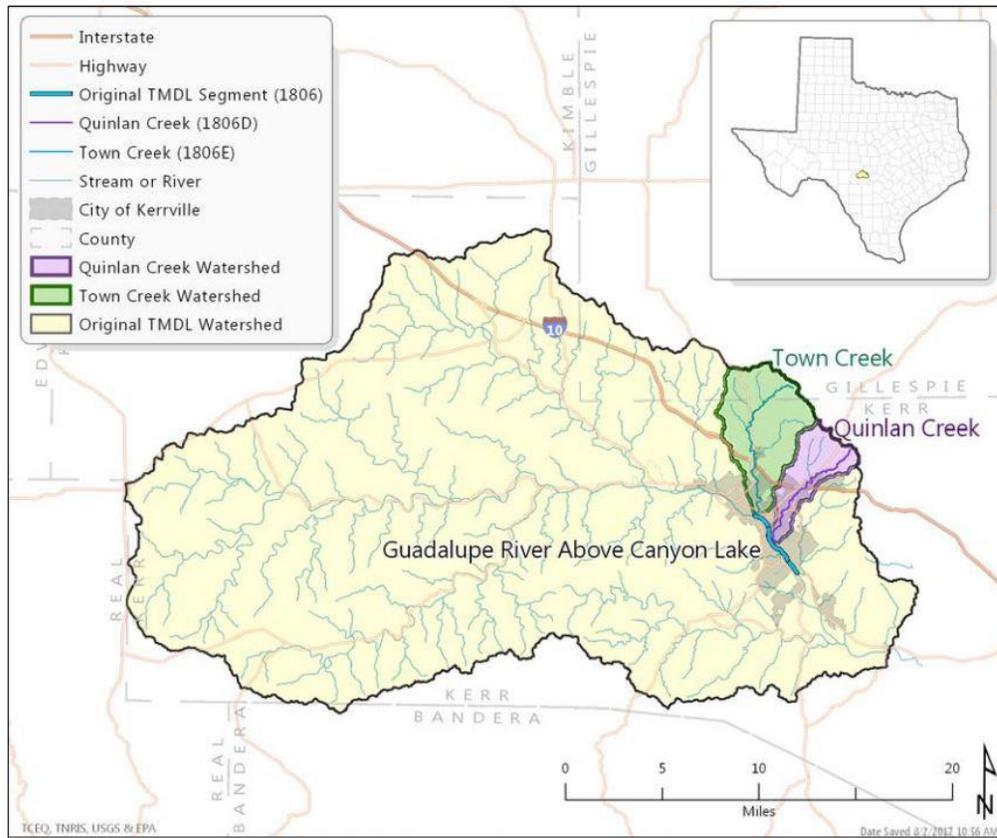


Figure 2. Map showing the Guadalupe River Above Canyon Lake TMDL watershed and the two watersheds considered in the addendum

Implementation Progress and Current Status

The following is a summary of implementation progress and current status of management measures under the Guadalupe River Above Canyon Lake 2011 I-Plan. Implementation progress and current status of additional management measures introduced in this revised I-Plan are also included. In general, the progress updates cover the timeframe of FY14-FY17. However, a few implementation measures report activities outside of that range.

Adaptive Implementation

This revised I-Plan will be implemented using adaptive management, wherein measures are periodically assessed for efficiency and effectiveness. The iterative process to evaluate and adjust the management measures and control actions in the I-Plan will ensure continuing progress toward achieving water quality goals and shows a commitment to improving water quality. Existing management measures may be adjusted or eliminated by the entities responsible for their implementation after assessment of progress using a schedule of implementation, interim milestones, water quality data, and changed circumstances.

Management Measures and Control Actions in the Revised I-Plan

Management Measures:

- 1.0 Reduce bird feeding at Louise Hays Park and Kerrville-Schreiner Park
 - 1.1 Public Education
- 2.0 Reduce number of birds roosting and nesting on bridges directly over the study area waterways
- 3.0 Manage the waterfowl population at Louise Hays Park and Kerrville-Schreiner Park
- 4.0 Reduce human contributions through ongoing lateral sewage line re-placement, sewer inspection and rehabilitation, ongoing septic system plan review and registration, mapping of the priority OSSF area, and an education program for OSSF owners.
 - 4.1 City of Kerrville Wastewater Infrastructure
 - 4.2 On Site Sewage Facilities
- 5.0 Implement an education program for pet owners and install pet waste stations at public parks.
 - 5.1 Pet Waste Stations
 - 5.2 Public Education
- 6.0 Reduce contributions from general urban runoff through street sweeping, river clean ups, and storm water education programs.
 - 6.1 Street Sweeping
 - 6.2 Storm Drain Marking Program
 - 6.3 Trash Removal
 - 6.4 Public Education
- 7.0 Preserve riparian areas through education of riparian area structure and function and restoration efforts (*new for revised I-Plan*)
 - 7.1 Public Education
 - 7.2 Healthy Creeks Initiative
 - 7.3 Feral Hogs
- 8.0 Promote green infrastructure to reduce stormwater runoff (*new for revised I-Plan*)
 - 8.1 Rainwater Harvesting
 - 8.2 UGRA EduScape

Control Actions:

- 1.0 Monitor and report *E. coli* concentrations from WWTFs.

Management Measure 1.0: Reduce bird feeding

Ducks and geese have long been suspected as a primary cause of the impairment in the Upper Guadalupe River. They are often present in large numbers at Louise Hays Park and Kerrville-Schreiner Park, where they are often fed by park visitors (Figures 3, 4, and 5). Bacterial source tracking (BST) results from the TMDL study suggest that waterfowl are a significant source of bacteria loading to the impaired reach (TCEQ 2007). At both Louise Hays Park and Kerrville-Schreiner Park, 8% of BST isolates were attributed to ducks. The BST study did not attempt to quantify the contribution of geese. Also, it should be noted that over 40% of the total BST isolates were unidentified, so the actual percent contribution may be higher.



Figure 3. Waterfowl at Louise Hays Park



Figure 4. Public feeding of Egyptian geese at Flat Rock Park (directly across the river from Kerrville-Schreiner Park)



Figure 5. Egyptian geese at swimming area at Kerrville-Schreiner Park

The numbers of waterfowl present along the Guadalupe River have been estimated from routine animal surveys, conducted as part of the Bacteria Reduction Plan and previous studies. In Louise Hays Park, waterfowl were counted between the Tranquility Island foot bridges and the dam. Figure 6 shows the water quality and animal monitoring locations in Louise Hays Park. At Kerrville-Schreiner Park, waterfowl were counted only at the boat ramp. A summary of the results is included in Figure 7 and Figure 8. From July 2008 – December 2017, a total of 273 surveys were conducted at each location.

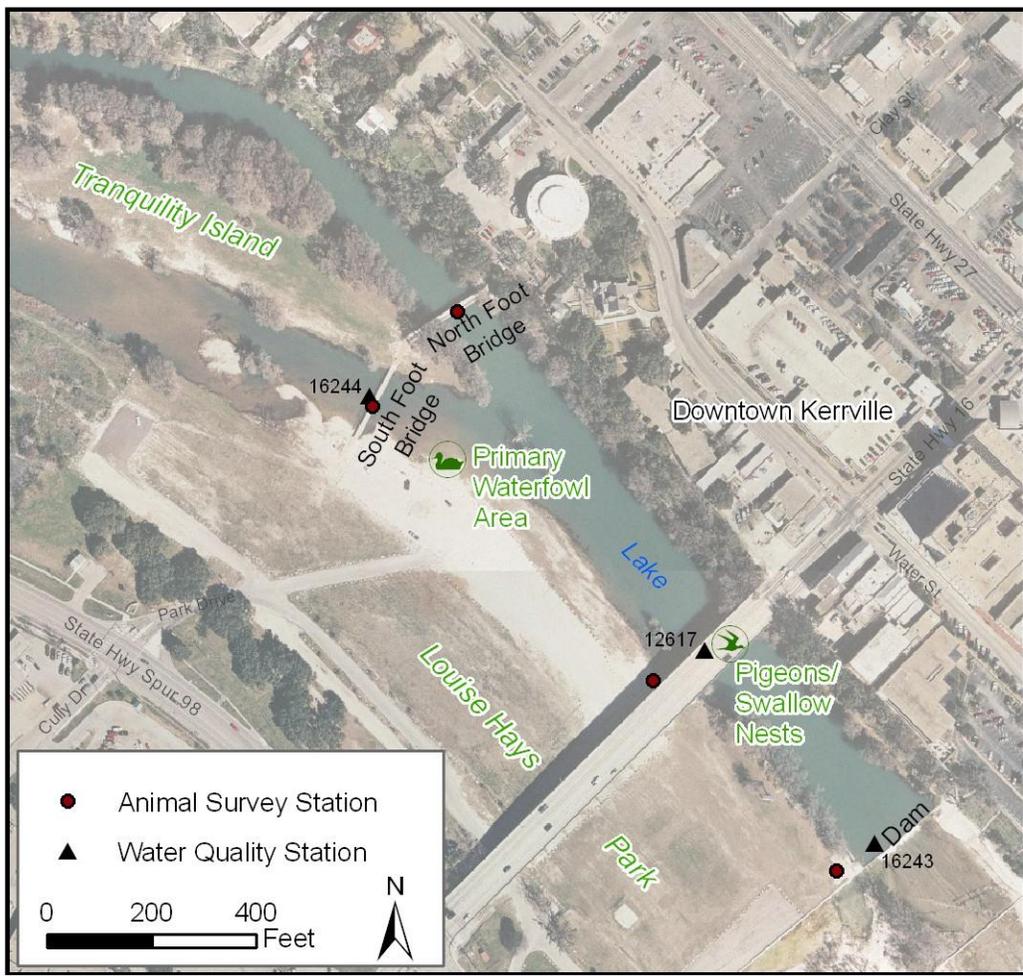


Figure 6. Louise Hays Park Map with monitoring locations indicated

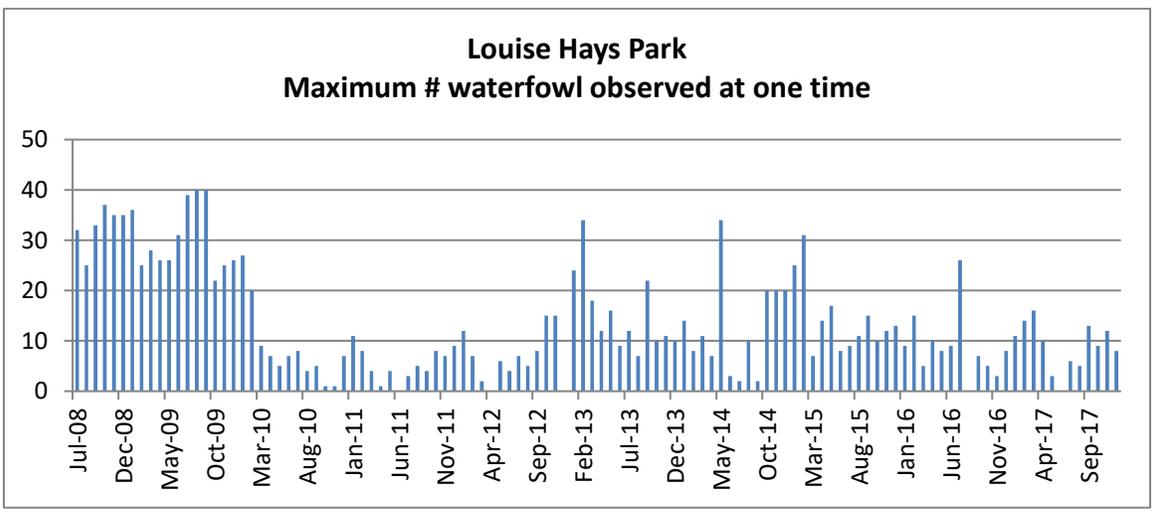


Figure 7. Summarized waterfowl counts at Louise Hays Park

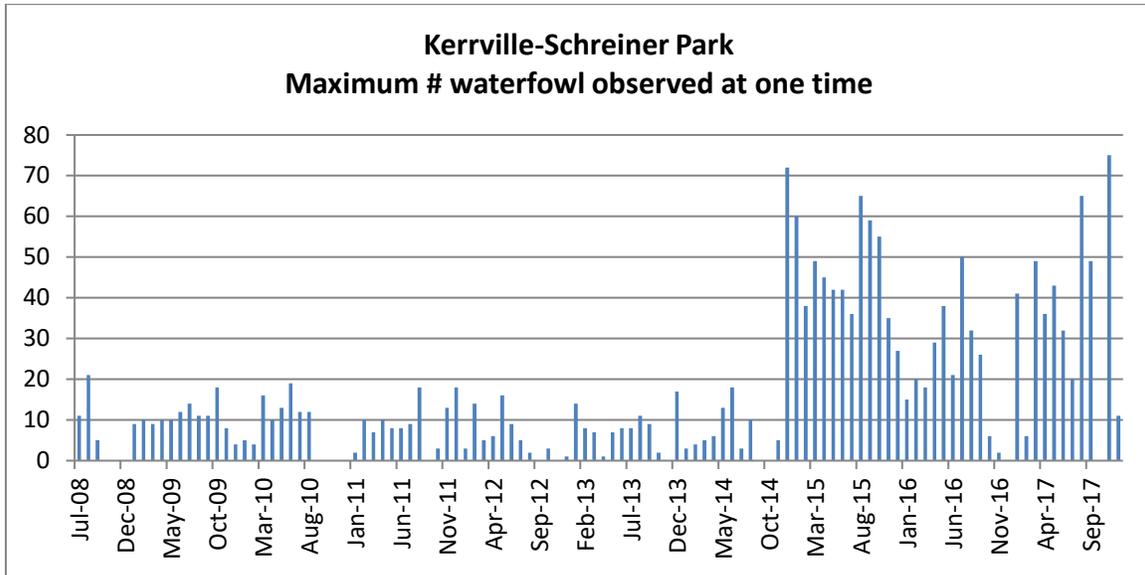


Figure 8. Summarized waterfowl counts at Kerrville-Schreiner Park

1.1 Public Education

UGRA staff has routinely provided the public with information regarding the impact public feeding of waterfowl can have on water quality. The "Do Not Feed the Ducks," message has been displayed at information booths and been the topic of newspaper articles, radio programs, and radio public service announcements (Figure 9). In addition, UGRA has encouraged the public to not release unwanted domestic waterfowl into riverside parks. This message has been conveyed through an annual press release entitled "What to Consider Before You Purchase a Baby Duck or Goose for Easter" as well as through radio programs and newspaper articles.



Figure 9. "Don't Feed the Ducks" information at routine public information booths

In late 2016, UGRA worked with City of Kerrville Parks and Recreation staff to develop signs encouraging the public not to feed ducks and geese in Kerrville parks. Six signs were fabricated and installed at the following Kerrville riverside parks: Cypress Boat Ramp, Knapp Crossing Boat Ramp, Tranquility Island, LHP - under the Hwy 16 bridge, Guadalupe Park, and Kerrville-Schreiner Park (Figure 10 and Figure 11).



Figure 10. "Don't Feed the Ducks" sign at Kerrville-Schreiner Park

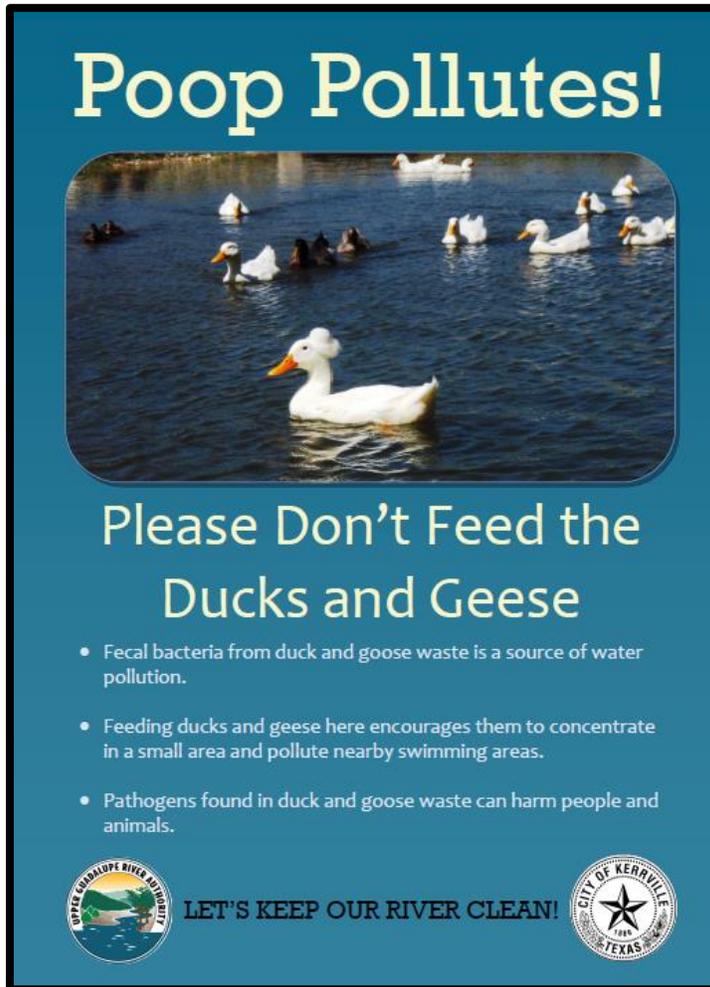


Figure 11. “Don’t Feed the Ducks” sign (enlarged to show content)

Table 1. Management Measure 1.0 – Bird Feeding at Parks

(1) Management Measure	Reduce bird feeding at Louise Hays Park and Kerrville-Schreiner Park.
(2) Best Management Practice	Increase public education awareness of the connection between large flocks of waterfowl and water quality
(3) Area of Emphasis	Riverside parks in the City of Kerrville; primarily Louise Hays Park and Kerrville-Schreiner Park
(4) Education Target	Park users and general public

Revised Implementation Plan for One TMDL for Bacteria in Guadalupe River Above Canyon Lake

<p>(5) Schedule of Implementation</p>	<p>FY18-FY22: Maintain current signs at parks and replace as needed. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between large flocks of waterfowl and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution</p>
<p>(6) Interim, Measurable Milestones</p>	<p>Monthly survey data does not indicate observations of public feeding. Reduced number of waterfowl congregating in public parks</p>
<p>(7) Progress Indicators</p>	<p>Reduction in <i>E. coli</i> concentrations at the monitoring stations adjacent to areas know for public feeding of waterfowl.</p>
<p>(8) Monitoring Component</p>	<p>Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.</p>
<p>(9) Responsible Organizations</p>	<p>UGRA, City of Kerrville (city maintained parks), Kerr County (county maintained parks)</p>

Management Measure 2.0: Reduce roosting birds

Birds that roost on bridges are of particular concern because they can contribute fecal matter directly to a watercourse. BST results from the TMDL study suggest that bridge-roosting birds are a significant source of bacteria loading to the impaired reach (TCEQ 2007). At Louise Hays Park, 12% and 1% of BST isolates were attributed to pigeons and swallows, respectively. At Kerrville-Schreiner Park, 5% and 4% of BST isolates were attributed to pigeons and swallows, respectively. It should be noted that over 40% of the total BST isolates were unidentified, so the actual percent contribution may be higher.

Large colonies of cliff swallows (*Hirundo pyrrhonota*) nest under the Highway 16 bridge in Louise Hays Park and under the Loop 534 bridge upstream of Kerrville-Schreiner Park. During an April 2009 intensive survey, the number of viable (undamaged) swallow nests over the river was counted from a canoe. There were approximately 160 swallow nests located over the water at Highway 16, and 400 swallow nests located over the water at Loop 534. Additional swallow nests exist on portions of the bridges that are not directly over the water.

Cliff swallows spend the summer breeding season in North America and the winter in South America. Studies suggest that colonies are typically occupied for about 110 days (Gorenzel and Salmon 1982), probably sometime between March and July. Swallows have been observed at the Highway 16 and Loop 534 bridge from approximately late-March through mid-August (Miertschin 2010)

The management measure (install bird exclusion/deterrent devices on bridges directly over the waterway) outlined in the Guadalupe River Above Canyon Lake Implementation Plan (TCEQ 2011) was implemented in the study area to address bacteria contributions from roosting and nesting birds. Plans and specifications were prepared for installation of bird exclusion netting to the sides and underside of the Hwy 16 and Loop 534 bridge spans adjacent to and directly above the water surface. After competitive bids were evaluated, the project scope was limited to installation of bird exclusion netting to the sides and underside of three Hwy 16 bridge spans. A contractor was selected, and the installation was completed in January 2013. The work proved to be difficult and highly specialized, especially due to the need to work high above the water surface. Photos of the installation are shown in Figures 12, 13, and 14.



Figure 12. Installation of bird exclusion netting on Hwy 16 Bridge



Figure 13. Netting installation taking place on span of Hwy 16 Bridge over Guadalupe River



Figure 14. Final netting system over Spans 2,3, and 4 of Hwy 16 Bridge

UGRA conducted bi-weekly animal count surveys from 2008-2010 and monthly surveys from 2011 – present. The survey results indicate that the installation of exclusion netting has eliminated both roosting and nesting from the bridge spans where the netting was installed.

Table 2. Management Measure 2.0 – Bird Deterrent Devices on Bridges

<p>(1) Management Measure</p>	<p>Reduce number of bridge roosting and nesting on bridges directly over the study area waterways</p>
<p>(2) Best Management Practice</p>	<p>Install bird exclusion/deterrent devices on bridges directly over the waterway.</p>
<p>(3) Area of Emphasis</p>	<p>Two spans of the SH16 bridge directly over the Guadalupe River and one adjacent span directly over the land in Louise Hays Park.</p>

(4) Education Target	General public
(5) Schedule of Implementation	Installation of the bird deterrent devices was completed in FY13 and monitored monthly for effectiveness since that date. FY18-FY22: Continue to monitor effectiveness of exclusion devices to ensure that equipment continues to function properly. Continue to include information about this BMP in discussions of water quality of the Upper Guadalupe River in Kerrville.
(6) Interim, Measurable Milestones	Monthly survey data does not indicate observations of failed exclusion equipment or presence of birds within the exclusion device.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations at the monitoring stations adjacent to area where the deterrent devices are installed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA, TxDOT and City of Kerrville if repair to the deterrent devices are needed.

Management Measure 3.0: Manage waterfowl populations

City of Kerrville staff periodically conducted removal efforts at Louise Hays Park from 2008 - 2010. A total of 59 ducks and geese were removed during 10 events. In June 2015, UGRA partnered with USDA Wildlife Services to remove Egyptian geese from Flat Rock Park (immediately across the Guadalupe River from Kerrville-Schreiner Park). Animal counting surveys by UGRA staff have shown variability in the number of waterfowl per visit (Figures 7 and 8). Reduced populations have been observed at times, for example during the 2010-2012 time frame at Louise Hays Park. In December 2014, the number of waterfowl increased significantly at Kerrville-Schreiner Park and has remained elevated since that time. Observations recorded during the surveys indicate the first appearance of Egyptian geese in Kerrville in March 2014 and they have been observed consistently since and in increasing numbers. A systematic waterfowl removal program has the potential to reduce bacteria loads and the City of Kerrville and UGRA have committed to managing waterfowl populations in Kerrville parks.

Table 3. Management Measure 3.0 – Waterfowl Populations in Parks

(1) Management Measure	Manage the waterfowl population at Louise Hays Park and Kerrville-Schreiner Park
(2) Best Management Practice	Reduce the number of waterfowl gathered in flocks in public parks
(3) Area of Emphasis	Riverside parks in the City of Kerrville; primarily Louise Hays Park, Kerrville-Schreiner Park, and Flat Rock Park
(4) Education Target	Park users and general public
(5) Schedule of Implementation	FY18-FY22: Continue communication with the City of Kerrville and Kerr County regarding the size and location of flocks of waterfowl in public parks. Establish threshold of flock size and <i>E. coli</i> bacteria counts to warrant removal of waterfowl. Annually publish articles in local newspapers about the connection between large flocks of waterfowl and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution.
(6) Interim, Measurable Milestones	Monthly survey data does not indicate observations of flocks of waterfowl greater than 15 individuals.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations at the monitoring stations adjacent to areas know for flocks of waterfowl .
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA, City of Kerrville (city maintained parks), Kerr County (county maintained parks and Animal Services Department for removal assistance)

Management Measure 4.0: Reduce human contributions

4.1 City of Kerrville Wastewater Infrastructure

The management measure (reduce human contributions through ongoing lateral sewage line replacement and sewer inspection and rehabilitation) is addressed in the study area through the City of Kerrville Public Works Department's ongoing efforts to inspect, repair, and replace wastewater infrastructure.

During the stakeholder review of this document, a stakeholder expressed concerns that bacterial contamination from runoff comes from failed septic systems and from sewer contamination into the storm drain system. The Kerr County Environmental Health Department (KCEHD) is the local authorized agent for OSSF permitting and enforcement and investigates systems that are suspected of failing. KCEHD along with UGRA work to spread information to homeowners with septic systems regarding how to properly maintain their system and recognize signs of failure (see section 4.2 for additional information). KCEHD and UGRA will continue these efforts and look for additional opportunities to address contamination from failing septic systems.

As evidenced by the information in Tables 4-6 below, the City of Kerrville consistently dedicates resources to maintain and improve wastewater infrastructure. Routine inspection and cleaning of the wastewater mains help maintain the integrity of the collection system as well as assure that there are no cross connections between the City wastewater collection system and the storm drain system.

The City has a dedicated wastewater team, on call 24 hours a day, to quickly respond to any suspected cross connections or overflows. Once notified they are quickly on site to inspect and remedy any suspected wastewater related issues. No cross connections have been discovered.

Table 4. Kerrville Wastewater Infrastructure Improvements during FY12 and FY13

Item	Quantity FY12 (2011-2012)	Quantity FY13 (2012-2013)
Amount spent to improve collection system	\$7,938,219.60	\$7,120,038.22
Lateral feet of collection line system repaired or replaced	25,660 LF	303 LF
Number of lift stations rehabilitated/improved	Initiated replacement of Birkdale Lift Station	<ul style="list-style-type: none"> • Birkdale Lift Station completed and in operation • Initiated design phase to replace Jefferson Lift Station • Improvements or repairs at 9 lift stations: <ul style="list-style-type: none"> ▪ Upgraded pump level controls ▪ Upgraded SCADA system ▪ Added chemical odor control ▪ Added emergency pump

Revised Implementation Plan for One TMDL for Bacteria in Guadalupe River Above Canyon Lake

Item	Quantity FY12 (2011-2012)	Quantity FY13 (2012-2013)
		<ul style="list-style-type: none"> ▪ Repaired pump sensors and other components ▪ Replaced pumps and other components ▪ Replaced sections of discharge piping ▪ Suction piping replaced ▪ Check valves replaced ▪ Replaced alarm lights ▪ Replaced pipe discharge manifold
Number of sanitary manholes replaced	<ul style="list-style-type: none"> • Manholes replaced – 15 • Manholes rehabilitated – 59 • City Cleanouts replaced – 9 	<ul style="list-style-type: none"> • Manholes replaced – 1 • Manholes rehabilitated – 0 • City Cleanouts replaced – 0
Number of broken customer cleanouts repaired	276	25
Footage of gravity main inspected, smoked tested, and cleaned	<ul style="list-style-type: none"> • Inspected through CCTV camera – 54,481 LF • Cleaned/vacuumed – 190,255 LF • Root sawed – 1698 LF 	<ul style="list-style-type: none"> • Inspected through CCTV camera – 22,776 LF • Cleaned/vacuumed – 175,798 LF • Root sawed – 200 LF

Table 5. Kerrville Wastewater Infrastructure Improvements during FY14 and FY15

Item	Quantity FY14 (2013-2014)	Quantity FY15 (2014-2015)
Amount spent to improve wastewater collection system	\$993,340	\$3,822,610
Amount spent to improve wastewater treatment system	\$168,126	\$71,860
Improvements to wastewater treatment system	<ul style="list-style-type: none"> • WW Master Plan update • New Alum Storage Tank • New Portable Composite sampler 	<ul style="list-style-type: none"> • Add two new floating surface rotors to subsidize aeration
Linear feet (LF) of collection system repaired or replaced	<ul style="list-style-type: none"> • Sewer repaired - 23 LF • Replace Jefferson LS Force Main and Gravity lines to Birkdale LS - 5021 LF 	<ul style="list-style-type: none"> • Broadway LS Force Main slip lining - 1,829 LF
Number of lift stations rehabilitated/improved	<ul style="list-style-type: none"> • Removed G Street Lift Station from service due to new Birkdale LS & a new Interceptor sewer main • Broadway LS pump and piping replacement 	<ul style="list-style-type: none"> • New Jefferson LS completed and in operation • Quail Valley Lift station (Kerr South) pump and control replacements

Revised Implementation Plan for One TMDL for Bacteria in Guadalupe River Above Canyon Lake

Item	Quantity FY14 (2013-2014)	Quantity FY15 (2014-2015)
Number of broken customer cleanout replaced	12	15
Footage of gravity sewer main inspected, smoked tested, and cleaned	<ul style="list-style-type: none"> • 261,889 LF of sewer main cleaned • 44,148 LF of sewer main inspected 	<ul style="list-style-type: none"> • 176,894 LF of sewer main cleaned • 29,521 LF of sewer main inspected • 221 LF of sewer main root sawed
Other improvements not included in above categories		<ul style="list-style-type: none"> • Purchase of new CCTV sewer line inspection unit (\$174,870)
Treatment Facility, Collection System, and Reclaimed Water System Annual Operating Budget	\$1,564,661	\$1,593,284

*Note that items differ slightly from those reported in Table 4.

Table 6. Kerrville Wastewater Infrastructure Improvements during FY16 and FY17

Item	Quantity FY16 (2015-2016)	Quantity FY17 (2016-2017)
Amount spent to improve wastewater collection system	\$4,373,320	\$420,557
Amount spent to improve wastewater treatment system	\$2,507,777	
Improvements to wastewater treatment system	<ul style="list-style-type: none"> • Added new clarifier to treatment facility • Replaced MCC (Electrical Controls) at treatment facility 	
Linear feet (LF) of collection system repaired or replaced	<ul style="list-style-type: none"> • Misc. piping repairs – 78 LF • Replace Jefferson LS Force Main/Gravity lines – 6779 LF 	<ul style="list-style-type: none"> • Misc. piping repairs – 42 LF
Number of lift stations rehabilitated/improved		<ul style="list-style-type: none"> • Purchase spare pump for Knapp Road LS • Quinlan LS pump rail rehab • Legion LS replacement – design initiated
Number of broken customer cleanout replaced	7	3
Footage of gravity sewer main inspected, smoked tested, and cleaned	<ul style="list-style-type: none"> • 326,781 LF of sewer main cleaned • 75,332 LF of sewer main inspected 	<ul style="list-style-type: none"> • 373,830 LF of sewer main cleaned • 47,937 LF of sewer main inspected

Item	Quantity FY16 (2015-2016)	Quantity FY17 (2016-2017)
Other improvements not included in above categories		
Treatment Facility, Collection System, and Reclaimed Water System Annual Operating Budget	\$1,769,351	\$1,742,701

Table 7. Management Measure 4.1 – Reduce Human Contributions – Wastewater Infrastructure

(1) Management Measure	Reduce human contributions through ongoing lateral sewage line re-placement, sewer inspection and rehabilitation, ongoing septic system plan review and registration, mapping of the priority OSSF area, and an education program for OSSF owners.
(2) Best Management Practice	Improve wastewater infrastructure in the City of Kerrville.
(3) Area of Emphasis	City of Kerrville wastewater infrastructure network. Includes portions of the Upper Guadalupe, Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public
(5) Schedule of Implementation	FY18-FY22: As evidenced by Tables 4-6, the City of Kerrville continues to prioritize maintenance of existing wastewater infrastructure and improvements to the wastewater infrastructure network in the annual operating budget. Schedule of annual improvements to the infrastructure are prioritized by the City of Kerrville Public Works Department. Schedules may also be outlined in the City of Kerrville Wastewater Master Plan.
(6) Interim, Measurable Milestones	Annual summaries of improvements to wastewater system.
(7) Progress Indicators	Metrics listed in Tables 4-6 .

(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Or- ganizations	City of Kerrville Public Works Department – Water Reclamation.

4.2 On-site Sewage Facilities (OSSF)

The management measure (reduce human contributions through ongoing OSSF plan review and registration, mapping of the priority OSSF area, and an education program for OSSF owners) was implemented in the study area to address bacteria contributions from OSSFs.

OSSFs (also known as septic systems) can act as sources of pathogens due to inadequate design, inappropriate installation, neglectful operation, or exhausted lifetime. However, many of these pitfalls can be avoided through improved maintenance and inspection activities.

This management measure was primarily addressed through the mapping of priority areas for septic system management. The priority area was defined based upon proximity to the impaired reach of the Upper Guadalupe River and its contributing tributaries.

Septic systems in the study area watersheds have been inventoried by the Kerr County Environmental Health Department (KCEHD). The KCEHD is the local authorized agent for OSSF permitting and enforcement. They receive applications for OSSFs, issue licenses, and conduct inspections/investigations for enforcement and nuisance conditions as per state law.

The inventory of septic systems in Kerr County was obtained from KCEHD (KCEHD 2012). The database included a location with street address, a parcel number that corresponds to records of the Kerr Central Appraisal District (KCAD), type of septic system, and license date. The intersection of the information from KCEHD and KCAD enabled creation of a map of all the parcels in Kerr County that are served by septic systems.

For the purposes of the present analysis, a distance of 300 feet (ft) from a major watercourse was established to define the priority zone for septic systems. Within the watershed of the impaired reach of the Guadalupe River, specific subwatersheds of the primary tributaries were delineated. This included subwatersheds for Town Creek, Camp Meeting Creek, Quinlan Creek, and those areas that drain directly to the mainstem of the Guadalupe. These subwatershed delineations are displayed in Figure 15.

The septic system priority zone for Town Creek is shown in Figure 16. The entire Town Creek watershed contains 276 parcels that are designated as having septic systems. The defined priority area surrounding the watercourse contains 21 parcels

with septic systems. These properties are located north of the Kerrville city limits along several miles of creek frontage.

The septic system priority zone for Camp Meeting Creek is shown in Figure 17. The Camp Meeting Creek watershed contains 906 properties with septic systems. Of that total, 69 parcels are located within the priority zone adjacent to the watercourse. These parcels are located west of the Kerrville city limits.

The Quinlan Creek priority zone is shown in Figure 18. This watershed contains a total of 121 parcels with septic systems. The priority zone contains 9 properties with septic systems. The Quinlan Creek septic system parcels are generally north of the Kerrville city limits.

The miscellaneous watersheds that drain directly to the Guadalupe River were also addressed. The priority zone for the mainstem and its miscellaneous watersheds are shown in Figure 19. A total of 84 septic system parcels are located within these watersheds, and of that total, 6 are within the designated priority zone.

The statistics for the septic systems in the watersheds are shown in Table 8. For the subwatersheds described above, there are an estimated 1387 parcels that are served by septic systems. Of that total, 105 have been identified as being located within a 300-ft priority area. The priority zone therefore contains roughly eight percent of the total number of systems that exist in the subwatersheds.

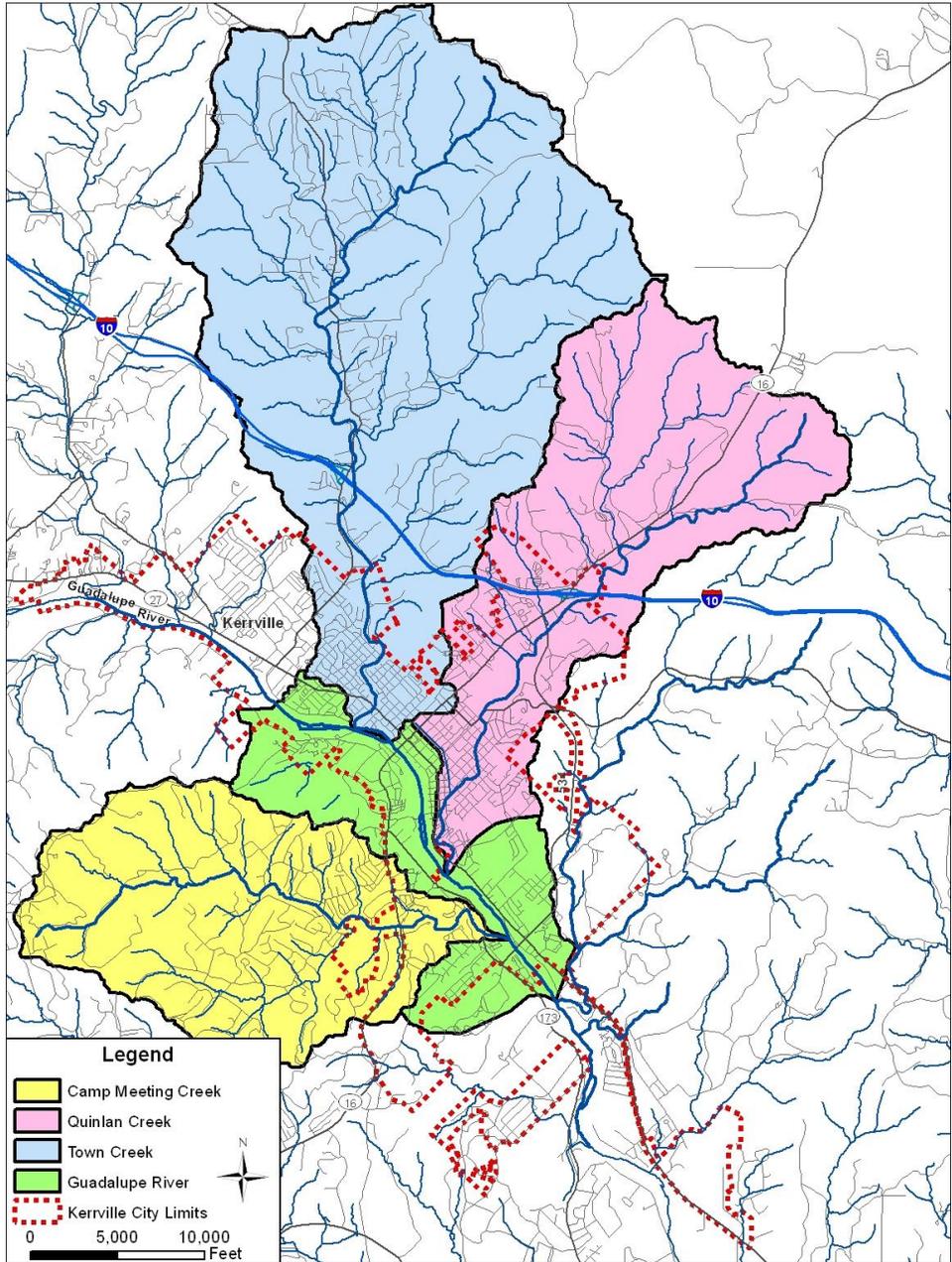


Figure 15. OSSF study area subwatersheds

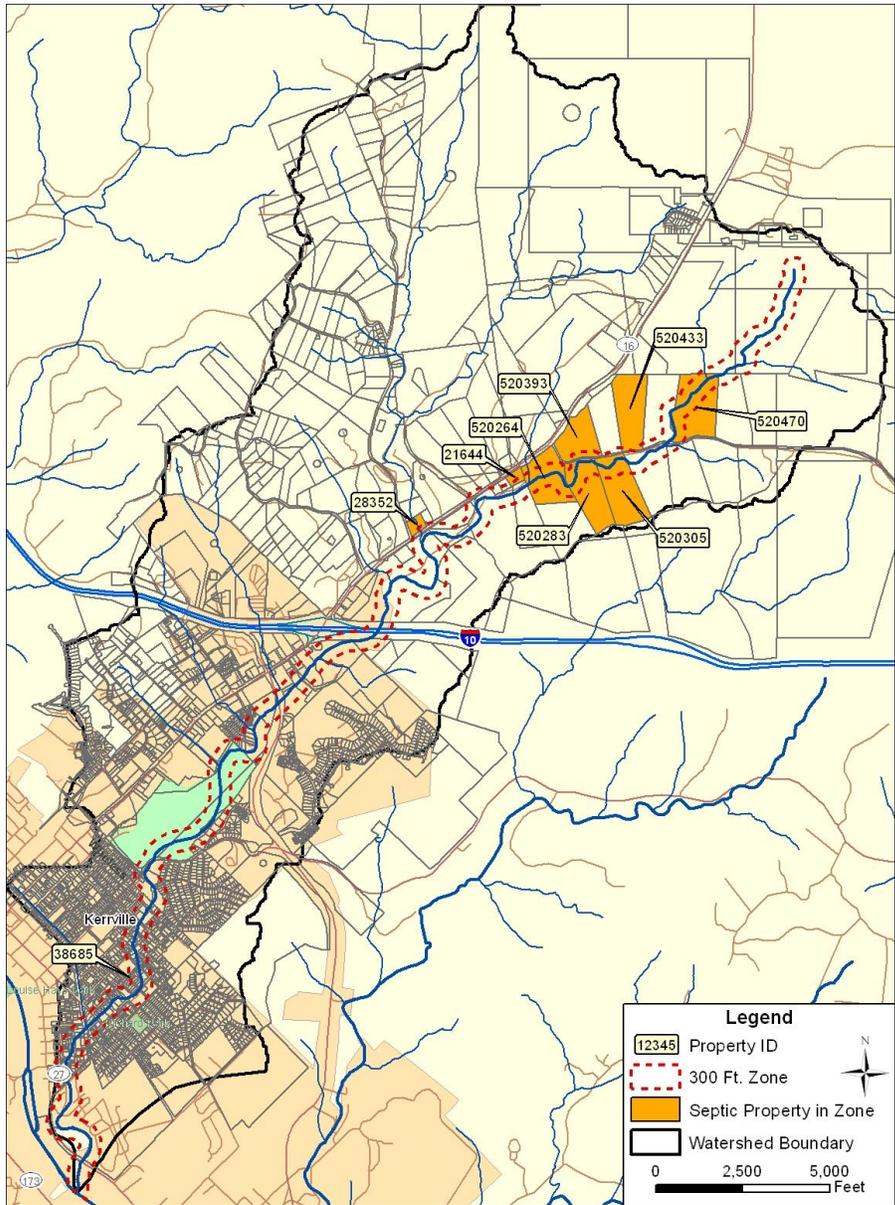


Figure 18. Quinlan Creek septic system priority zone

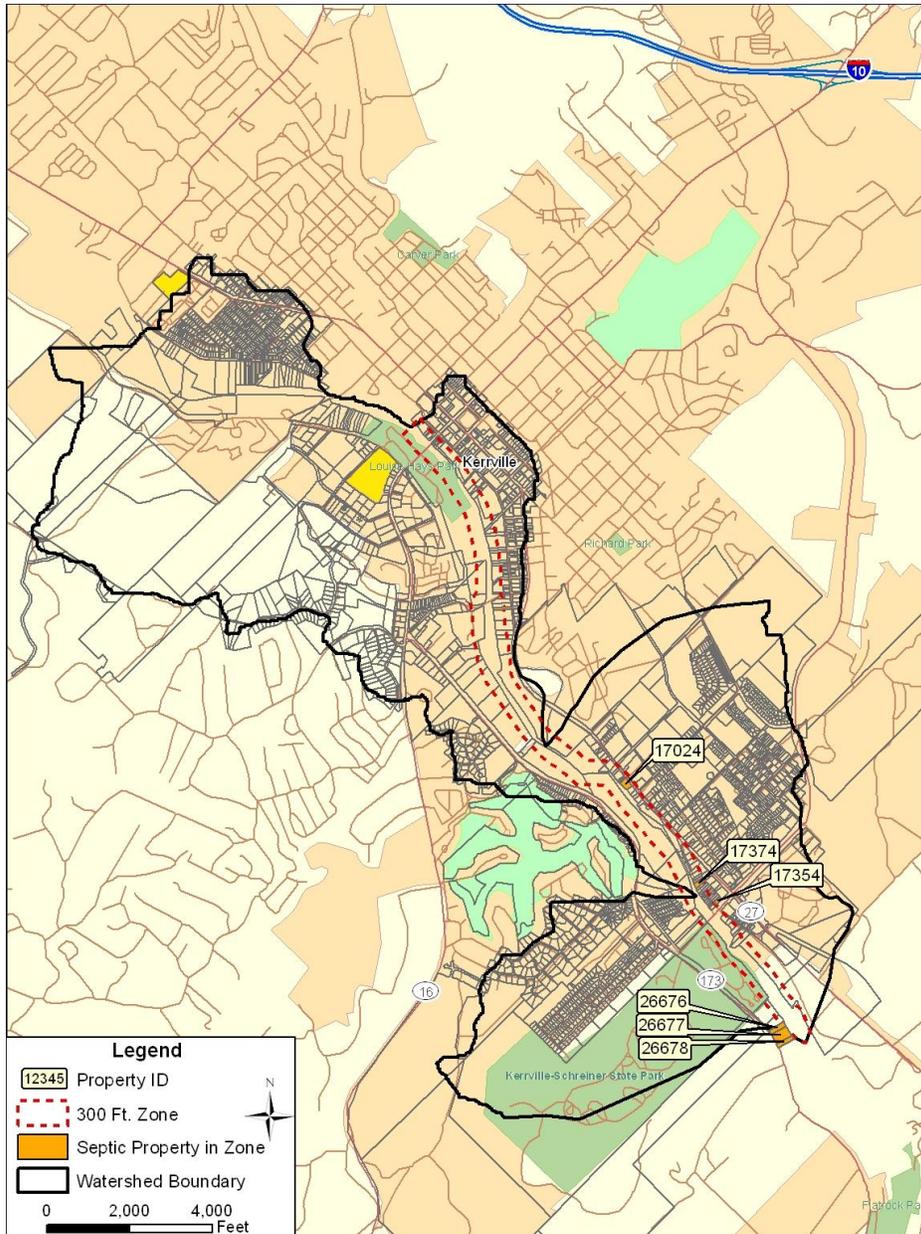


Figure 19. Guadalupe River main stem septic system priority zone

Table 8. Septic system summary

Watershed	Total Number of Septic Properties	Number of Septic Properties in 300 ft. Buffer
Town Creek	276	21
Camp Meeting Creek	906	69
Quinlan Creek	121	9

Watershed	Total Number of Septic Properties	Number of Septic Properties in 300 ft. Buffer
Guadalupe River	84	6
Totals	1,387	105

UGRA developed an informational packet for homeowners with either aerobic or conventional septic systems. The packet includes a flyer describing the "Do's and Don'ts of Septic Systems" and a magnetic reminder of the signs of septic system failure. These items were mailed to homeowners in the priority area in August 2014 along with a card explaining that they have received this information due to the proximity of their septic system to the relevant waterway. In a few cases, the septic system homeowner also received a message in the packet that their system is currently unlicensed. Additionally, the materials are distributed to interested Kerr County septic system homeowners and all homeowners with a newly licensed system through the KCEHD. See Table 9 for a summary of the distribution of these materials. The materials are also available through UGRA outreach and education programs and information booths. The septic system information for homeowners can be found at <http://www.ugra.org/major-initiatives/bacteria-reduction-plan>.

KCEHD staff will track any investigations or complaints that occur regarding systems in the priority area after the materials have been mailed out and report this information to UGRA on a quarterly basis. During FY14 – FY17, only one property in the priority area contacted KCEHD regarding their septic system. Information about the septic system was provided to the homeowner and no investigation was initiated.

In addition to the print materials, radio public service announcements to reinforce the importance of properly maintaining your septic system were developed by UGRA and routinely broadcast on three local radio stations.

Table 9. Summary of distribution of OSSF informational packets to newly licensed systems

Calendar Year	Number Packets Distributed
2014	155
2015	141
2016	155
2017	163

Table 10. Management Measure 4.2 – Reduce Human Contributions – OSSF

(1) Management Measure	Reduce human contributions through ongoing lateral sewage line re-placement, sewer inspection and rehabilitation, ongoing septic system plan review and registration, mapping of the priority OSSF area, and an education program for OSSF owners.
(2) Best Management Practice	Increase public education awareness of the connection between improperly maintained OSSFs and water quality.
(3) Area of Emphasis	OSSFs in Kerr County, with particular emphasis on OSSFs within 300 ft of waterways in the Upper Guadalupe, Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	Homeowners with OSSFs.
(5) Schedule of Implementation	FY18-FY22: Continue distribution of homeowners guide for septic systems through the Kerr County Environmental Health Department and UGRA information booths. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between improperly maintained OSSFs and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution.
(6) Interim, Measurable Milestones	Number of homeowner guides distributed annually by Kerr County Environmental Health Department.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations in the affected watershed.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA, Kerr County Environmental Health Department

Management Measure 5.0: Reduce contributions from pet waste

5.1 Pet Waste Stations

Strategies to reduce *E. coli* sources for pet waste were one of the first implementation measures applied in the watershed. UGRA acquired educational materials and waste-collection bag dispensers for seven pet waste stations at Flat Rock Park. The park signs, shown in Figure 20, emphasize pet waste bacteria contributions and cite the Texas Health and Safety Code for surface water contamination. Two park signs are installed at Flat Rock Park; one at the entrance of the park and the second at the entrance of the dog park within the park. Through a partnership with Kerr County, the pet waste stations in Flat Rock Park were installed in 2010 and have been continually maintained. An example of a pet waste bag dispenser station is shown in Figure 21. UGRA maintained weekly records of pet waste collected from November 2010 to November 2014 (Table 11).



Figure 20. Pet waste educational park sign



Figure 21. Pet waste bag dispenser station

Table 11. Summary of pet waste collected at select stations from 2010-2014.

Station No.	Pounds Pet Waste	Number of Trips
1	271	235
2	253	235
3	314	235
4	1,559	235
5	1,023	235
6	1,089	235
7	1,545	235
Total	6,054	

If it is assumed that dog waste contains 2.3×10^7 cfu of fecal coliform per gram, the 6,054 pounds of waste captured represents a bacteria load reduction of 1.04×10^9 cfu *E. coli*. $[(2.3 \times 10^7 \text{ cfu/g}) \times (6054 \text{ lb}) \times (453.6 \text{ g/lb})]$. (Schueler and Holland 2000)

Sixteen additional pet waste stations were acquired by UGRA through CWA §319 funding and installed by the City of Kerrville. In addition, ten stations have been purchased by UGRA and relinquished to the City of Kerrville for installation along the River Trail. In total, 33 pet waste stations are currently in use in the Guadalupe River watershed in Kerrville.

Table 12. Management Measure 5.1 – Pet Waste Stations

(1) Management Measure	Implement an education program for pet owners and install pet waste stations at public parks.
(2) Best Management Practice	Install and maintain pet waste stations in public parks.
(3) Area of Emphasis	Riverside parks in Kerr County.
(4) Education Target	Park users and general public.
(5) Schedule of Implementation	FY18-FY22: Maintain the 33 pet waste stations currently installed in Kerr County. Identify areas where additional stations are needed and budget to fund these new stations.
(6) Interim, Measurable Milestones	Number of active pet waste stations, number of refill bags distributed to Kerr County Maintenance Department staff, number of new pet waste stations installed.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to areas known for high concentrations of dogs (i.e. adjacent to dog parks).
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA, City of Kerrville (city maintained parks), Kerr County (county maintained parks)

5.2 Public Education

UGRA staff has routinely provided the public with information regarding the impact pet waste can have on water quality. The themes of "pick up after your pet" and "don't leave pet waste on the ground" have been displayed at information booths and been the topic of newspaper articles, radio programs, and radio public service announcements.

Table 13. Management Measure 5.2 – Pet Waste Public Education

(1) Management Measure	Implement an education program for pet owners and install pet waste stations at public parks.
(2) Best Management Practice	UGRA staff has routinely provided the public with information regarding the impact pet waste can have on water quality.
(3) Area of Emphasis	Riverside parks in Kerr County.
(4) Education Target	Park users and general public.
(5) Schedule of Implementation	FY18-FY22: Maintain current information signs adjacent to pet waste stations describing impact of pet waste on water quality. Replace degraded signs as needed. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between pet waste and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution.
(6) Interim, Measurable Milestones	Number of times pet waste public service announcement is broadcast, number of newspaper articles highlighting this bacteria source, number of presentations including information about this bacteria source.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to areas known for high concentrations of dogs (i.e. adjacent to dog parks).
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.

(9) Responsible Organizations	UGRA, City of Kerrville (city maintained parks), Kerr County (county maintained parks)
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Management Measure 6.0: Reduce contributions from urban runoff

Indirect sources contribute fecal bacteria to the surface of the land instead of directly to the watercourse. These bacteria are then available for runoff during subsequent rainfall events. Many species of animals (including humans) can contribute to indirect loading. This management measure was addressed in the study area through street sweeping, storm drain marking, trash removal, and public education.

6.1 Street sweeping

The City of Kerrville has operated an ongoing street sweeping program since 1978. City staff currently operates two sweepers. A 2005 Elgin Pelican mechanical sweeper and 2014 Tymco regenerative air street sweeper. The regenerative air sweeper also features a rear vacuum tube which can be used to collect heavy deposits and clean drain inlet boxes. The sweepers are run on a daily basis with the exception of poor weather and breakdowns. When sufficient manpower exists, both sweepers may be in use. However, due to personnel shortages, typically only one is used at a time.

Each sweeper collects an average of 6 cubic yards of debris per day which consists of litter, gravel, dirt, and leaves. The mechanical sweeper is most efficient at collecting solid, heavy items such as gravel. The air sweeper is best suited for lighter debris such as litter and leaves. Recently, due to age, the mechanical sweeper has required more frequent repairs which has decreased the amount of time it is in use. Table 14 summarizes the number of hours spent street sweeping in the watershed of the study area during the “Bacteria Reduction Plan” project term and an estimated amount of waste collected during each quarter. During the time of the Bacteria Reduction Plan, the street sweeping metrics were documented based on fiscal year quarters. However, starting in January 2015, they were documented by calendar year. For this reason, the street sweeping data is presented in two separate tables below (Table 14 and 15).

Table 14. Summary of street sweeping in study area FY12 – FY14

Fiscal Year	Hours Street Sweeper In Operation	Estimated Amount of Debris Collected (cubic yards)
FY12: September 2011 – August 2012	488	449
FY13: September 2012 – August 2013	322	297

Fiscal Year	Hours Street Sweeper In Operation	Estimated Amount of Debris Collected (cubic yards)
FY14: September 2013 – August 2014	433	398
Total	1243	1144

The City of Kerrville’s street sweeping program continues on a routine basis. Table 15 summarized the number of hours spent street sweeping in the watershed of the study area from 2015 – 2017.

Table 15. Summary of street sweeping in study area 2015 - 2017

Calendar Year	Hours Street Sweeper In Operation	Estimated Amount of Debris Collected (cubic yards)
2015	1503	1122
2016	1494	1119
2017	1579	1183
Total	4576	3424

Table 16. Management Measure 6.1 – Reduce General Urban Runoff Contributions – Street Sweeping

(1) Management Measure	Reduce contributions from general urban runoff through street sweeping, river clean ups, and storm water education programs.
(2) Best Management Practice	Continue routine street sweeping in the City of Kerrville.
(3) Area of Emphasis	City of Kerrville streets. Includes portions of the Upper Guadalupe, Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public.

<p>(5) Schedule of Implementation</p>	<p>FY18-FY22: As evidenced by Table 15, the City of Kerrville continues to prioritize street sweeping as a method to remove solid waste from the roadways in Kerrville. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between urban runoff and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution</p>
<p>(6) Interim, Measurable Milestones</p>	<p>Annual summary of street sweeping program. Number of times storm water public service announcement is broadcast, number of newspaper articles highlighting this bacteria source, number of presentations including information about this bacteria source.</p>
<p>(7) Progress Indicators</p>	<p>Metrics listed in Table 14. Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to the City of Kerrville urban area (highest contribution of storm drains).</p>
<p>(8) Monitoring Component</p>	<p>Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.</p>
<p>(9) Responsible Organizations</p>	<p>City of Kerrville Public Works Department – Streets Division</p>

6.2 Storm Drain Marking Program

UGRA coordinated with the City of Kerrville and the Texas Department of Transportation (TxDOT) to initiate a storm drain marking program within the City of Kerrville. These signs raise awareness about the connection between storm drains and receiving waters and can help to deter littering, excess fertilizer use, dumping, and other practices that contribute to storm water pollution. The storm drain markers are 4” diameter, stainless steel, and embossed with the message “No Dumping - Drains to River” (Figure 22)



Figure 22. Storm drain marker installed in Kerrville

During the first phase of this program, 100 markers were installed in the study area between October 2014 and December 2017. Locations were prioritized by vicinity to the impaired reach of the Guadalupe River as well as the contributing tributaries. Locations were also prioritized to send the message to the maximum number of citizens (for example, in areas of high pedestrian traffic). Locations for the first phase of installation are depicted in Figure 23. Students from Schreiner University in Kerrville installed the majority of the storm drain markers while completing and internship with UGRA (Figure 24).

The concept of marking storm drains is to raise awareness for protecting the Guadalupe River from storm water runoff. Buildings, streets, parking lots and other impervious surfaces don't allow rainfall to infiltrate the soil. Instead, the impervious surfaces are often designed to channel runoff into storm drains which dump directly into the creeks and river. Anything spilled, dropped, or otherwise deposited on the impervious surfaces ends up in the river. Some of the problems with high bacteria levels in the river are directly attributable to storm water runoff.

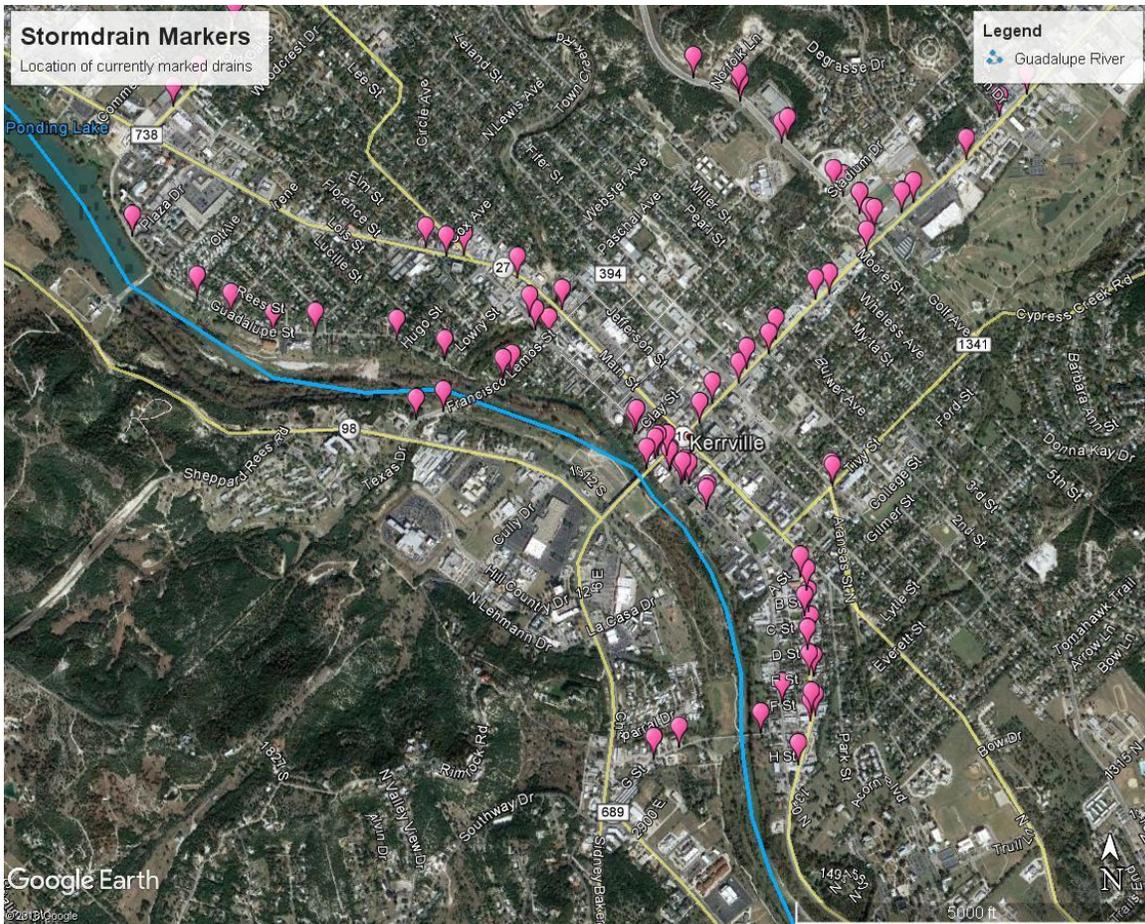


Figure 23. Location of storm drain markers in City of Kerrville



Figure 24. Installation of storm drain markers by Schreiner University students

Table 17. Management Measure 6.2 – Reduce General Urban Runoff Contributions – Storm Drain Marking

<p>(1) Management Measure</p>	<p>Reduce contributions from general urban runoff through street sweeping, river clean ups, and storm water education programs.</p>
<p>(2) Best Management Practice</p>	<p>Install markers adjacent to storm drains with the message “Drains to River”.</p>
<p>(3) Area of Emphasis</p>	<p>Storm drains in the Guadalupe River Watershed in Kerrville and immediately upstream of Kerrville.</p>
<p>(4) Education Target</p>	<p>Pedestrians and general public.</p>
<p>(5) Schedule of Implementation</p>	<p>FY18-FY22: 100 storm drain markers were installed and a subset will be monitored periodically to ensure the marker is legible and firmly affixed to the curb. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between urban runoff and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution.</p>

(6) Interim, Measurable Milestones	Number of storm drain markers still in place. Number of times storm water public service announcement is broadcast, number of newspaper articles highlighting this bacteria source, number of presentations including information about this bacteria source.
(7) Progress Indicators	Anecdotal accounts from the public relaying awareness of the storm drain markers and the connection between storm drains and surface water. Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to the City of Kerrville urban area (highest contribution of storm drains).
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA

6.3 Trash Removal

UGRA’s Trash Removal efforts are comprised of three main components: 1) year round routine garbage pickup at river crossings; 2) the annual river clean up; and 3) citizen organized clean ups. UGRA currently contracts with a local company to pick up trash at fifteen low water crossings throughout the Guadalupe River watershed in Kerr County, including three sites within the study area. UGRA records the total amount of trash collected on each day the river crossing clean up is conducted. The summer months are consistently the time of year when littering is at a peak as many people flock to the Guadalupe River for recreation. In addition to the year-round effort, UGRA hosts an annual river clean up to promote awareness of the litter problem by involving the community. Since 2004, thousands of participants have worked to remove trash from the Guadalupe River watershed in Kerr County with the majority of volunteers concentrating on trash accumulated in the study area. Table 18 summarizes these trash removal efforts.

Table 18. Summary of UGRA Trash Removal Programs

Year	River Crossing Clean Up	Annual River Clean Up
FY12	15,435 pounds removed 739 site visits	11,165 pounds removed 273 participants
FY13	19,295 pounds removed 739 site visits	6,830 pounds removed 337 participants

Year	River Crossing Clean Up	Annual River Clean Up
FY14	27,275 pounds removed 754 site visits	6,495 pounds removed 312 participants
FY15	24,933 pounds removed 754 site visits	6,315 pounds removed 403 participants
FY16	38,235 pounds removed 729 site visits	9,200 pounds removed 443 participants
FY17	43,420 pounds removed 739 site visits	12,025 pounds removed 550 participants

UGRA has also sponsored two routine community groups that are enthusiastic about keeping the Guadalupe River and Kerr County trash free. Both the Town Creek Clean Up Team and the Kerrville South Community Action Group organized routine clean ups and UGRA provided supplies to support their efforts. The Town Creek Clean Up Team was active 2012-2016 and the Kerrville South Community Action Group continues to conduct monthly clean ups. UGRA also coordinates clean up supplies and trash disposal for other groups in the community organizing clean ups. These efforts are often assisted by the City of Kerrville by waiving dump fees.

In Summer of 2017 and 2018, UGRA contracted with off duty peace officers to patrol the three crossings in Kerr County that are known to have the highest incidence of illegal dumping and littering. The peace officers spoke with river recreators about littering, handed out trash bags, and promoted the message, “Pack it In; Pack it Out.”

Table 19. Management Measure 6.3 – Reduce General Urban Runoff Contributions – Trash Removal

(1) Management Measure	Reduce contributions from general urban runoff through street sweeping, river clean ups, and storm water education programs.
(2) Best Management Practice	Remove trash from the Upper Guadalupe River and immediate watershed.
(3) Area of Emphasis	The Upper Guadalupe, Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.

(4) Education Target	River users for recreation and general public.
(5) Schedule of Implementation	FY18-FY22: Continue routine crossings clean up, annual river clean up, and possibly continue summer litter patrols. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between solid waste runoff, littering, and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution.
(6) Interim, Measurable Milestones	Amount of trash removed. Number of participants in clean up events. Number of times storm water public service announcement is broadcast, number of newspaper articles highlighting this bacteria source, number of presentations including information about this bacteria source.
(7) Progress Indicators	Reduction in pounds of trash collected during clean up events.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA

6.4 Public Education

A central education component is an interactive kiosk to teach users about non-point source pollution and stormwater runoff. The kiosk supports the “Water Down the Drain” education program developed by the Center for Global Environmental Education at Hamline University and provides a focused learning experience in Spanish and English about surface-water pollution in urban environments. Users access the program through a multimedia computer kiosk. Each of the six modules consist of three to five minutes of interactivity on topics including the water cycle, storm water runoff and pollution, impervious cover, watersheds, and water testing. The program's administrative features allowed UGRA to track user activities. Table 20 summarizes use of the kiosk during the term of the “Bacteria Reduction Plan” grant. UGRA staff continues to rotate the kiosk among relevant locations in the community including the public library and Riverside Nature Center.

Table 20. Summary of interactive kiosk use

Location	Time Period	No. Modules Accessed in English	No. Modules Accessed in Spanish
Riverside Nature Center	January 2013 – June 2013	508	26
Butt-Holdsworth Memorial Library	July 2013 – March 2014	2,468	508

UGRA also made numerous presentations in classrooms, during field trips and at summer camps using the EnviroScape watershed model. The model helps people of all ages better understand the sources and prevention of water pollution through visual, hands-on interaction. EnviroScape makes the connection between what we do on the land and the impact those actions have on the health of our waterways.

Finally, radio public service announcements to raise awareness of the connection between stormwater runoff and water quality were developed by UGRA and are routinely broadcast on three local radio stations.

Table 21. Management Measure 6.4 – Reduce General Urban Runoff Contributions – Public Education

(1) Management Measure	Reduce contributions from general urban runoff through street sweeping, river clean ups, and storm water education programs.
(2) Best Management Practice	Increase awareness of storm water runoff as a bacteria source through the use of an interactive kiosk, presentations, and radio public service announcements.
(3) Area of Emphasis	The Upper Guadalupe, Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public in Kerr County
(5) Schedule of Implementation	FY18-FY22: Continue use of interactive kiosk to broadcast the “Water Down the Drain” educational program. Continue routine broadcast of public service announcement. Annually publish articles in local newspapers about the connection between solid waste runoff, littering, and water quality. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution. Continue to use the EnviroScape model to reinforce these messages.

(6) Interim, Measurable Milestones	Number of kiosk modules accessed. Number of times stormwater public service announcement is broadcast, number of newspaper articles highlighting this bacteria source, number of presentations including information about this bacteria source.
(7) Progress Indicators	Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to the Kerrville urban area.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA

Management Measure 7.0: Preserve riparian areas

New management measure in Revised I-Plan: Preserve riparian areas through education of riparian area structure and function and restoration efforts

7.1 Public Education

A riparian area is the place where the land and water meet and can be recognized by the unique combination of plants and animals that live there. This distinct habitat is the site of many interactions between river and bank that are vital to maintaining a variety of species. Riparian areas also provide numerous beneficial functions that support a healthy environment. Preserving and enhancing these important ecological features is a crucial land stewardship activity.

Riparian areas provide a variety of functions including filtering and reducing pollution into streams, reducing erosion, providing wildlife habitat, and creating shade to control water temperature. The distinct soil and vegetation form a network of roots and ground cover that intercepts runoff from upland areas and stabilizes the river bank. Riparian areas also capture rushing flood waters and slow them down so contaminants can be filtered out and water can be absorbed into the soil.

Riparian areas adjacent to urban waterways like the Guadalupe River in Kerrville help to mitigate impacts from stormwater runoff. Unfortunately, they are also some of the more vulnerable due to development of sought after waterfront real estate. UGRA’s public education program frequently features the topic of riparian structure and function during presentations to the public, newspaper articles, and live segments on local radio stations. UGRA also supplies a field guide to riparian plants (“Your Remarkable Riparian”) to any Kerr County landowners interested in learning

more about riparian areas and the function of the vegetation they support. Additionally, the interactive kiosk has also been modified to run the GBRA developed multimedia presentation “Components of a Riparian System”. This module rotates with the other kiosk content and has recently been presented in the main exhibit at Riverside Nature Center in Kerrville.

During the stakeholder review of this document, a stakeholder expressed the benefit of working in public streamside areas to create demonstration areas (i.e. grow zones) to show what healthy riparian areas look like.

Table 22. Management Measure 7.1 – Preserve Riparian Areas – Public Education

(1) Management Measure	Preserve riparian areas through education of riparian area structure and function and restoration efforts (new for revised I-Plan).
(2) Best Management Practice	Increase awareness of riparian areas structure and function, and the benefits they contribute to water quality.
(3) Area of Emphasis	Upper Guadalupe River watershed riparian areas including Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public in Kerr County and streamside landowners.
(5) Schedule of Implementation	FY18-FY22: Maintain awareness of riparian areas structure and function, and the benefits they contribute to water quality as an educational priority for UGRA. Work with public partners who manage streamside land to initiate a demonstration project showing a healthy riparian area.
(6) Interim, Measurable Milestones	Number of days kiosk module “Components of a Riparian System” is presented. Number of newspaper articles highlighting the function of riparian areas, number of presentations including information about the benefit of healthy riparian areas. Number of “Your Remarkable Riparian” field guides distributed. Number of workshops help focusing on the function of riparian areas. Number of healthy riparian area demonstration projects.
(7) Progress Indicators	Anecdotal accounts of understanding of riparian areas by the general public (awareness of the definition of the term and where the areas are found). Increased occurrence of grown zones adjacent to waterways.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.

(9) Responsible Organizations	UGRA
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7.2 Healthy Creeks Initiative

In 2018, UGRA partnered with the Texas Parks & Wildlife Department (TPWD) to manage and control a non-native, invasive plant, *Arundo donax* at no cost to landowners through a program called the Healthy Creeks Initiative.

Arundo is highly invasive and devastating to the health of Hill Country streams and rivers by worsening flooding, displacing native plants, destabilizing banks, contributing to erosion, increasing fire risk, and harboring other invasive species such as feral hogs. *Arundo* thrives in riparian areas and can quickly spread to become a monoculture in these sensitive ecosystems.

The Healthy Creeks Initiative is a voluntary partnership with landowners to protect and improve water quality and habitat health along rivers and creeks in the Guadalupe River watershed. This is done through the control of *Arundo donax* and by restoring healthy, diverse native plant communities in the riparian area. Interested streamside landowners can grant permission for TPWD to coordinate targeted, aquatic-approved herbicide application to *Arundo* on their property. This control method has the least impact on the stream ecosystem. UGRA promotes the control of *Arundo* and has facilitated the partnership of dozens of landowners with TPWD through the Health Creeks Initiative to combat the spread of *Arundo* in Kerr County.

Table 23. Management Measure 7.2 – Preserve Riparian Areas – Healthy Creeks Initiative

(1) Management Measure	Preserve riparian areas through education of riparian area structure and function and restoration efforts (new for revised I-Plan).
(2) Best Management Practice	Reduce the abundance of <i>Arundo donax</i> in the Upper Guadalupe River watershed
(3) Area of Emphasis	Upper Guadalupe River watershed riparian areas including the Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public in Kerr County and streamside landowners

<p>(5) Schedule of Implementation</p>	<p>FY18-FY22: Enroll landowners in the Healthy Creeks Initiative and begin to treat Arundo in Kerr County. Annually publish articles in local newspapers about the occurrence of Arundo and its impact on healthy function of riparian areas. Continue to emphasize this topic during presentations to student and adult groups about healthy riparian areas.</p>
<p>(6) Interim, Measurable Milestones</p>	<p>Number of landowners enrolled in Healthy Creeks Initiative, number of acres treated, number of newspaper articles discussing abundance of Arundo, number of presentations including information about Arundo.</p>
<p>(7) Progress Indicators</p>	<p>Reduction in abundance of Arundo in Kerr County.</p>
<p>(8) Monitoring Component</p>	<p>Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.</p>
<p>(9) Responsible Organizations</p>	<p>UGRA, TPWD</p>

7.3 Feral Hogs

Feral hogs are a major threat to agricultural production and to water quality in our creeks and rivers. The USDA has spent almost \$20 million trying to address the exploding feral hog population that has spread to 39 states and counting. Texas alone is estimated to have more than 3 million feral hogs with Kerr County’s population conservatively estimated at over 2,200. In Texas, the feral hog population has reached epidemic proportions. It’s causing an estimated \$52 million annually in agricultural damage and serious loss of vital riparian areas along creeks and streams resulting in contaminated waterways.

Feral hogs heavily use riparian areas to wallow and as travel corridors. It doesn’t take long for large groups of feral hogs to root up, trample and destroy these sensitive riparian areas. The loss of riparian vegetation due to rooting and trampling leads to increased runoff and erosion. The increased runoff contributes to sediment pollution in the waterway and carries bacterial contamination and nutrients from hog feces into the waterway. In some areas, hogs are contributing to water quality degradation so severe that the waterbody cannot support contact recreation (swimming, wading, etc.) or aquatic life. An example of this water quality degradation by feral hogs is occurring in a nearby area of the Guadalupe River basin in the Plum Creek Watershed. Plum Creek originates in Hays County and flows to the San Marcos river which in turn flows into the Guadalupe River downstream of Kerr County.

In 2017, UGRA partnered with Texas AgriLife Extension Service and Kerr County to increase funding of programs to control feral hog populations. These programs may include a bounty, trapping equipment, aerial harvesting, and/or technical assistance for trapping. Specifically, UGRA contributed funding that allowed the feral hog bounty to increase to \$20 per hog for FY18.

Table 24. Management Measure 7.3 – Preserve Riparian Areas – Feral Hogs

(1) Management Measure	Preserve riparian areas through education of riparian area structure and function and restoration efforts (new for revised I-Plan).
(2) Best Management Practice	Reduce the abundance of feral hogs in the Upper Guadalupe River watershed.
(3) Area of Emphasis	Upper Guadalupe River watershed riparian areas. Primarily outside of Kerrville City limits due to hunting area restrictions.
(4) Education Target	General public in Kerr County and hunters.
(5) Schedule of Implementation	FY18-FY22: Supplement feral hog bounty in Kerr County to encourage increased reporting and increased harvest of feral hogs. Annually publish articles in local newspapers about the connection between large feral hog populations, water quality, and healthy riparian areas. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution and healthy riparian areas.
(6) Interim, Measurable Milestones	Number of feral hogs harvested reported in Kerr County. Amount of bounty payments processed, number of newspaper articles discussing abundance of feral hogs, number of presentations including information about feral hogs as a contributor to <i>E. coli</i> bacteria concentrations.
(7) Progress Indicators	Reduction in abundance of feral hogs in Kerr County.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA, Kerr County, Texas AgriLife Extension

Management Measure 8.0: Promote green infrastructure

New management measure in Revised I-Plan: Promote green infrastructure to reduce stormwater runoff.

Stormwater runoff is the dominant mechanism by which nonpoint source *E. coli* loads are transported to receiving waters. Management of stormwater to reduce bacteria can be achieved with non-structural BMPs like riparian zone enhancement or preservation (see Management Measure 7.0), or with structural control measures like green infrastructure.

8.1 Rainwater Harvesting

Rainwater harvesting helps control stormwater runoff by diverting runoff from local stormwater infrastructure and reducing the threat of flooding. Stored rainwater also can be used for both outdoor and indoor uses from landscape irrigation to drinking water. UGRA currently promotes water conservation and watershed stewardship through rainwater harvesting with a rebate and a cost assistance program (<http://www.ugra.org/major-initiatives/rainwater-catchment>).

The Rainwater Catchment System Rebate Program is available to anyone with a Kerr County address and will reimburse eligible applicants 50% of their costs up to \$100 for their purchase of rainwater catchment system equipment. Limit one application per Kerr County address per calendar year. Maximum rebate amount was increased from \$50 to \$100 in 2017. Since the beginning of the program in March 2011, a total of 436 applications have been funded for \$20,073.69.

The Rainwater Catchment System Cost Assistance Program is a competitive application process to annually award \$2,500 towards a rainwater catchment system. Funding can be provided in a lump sum or split among projects. The program is open to all individuals, but the applications submitted by entities that promote water conservation education to the public will be given a higher priority. Funding is awarded annually in January and recipients will enter into a contract with UGRA outlining the terms of payment reimbursement. The program was initiated in 2017 and two recipients have each received \$2,500 to implement new rainwater catchment systems. Both systems function to supply a water source for irrigation and are used to educate groups visiting the facilities about rainwater harvesting.

Table 25. Management Measure 8.1 – Promote Green Infrastructure – Rainwater Harvesting

(1) Management Measure	Promote green infrastructure to reduce stormwater runoff (new for revised I-Plan).
(2) Best Management Practice	Promote rainwater harvesting.

(3) Area of Emphasis	Upper Guadalupe River watershed in Kerr County including the Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public in Kerr County and homeowners.
(5) Schedule of Implementation	FY18-FY22: Continue to fund the rainwater catchment system rebate program and cost assistance program. Annually publish articles in local newspapers about the connection between stormwater runoff and water quality, and the benefit of rainwater harvesting. Continue to emphasize this topic during presentations to student and adult groups about nonpoint source pollution and green infrastructure.
(6) Interim, Measurable Milestones	Number of rebates granted, and number of systems funded through cost assistance program. Number of newspaper articles discussing rainwater harvesting, number of presentations including information about rainwater harvesting and connection to reducing stormwater runoff.
(7) Progress Indicators	Increase use of rainwater harvesting in Kerr County. Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to the Kerrville urban area.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA

8.2 UGRA EduScape

In 2018, UGRA initiated a landscape renovation program to improve the aesthetics of the office building lot and create a demonstration area for numerous water conservation and stormwater detention practices. The educational landscape program, called UGRA EduScape, provides examples of rainwater harvesting, pervious surfaces, use of dry creek beds and bioswales, condensate collection, and xeriscaping. Each practice is identified and explained through interpretive signs and links to the UGRA website for additional information is provided as well (<http://www.ugra.org/major-initiatives/eduscape>). Future plans include routine tours to further demonstrate how the practices can be implemented in a residential or commercial landscape.

Table 26. Management Measure 8.2 – Promote Green Infrastructure – UGRA EduScape

(1) Management Measure	Promote green infrastructure to reduce stormwater runoff (new for revised I-Plan).
(2) Best Management Practice	Promote and demonstrate water conservation and stormwater detention practices.
(3) Area of Emphasis	Upper Guadalupe River watershed in Kerr County including the Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds.
(4) Education Target	General public in Kerr County and homeowners.
(5) Schedule of Implementation	FY18-FY22: Design and construct the EduScape in FY18. Complete the interpretive signs in FY18. Maintain the EduScape in FY19-FY22. In FY19, initiate educational tours of landscaping, add content to UGRA website to enhance interactive component.
(6) Interim, Measurable Milestones	Number of visitors to the UGRA EduScape. Number of visitors to EduScape section of UGRA website. Number of newspaper articles discussing green infrastructure practices that can be implemented in residential and commercial landscapes, number of presentations including information about green infrastructure and connection to reducing stormwater runoff and conserving water.
(7) Progress Indicators	Increase use of green infrastructure practices in Kerr County. Reduction in <i>E. coli</i> concentrations (or maintenance of low <i>E. coli</i> concentrations) at the monitoring stations adjacent to the Kerrville urban area.
(8) Monitoring Component	Water quality monitoring will continue in the affected watershed through the Texas Clean Rivers Program and UGRA in-house water quality monitoring programs.
(9) Responsible Organizations	UGRA

Control Action: Monitor and report *E. coli* concentrations from WWTFs.

Control Action 1

There is currently one waste water treatment facility (WWTF) which treats domestic wastewater in the Upper Guadalupe River Above Canyon Lake watershed. This WWTF (Hill Country Camp) is permitted to discharge effluent into an unnamed tributary to Town Creek, but the available Discharge Monitoring Report data indicate that there has been no discharge from May 2016 – July 2018. The permittee will monitor and report *E. coli* concentrations in their final effluent if/when they begin to discharge, and monitoring will then continue as required by the permit.

The goal of the monitoring is to ensure that the facility's effluent has concentrations less than the water quality stream standard for contact recreation. If monitoring results indicate concentrations approaching or exceeding the standard, the facility will make necessary operational changes to reduce bacteria concentrations.

In November 2009, the TCEQ's Commissioners approved Rule Project No. 2009-005-309-PR. The rulemaking adds bacteria limits for either *E. coli* for fresh water discharges or *Enterococci* for saltwater discharges to Texas Pollution Discharge Elimination System domestic permits in Chapter 309 and sets the frequency of testing for bacteria in Chapter 319.

The TCEQ is responsible for enforcement of compliance with permits. The goal of the monitoring is to ensure that the facilities' effluent has concentrations less than the limits stated in each facility's permit.

Implementation Tracking, Sustainability, and Milestones

The TCEQ and stakeholders in TMDL implementation projects periodically assess the results of the planned activities and other sources of information to evaluate the efficiency of the I-Plan. Stakeholders evaluate several factors, such as the pace of implementation, the effectiveness of BMPs, load reductions, and progress toward meeting water quality standards. The TCEQ will document the results of these evaluations and the rationale for maintaining or revising elements of the I-Plan, and will present them as summarized in the following section.

The TCEQ and stakeholders will track the progress of the I-Plan 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 Milestones** – A measure of administrative actions undertaken to effect an improvement in water quality.

Water Quality Indicators

Water quality indicators are a measure of water quality conditions for comparison to pre-existing conditions or water quality standards. Routine *E. coli* bacteria monitoring will occur within each of the identified impaired assessment units included in this revised I-Plan to track the success of management measures and control actions over time.

Follow-up monitoring will be conducted within the watershed throughout the implementation schedule. The monitoring strategy will consider the spatial and temporal aspects necessary to characterize trends in water quality that result from implementing the activities in this plan. Follow-up monitoring will also provide water quality data for evaluation of standards attainment. The monitoring program is expected to consist of routine sampling exercises that emphasize historical monitoring locations, with some potential modifications as needed. Water quality monitoring and data collection will occur routinely throughout the year. As stated in the TMDL report, the summer season represents the critical condition, during which time the study area has the highest levels of bacteria and contact recreation. The TMDL and respective reductions are based on the critical condition.

UGRA, with support from TCEQ, began a three-year monitoring regime in July 2008. The objective of this monitoring was to provide data for characterizing *E. coli* bacteria loads in the impaired reach. The scope of this monitoring included three types of surveys: synoptic sampling surveys, spatially intensive surveys, and animal (including bird) surveys.

UGRA has continued the synoptic (routine) monitoring plan established in 2008 through support from TCEQ due to a combination of funding from the Texas Clean Rivers Program and CWA §319. Currently, nine sites are monitored monthly as a continuation of the monitoring plan originally developed in 2008 (Figure 25).

The synoptic sampling surveys are used to determine temporal variations in *E. coli* levels at key locations within the study area. The synoptic monitoring is performed irrespective of hydrologic conditions. The second type of monitoring is spatially intensive surveys that were performed under base flow conditions. This sampling was designed to support the load determinations and was conducted in 2008, 2009, 2010, 2013, and 2014. For this monitoring the sampling density was much greater than that of synoptic sampling surveys. Sampling for spatial intensive surveys was performed at regular intervals along the length of the waterway and at any flowing outfalls or tributaries rather than at prescribed stations.

The last type of monitoring is the animal surveys. Animal surveys are used to determine the numbers and types of animals typically present along the impaired reach. These surveys have continued on a routine basis since 2008. Surveyed animals include humans, ducks, geese, bridge-roosting birds, and dogs. The data from these surveys combined with water quality sampling data can be used to measure the success of implementation measures.

The UGRA is responsible for coordinating the monitoring activities of the Clean Rivers Program in Kerr County. The data from these activities are included in the

TCEQ's Surface Water Quality Monitoring database (SWQMIS), which houses the primary data used for the state's biennial assessment of water quality. The UGRA collects data quarterly from 11 fixed stations within the Upper Guadalupe River watershed. During the summer months, UGRA also monitors bacteria levels at 21 swimming areas, but this data has not been included in SWQMIS since 2007. Progress related to these environmental indicators will be analyzed by UGRA and the TCEQ.

UGRA will continue to collect *E. coli* bacteria samples from established monitoring sites under a TCEQ-approved Quality Assurance Project Plan (QAPP) following TCEQ Surface Water Quality Monitoring Procedures Manual guidelines (https://www.tceq.texas.gov/waterquality/monitoring/swqm_guides.html#procedure). Results will be submitted to TCEQ for inclusion in future assessments through the Texas Clean Rivers Program (<https://www.tceq.texas.gov/waterquality/clean-rivers>). Conventional water quality parameters including nutrients and physiochemical parameters may also be collected to assist with continued fecal contamination source identification.

The TCEQ will assess Guadalupe River Above Canyon Lake every two years as part of developing the Texas Integrated Report of Surface Water Quality. If the Texas Surface Water Quality Standards criteria for contact recreation are revised or changes in the creek's water quality are observed, this plan will be modified. This management strategy allows stakeholders to learn and adapt the plan as progress is made. The ultimate goal is for the AUs of the Guadalupe River Above Canyon Lake to continue to meet water quality standards for contact recreation.

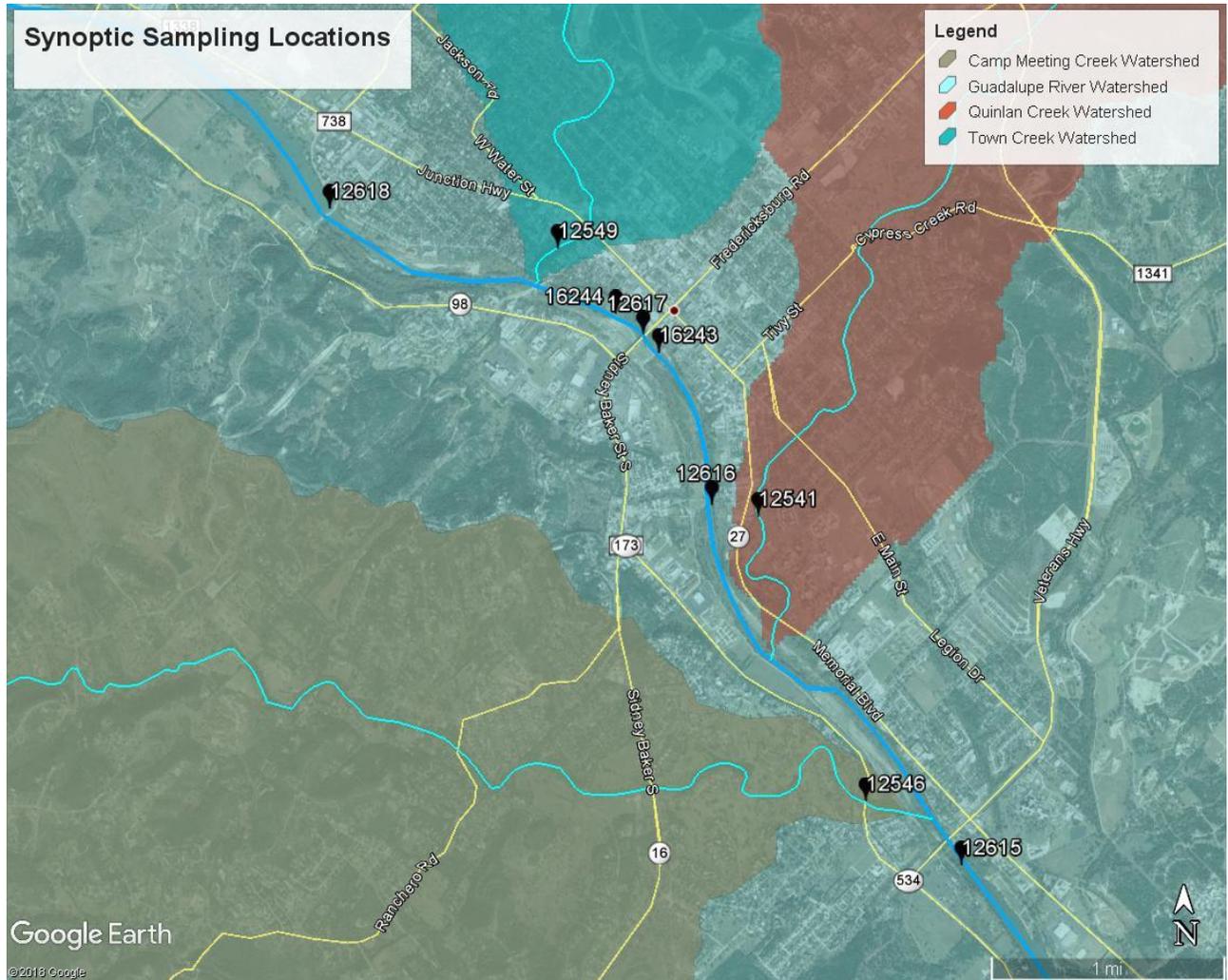


Figure 25. Location of monthly monitoring stations for *E. coli* bacteria

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 the actions taken, identify those which may not be working, and make any changes that may be necessary to get the plan back on target. Schedules of implementation activities and milestones for this I-Plan are included in the management measure tables included in the Management Measures 1.0 – 8.0 above.

Communication Strategy

Communication is necessary to ensure stakeholders understand the I-Plan and its progress in restoring water quality conditions. The TCEQ and UGRA will disseminate the information derived from tracking I-Plan activities to interested parties, including watershed stakeholders, state leadership, government agencies, non-governmental organizations, and individuals.

The TCEQ will report results and evaluations from implementation tracking as the information is provided by UGRA and will post that information on the TMDL website. Responsible parties are committed to providing appropriate information to the UGRA to update these progress assessments and communicating information at future meetings. Regionally, the progress and results of the I-Plan will be reported in annual reports prepared by the Upper Guadalupe River Authority under provisions of the Texas Clean Rivers Program.

In accordance with CWA §319, the state must annually report to U.S. EPA on success in achieving the goals and objectives of the *Texas Nonpoint Source Management Program*, including progress in implementing the NPS portion of TMDLs. The TCEQ and Texas State Soil and Water Conservation Board jointly publish *Managing Nonpoint Source Water Pollution in Texas: Annual Report*, which highlights the state's efforts during each fiscal year to collect data, assess water quality, implement projects that reduce or prevent NPS pollution, and educate and involve the public to improve the quality of water resources. Information derived from tracking and review activities of this I-Plan will be reported in each annual report. Previously published annual reports are available at www.tceq.texas.gov/waterquality/nonpoint-source/.

Stakeholders will continue to take part in future meetings organized by UGRA to evaluate implementation efforts. During those meetings, stakeholders will assemble and evaluate the actions, overall impacts, and results of their implementation efforts.

Summary and Discussion of Data Used

UGRA monitors water quality in the study area according to the Guadalupe-Blanco River Authority Clean Rivers Program QAPP. All data collected under this QAPP is submitted to TCEQ's Surface Water Quality Monitoring Information System (SWQMIS <https://www80.tceq.texas.gov/SwqmisPublic/public/default.htm>) on a routine basis.

Using data from FY2008 to FY2017, the geometric mean *E. coli* concentrations exceed the primary contact recreation criteria of 126 cfu/100 mL at 3 of 9 sites (Table 27). This table shows *the number of samples (#), year of first sample (First), year of last sample (Last), minimum E. coli measurement (Min), maximum E. coli measurement, geometric mean E. coli using all data within the times range (Geomean), and average instantaneous streamflow measured in cubic feet per second. Note that the average flow measurement is not based on the same number of samples as the E. coli geomean.*

Table 27. Summary of *E. coli* data used in this analysis

E. coli in MPN/100 mL. Highlighted cells exceed the 126 *E. coli* cfu/100 mL primary contact recreation criteria.

Site	Name	#	First	Last	Min	Max	Geomean	Average Flow
12618	Guadalupe River at Nimitz Dam	89	7/08	8/15	<1	170	7	47
12549	Town Creek at Hamilton Street	220	7/08	8/17	19	>4800	305	2.1
16244	Guadalupe River at South Foot Bridge to Tranquility Island (Louise Hays Park)	113	7/08	8/17	10	>2400	96	NA
12617	Guadalupe River at Highway 16 Bridge (Louise Hays Park)	113	7/08	8/17	6	>2400	71	NA
16243	Guadalupe River at Louise Hays Park Lake Dam	113	7/08	8/17	3	2000	53	NA
12616	Guadalupe River at G Street	118	2/08	8/17	4	>2400	43	66
12541	Quinlan Creek at Travis Street	163	7/08	8/17	2	>4800	260	0.90
12546	Camp Meeting Creek at Highway 173	189	2/08	8/17	3	>2400	171	0.66
12615	Guadalupe River at Kerrville-Schreiner Park	134	2/08	8/17	3	4800	80	104

Exceedances of the primary contact recreation criteria occur primarily on the tributaries to the Upper Guadalupe River with confluences in the City of Kerrville. The majority of the Town Creek, Quinlan Creek, and Camp Meeting Creek watersheds are residential and urban areas. The average streamflow rates of these tributaries are minimal and therefore do not contribute a large bacteria load to the mainstem of the Guadalupe River. Additionally, no contact recreation activities have been observed or documented by UGRA at the tributary sampling locations.

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