A WATERSHED PROTECTION PLAN FOR THE

EAST FORK SAN JACINTO RIVER WATERSHED

Photo Credit: Kendall Guidroz

EAST FORK SAN JACINTO RIVER WATERSHED PARTNERSHIP

Houston-Galveston Area Council

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

EPA United States Environmental Protection Agency

East Fork San Jacinto River Watershed Protection Plan

Developed for the East Fork of the San Jacinto River, Segment 1003 of the San Jacinto River Basin, by the Houston-Galveston Area Council on behalf of the East Fork San Jacinto River Watershed Partnership.

November 2023

Water Body	Segment	Assessment Units
East Fork San Jacinto River	1003	01, 02, and 03
Winters Bayou	1003A	01
Nebletts Creek	1003B	01
Boswell Creek	1003C	01

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EPA United States Environmental Protection Agency

Texas Commission on Environmental Quality

H-GAC Houston-Galveston Area Council

East Fork San Jacinto River Watershed Partnership

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Photo Credit: Kendall Goldrez

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Abbreviations List

AgriLife Extension	Texas A&M University AgriLife Extension
AU	Assessment Unit
BIG	Bacteria Implementation Group
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CBOD5	Carbonaceous Biochemical Oxygen Demand, 5-day
CFU	Colony Forming Unit(s)
CRP	Clean Rivers Program
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EQIP	Environmental Quality Incentive Program
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FOG	Fats, Oils, and Grease
GBEP	Galveston Bay Estuary Program
GIS	Geographic Information System
H-GAC	Houston-Galveston Area Council
HOA	Homeowners Association
I-Plan	(TMDL) Implementation Plan
Texas Integrated Report	Texas Integrated Report of Surface Water Quality
LDC	Load Duration Curve
LID	Low Impact Development

MGD	Million Gallons per Day
mL	Milliliters
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
MUD	Municipal Utility District
NGO	Non-governmental Organization
NHD+	National Hydrography Dataset Plus
NRCS	(USDA) Natural Resources Conservation Service
OSSF	On-Site Sewage Facility
Partnership	East Fork San Jacinto River Watershed Partnership
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SEP	Supplemental Environmental Project
SJRA	San Jacinto River Authority
SPCA	Society for the Prevention of Cruelty to Animals
SSO	Sanitary Sewer Overflow
SWCD	Soil and Water Conservation District
SWQS	Surface Water Quality Standards
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPWD	Texas Parks and Wildlife Department
TPDES	Texas Pollutant Discharge Elimination System
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
TST	Texas Stream Team

TWON	Texas Well Owner Network
TWRI	Texas Water Resources Institute
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WPP	Watershed Protection Plan
WQMP	Water Quality Management Plan
WWTF	Wastewater Treatment Facility

Supporting Documents

Several supporting documents providing additional detail about the analyses and processes the Partnership undertook to develop this watershed protection plan are hosted on the project website[1]. They include:

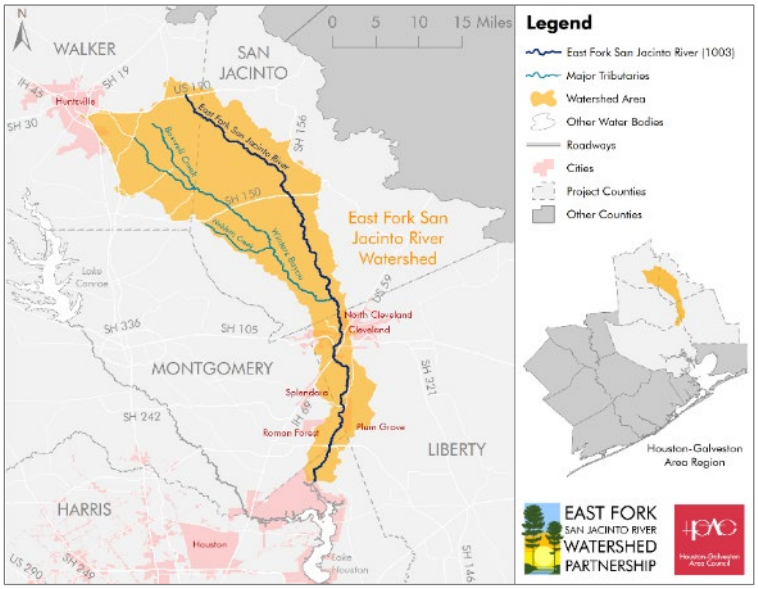
- **Quality Assurance Project Plan** – the quality assurance document indicating the manner and methods in which project modeling efforts were conducted to ensure results reflect project data quality objectives.
- **Acquired Data Analysis Summary Report** – a detailed report on analyses of various water quality data used to characterize the conditions in the project area waterways.
- **Bacteria Modeling Report** – a detailed summary of the development, implementation, and results of the bacteria modeling efforts.
- **Public Outreach Report** – a summary of the efforts and activities conducted by the Houston-Galveston Area Council to engage and inform project stakeholders, key partners, and general watershed audiences.

[1] Visit http://www.eastforkpartnership.weebly.com/ to lean more.

Executive Summary

The East Fork San Jacinto River Watershed

East Fork San Jacinto River (Segment 1003) runs south from headwaters in Walker County to a confluence with the Lake Houston reservoir, an important drinking water source for the region. Approximately 410 square miles of land area covering portions of Walker, San Jacinto, Montgomery, Liberty, and Harris counties, and spanning a landscape consisting mostly of forest and other natural land cover types form the watershed area. This area and its waterways represent an essential part of supporting local communities and economies, recreation, fisheries, and a diverse ecology.



Water Quality Challenges

High levels of fecal waste indicated by the presence of the indicator bacteria *Escherichia coli* (*E. coli*), are prevalent throughout the East Fork San Jacinto River watershed and are of particular concern as flows from East Fork San Jacinto River contribute to the Lake Houston reservoir. Elevated levels of fecal waste in area waterways can be a result of both human activities, such as overflow from sanitary sewers and on-site sewage facilities, as well as natural influences like waste from native wildlife and invasive species. Harmful pathogens associated with fecal waste can impact public health.

Water quality is sampled in East Fork San Jacinto River and its tributaries at least quarterly at 14 active monitoring stations, providing the basis for assessing the health of the system. As in past years, the 2022 Texas Integrated Report of Surface Water Quality (a summary of water quality in Texas waterways) indicates that East Fork San Jacinto River (1003) has a contact recreation impairment due to levels of *E. coli* that exceed the state water quality standard. Tributaries to the East Fork San Jacinto River also show high levels of bacteria, including Winters Bayou (1003A), which is impaired for contact recreation, and Boswell Creek (1003C), which has a concern for elevated *E. coli* levels.

The sources of water quality concerns and impairments in this watershed are widespread, diffuse, and diverse in origin, making them more difficult to address through traditional approaches focusing on single entities and regulation. Primary sources of concern are

livestock waste, wildlife waste, and waste from invasive feral hogs. Pollutant sources related to human activity will continue to increase as area growth drives future development in the watershed, exacerbating the existing situation. Watershed Protection Plan (WPP) project estimates indicate that necessary reductions of *E. coli* loads range from 35% to 38%.

Local concerns over the future of East Fork San Jacinto River led to the development of this WPP as a voluntary, locally-led approach to improving water quality for this area. The Houston-Galveston Area Council (H-GAC) and the Texas Commission on Environmental Quality (TCEQ) facilitated the formation and efforts of the East Fork San Jacinto River Watershed Partnership, a group of local stakeholders representing residents, government, industry, agricultural producers, community groups, and other local partners. The purpose of the WPP is to use sound science and local knowledge to identify sources of pollution and support community-led decision-making about potential solutions.

Finding Solutions

The Partnership used a variety of methods to evaluate the causes and sources of water quality issues. Interpretation of water quality monitoring data and computer modeling efforts were shaped by local knowledge. Local stakeholders reviewed and revised these results and used them to inform decisions about potential solutions. Specific focus was given to reducing fecal waste, which can directly impact human health, and precursors for low dissolved oxygen, which impacts aquatic life and recreational fishing. Activities to address fecal waste sources and other concerns were identified and discussed by members of the Partnership who worked diligently to balance local interests and ensure that solutions reflected community priorities. Because pollutant sources are diverse, the Partnership's recommendations represent a flexible range of solutions designed to adapt to changing conditions. The result of these efforts is a set of voluntary solutions that will guide efforts to improve water quality through 2040.

Implementing the Plan

Implementation of the WPP will require the continued coordination, cooperation, and commitment of the local partners. The general guidelines for implementation established by the stakeholders are that solutions should be voluntary, solutions should be cost-effective, decisions should continue to be made by local stakeholders, education should be a primary tool, due diligence should be given to avoiding unintended consequences, and that established programs or resources should be used whenever possible in place of new efforts. A crucial aspect of supporting these efforts will be an ongoing education and outreach campaign focused on increasing public awareness and participation. Successful implementation will rely on an active, engaged stakeholder group.

Ensuring Success

As the WPP is implemented, the stakeholders will review efforts periodically to ensure that progress is being made. The stakeholders established a series of milestones and measures of success to aid in determining whether progress is being made. The ultimate test of the WPP's success will be the ability of the waterways to meet state water quality standards based on water quality monitoring data. However, incremental progress will also be measured by achieving programmatic goals. The WPP will utilize adaptive management to modify approaches to meet new challenges and changing conditions. The following table is a guide to the contents of the WPP. Additional information on specific items can be found in Appendix A.

Watershed Protection Plan Content Guide

WPP Section	Description	EPA Element	Location
Section 1 – Project Background	An introduction to the watershed planning process for East Fork San Jacinto River	NA	pp. 1-7, Appendix A
Section 2 – Watershed Characterization	A summary of the physical (geography, climate, *etc.*), human (land use, political geography), and water quality characteristics of the watershed	NA	pp. 9-36, Appendix B
Section 3 – Identifying Pollutant Sources	An evaluation of water quality data, stakeholder knowledge and modeling results to identify and characterize causes and sources of pollution	• Element A – Identify the causes and sources of pollution	pp. 38-93, Appendix B
Section 4 – Improving Water Quality	Establishing the amount of reduction in pollutant source loads needed to achieve water quality goals	• Element B – Estimate of load reductions	pp. 95-110
Section 5 – Recommended Solutions	A description of the solutions recommended by the Partnership, including information about the selection process, and the cost and technical expertise needed to implement them	• Element C – Description of management measures • Element D - Estimate of technical and financial resources needed	pp. 112-151, Appendices C and D
Section 6 – Education and Outreach	An outline of the education and outreach efforts that will increase public awareness of the WPP and support its implementation	• Element E – Information and Public Education Component	pp. 153-164
Section 7 – Implementation	The schedules for implementation, and measurable milestones for tracking progress	• Element F – Schedule for implementation • Element G – Interim measurable milestones	pp. 166-183
Section 8 – Evaluating Success	An overview of the criteria and data that will be used to evaluate the success of implementation efforts	• Element H – Criteria for successful implementation • Element I – Monitoring component to evaluate effectiveness	pp. 185-190

Section 1

Project Background

Photo Credit: Kendall Guidroz

Section 1. Project Background

Background

The East Fork San Jacinto River Watershed Partnership (Partnership) developed this watershed protection plan (WPP) to address water quality issues in East Fork San Jacinto River and its tributaries. The purpose of this planning effort is to use a watershed approach to identify and reduce sources of contamination in the watershed through effective, voluntary solutions.

A Watershed Approach

A watershed is generally defined as all the area of land that drains to a common body of water. Watersheds can range in size from the drainage basins of large rivers to small catchments that may cover a few square miles of a local neighborhood. Regardless of the scale, they are more than just drainage boundaries. Watersheds are dynamic systems and represent the sum of everything that happens on that land. The way we use the land, the natural processes that take place on it, the way these things change over time; everything that takes place within a watershed influences the quality of the water that flows over it and into its water bodies (**Figure 1**[2]).

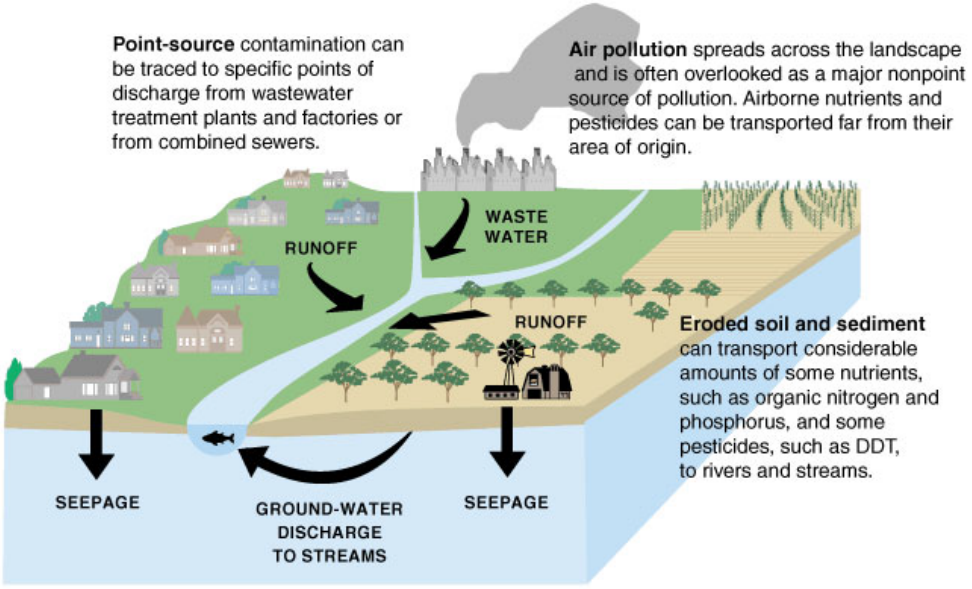


Figure 1. Pollution sources in a watershed

Because watersheds are determined by the topography of the land rather than political boundaries, they often cross multiple political jurisdictions. Water is not bound by political

[2] Image courtesy of United States Geological Survey (USGS)

geography; contaminants in the water can travel freely across borders. Pollution entering the waterway in one part of the watershed can impact other areas downstream. This fundamental aspect of watersheds limits the ability of individual political entities to wholly address sources of contamination in their waterways.

A **watershed approach** addresses water quality issues by focusing on both the waterways and their watershed as a linked system in which the drainage area's mix of land uses and potential sources of pollution are considered. Benefits of a watershed approach include:

- Reflecting the connection between land and water,
- Coordinating multi-jurisdictional efforts to focus on shared priorities, and
- Helping stakeholders understand potential future impacts to waterways based on the changing character of their watershed.

In Texas, the watershed approach to address water quality issues is often employed through the development of a WPP.

Watershed Protection Plans

WPPs are planning documents that serve as a road map for local communities to take active stewardship of their surface water resources. In Texas, most WPPs follow the United States Environmental Protection Agency's (EPA) nine element model[3], which outlines several key steps to characterizing a watershed, understanding its water quality challenges, and devising appropriate solutions. Developed through locally led planning projects, WPPs use scientific analysis and stakeholder knowledge to identify and characterize water quality priorities and identify voluntary solutions to meet specific goals. Unlike regulatory actions to restore water quality, the WPP process is a non-regulatory approach based on the use of voluntary management measures employed by local communities who have a stake in their waterways[4]. At the heart of the WPP process is a recognition of the value of natural benefits ("ecosystem services") provided by the watersheds.

Public participation is a core component of the WPP process because the successful implementation of a WPP relies on an engaged and committed stakeholder group. **Stakeholders** are defined as any person or group in the watershed who has a defined interest in the waterway or who may be impacted by the water quality issues or the WPP recommendations. Stakeholders can include residents, elected officials, local governments, landowners, agricultural producers, recreation enthusiasts, businesses, and community

[3] More information on EPA's guidance for developing watershed-based plans can be found at: https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

[4] While there are no mandatory elements recommended by this WPP, local partners currently engage in regulatory activities that are supplemental to this project as part of their normal operations (*e.g.,* enforcement of municipal pet waste ordinances).

groups. WPPs are best served by a diverse group of stakeholders who can represent the different interests in the watershed. The stakeholder group is often facilitated by state or regional organizations like the Texas Commission on Environmental Quality (TCEQ) and Texas State Soil and Water Conservation Board (TSSWCB) who use their expertise in watershed management to guide the stakeholders' efforts. Funding for WPPs is often provided through federal Clean Water Act (CWA) grants, some of which require matching funds or in-kind time from local stakeholders.

A Watershed Protection Plan for East Fork San Jacinto River

Water quality issues in the East Fork San Jacinto River system (Segment 1003) and local concern over the impact of future changes in the watershed were the impetus for undertaking a watershed-based plan. Previous projects in the greater Lake Houston Watershed area, including the Lake Conroe WPP, the East and West Forks of the San Jacinto River Total Maximum Daily Load (TMDL), the West Fork San Jacinto River and Lake Creek WPP, the Cypress Creek WPP, the Spring Creek WPP and various other TMDLs in the area established widespread local interest and commitment to address water quality[5]. The desire to evaluate these areas on a local level for East Fork San Jacinto River, and to consider other local concerns, led to the formation of the Partnership in 2022. The WPP model was chosen for its ability to address other local concerns in addition to surface water quality standard (SWQS) impairments and for its voluntary nature. Additionally, the intent to coordinate water quality issues with community concerns about hydrologic issues and sedimentation were at the forefront of local considerations.

The East Fork San Jacinto River Watershed Partnership

The Partnership is a group of local stakeholders from various interests and partner agencies committed to protecting the public health, economy, and environment of their communities. Local facilitation of the Partnership was supported by the Houston-Galveston Area Council (H-GAC) as part of a joint project with TCEQ, funded through a CWA §319(h) grant from EPA. The Partnership is a voluntary association of stakeholders, holding no regulatory power. This WPP is a summary of the multi-year planning effort conducted by the Partnership and serves as guidance for future implementation activities. Using the watershed planning model, this plan is based on local decision-making supported by local knowledge, robust public participation, and technical and scientific analysis. The Partnership held six/seven full Partnership meetings and two rounds of topical Work Group meetings between December 2022 and October 2023 to discuss and provide feedback on a

[5] More information on these projects can be found at: https://www.h-gac.com/watershed-based-plans/

variety of water quality issues[6] (**Table 1**). Representation from a diverse range of local stakeholders ensured that recommendations of the group were vetted from multiple viewpoints and interests. All meetings were open to the public, and materials were disseminated on the project website and via email. A core group of stakeholders served as a Steering Committee, and the meetings operated under a set of ground rules spelled out in the project's public participation plan[7]. Topical Work Group meetings were held as needed throughout the project to allow for detailed conversation on specific topics. Work Groups made recommendations to the full Partnership for items that required more detailed knowledge or deeper deliberation.

Table 1. Meetings of the East Fork San Jacinto River Watershed Partnership and workgroups

Date	Meeting Type	Topics
Dec. 12, 2022	Partnership (hybrid; in-person option at Montgomery County AgriLife Office)	Project introduction, water quality data review, and invitation to nominate Steering Committee
Feb. 15, 2023	Partnership (virtual)	Steering Committee formation, water quality analysis, pollution source model review and discussion, and invitation to join Work Groups
Apr. 27 & May 2, 2023	Work Groups (virtual) • Human Sources & Pet Waste • Agriculture, Wildlife & Invasives	Review of water quality improvement strategies commonly implemented throughout the region, and call for suggestions of new implementation measures/ opportunities for collaboration
May 17, 2023	Partnership (virtual)	
Jun. 30, 2023	Work Groups (virtual) • Combined Human Sources & Pet Waste, and Agriculture, Wildlife & Invasives	Further discussion and revision of modeling results
Jul. 12, 2023	Partnership (virtual)	Discussion of model revisions, and introduction to implementation strategies
Aug. 30, 2023	Partnership (virtual)	Final discussion of updated model results, further discussion of bacteria reduction targets' effect on implementation strategy selection
Oct. 19, 2023	Partnership (hybrid; in-person option at Montgomery County AgriLife Office)	Selection of implementation strategies to include in the WPP and discussion of details related to each strategy such as responsible parties and milestones
DECEMBER 2023/JANUARY 2024	Partnership (virtual)	Planned meeting to discuss WPP draft and suggestions for revision before final agency review

[6] More information on the individual meetings and process can be found on the project website at: http://www.eastforkpartnership.weebly.com/

[7] See: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_efsjr_ppp_final.pdf

In addition, project staff held meetings with local stakeholders and groups to gather more local knowledge and seek additional feedback. Local agencies and other organizations (*e.g.*, local Soil and Water Conservation Districts) served as non-voting technical advisors who helped provide expert knowledge and guidance to support the Partnership and coordinate its efforts with other local projects. Project staff further supported the efforts of the Partnership by engaging the public at local outreach events throughout the project.

Water Quality Goals

As part of developing the WPP, the Partnership developed a set of water quality goals that shaped their approach. Subsequent sections of this WPP expand on the details of how the Partnership established recommendations to meet these aims, and how they will be implemented, but the broad water quality goals for the Partnership are:

- *Plan for 2040* — The stakeholders balanced the need to account for future growth in this developing watershed with the potential uncertainty of future projections past a 15-year window. Based on the level of water quality issues, the likely path of development in the watershed, and the need to phase implementation over time to reduce local burden, 2040 was selected as the end of the planning horizon. The stakeholders and project staff consider this a viable timeframe based on WPPs approved for similar areas.

- *Reduce fecal waste* — Potential fecal pathogens, as measured by the bacteria species *Escherichia coli* (*E. coli*)[8] as an indicator of fecal waste, are the primary focus of the Partnership due to their potential impact on human health, presence as an impairment for many of the segments of the watershed, and relationship to causes and sources within the scope of the voluntary WPP effort. The focus of this WPP is to reduce excess levels of human and animal waste in the water for the sake of public health, recreational economy, and regulatory compliance with the *E. coli* geomean SWQS criterion for primary contact recreation 1 (126 colony forming units (cfu) per every 100 milliliters (mL)). This goal involves identifying and quantifying causes and sources of fecal waste and developing recommended best practices sufficient to meet modeled reduction goals. **The priority goal of the WPP is to improve and maintain *E. coli* levels at or below the contact recreation standard (primary contact recreation 1).**

[8] Throughout this WPP, "bacteria" or "*E. coli*" should be taken to mean *E. coli* in its role as an indicator of fecal waste and its associated pathogens in water rather than specifically attributing potential health impacts to *E. coli*.

- *Address other stakeholder concerns* — The WPP model allows for the consideration of other local water quality issues outside SWQS impairments and concerns. No modeling or specific quantification was conducted for stakeholder concerns, but the goal of the project remains to support or selectively implement related best practices to reduce issues as appropriate. Specific concerns include trash and illegal dumping, and impacts from hydrologic issues in the watershed.

Guiding Principles

In addition to the water quality goals, the Partnership detailed some guiding principles throughout the development of the WPP. Those principles include an emphasis on:

- *Distinct areas* — While the various elements of the East Fork San Jacinto River Watershed are part of a single system, areas within the system are unique in character and challenges. The consideration of the differing needs of these watershed areas is built into this WPP process and recommendations.

- *Locally-led decisions* — While project staff and other parties may provide information and guidance to the stakeholders, the ultimate decisions for the WPP, within the bounds of the WPP model, will be made by local stakeholders.

- *Voluntary solutions* — The WPP will only include recommendations that are voluntary. Neither the Partnership nor H-GAC will exercise any regulatory mandate through this WPP.

- *Use what works* — Where existing programs with proven success are available, they should be used. The Partnership will seek to coordinate efforts with similar projects to ensure a limitation to redundant efforts. The Partnership recognizes and respects the efforts of local agencies, organizations and individuals and seeks to support rather than supplant them.

- *Coordination is key* — this WPP seeks to coordinate its aims and recommendations with hydrologic and environmental mitigation activity already occurring in the watershed.

- *Education and outreach are vital* — Education and outreach are important implementation elements of the WPP and are essential to future success. The Partnership will seek to be transparent and build relationships with the community at every feasible opportunity.

Section 2

Watershed Characterization

Photo Credit: Kendall Guidroz

Section 2. Watershed Characterization

Watershed characterization considers the natural features of the land, the human elements that interact with them, and the relationship these factors have with water quality. This represents the first step in understanding the causes and sources of pollution in the watershed to identify effective means to address them. Evaluating all elements and factors that shape the connection between land and water is part of a watershed approach to improving water quality.

Geography

The watershed area of East Fork San Jacinto River includes portions of Harris, Montgomery, Liberty, San Jacinto and Walker counties (**Figure 2**). Small cities such as Cleveland, North Cleveland, Plum Grove, and Roman Forest intersect or are completely contained within the watershed area. Large cities intersecting the watershed area include Huntsville and Houston. This drainage area is connected to the Houston metropolitan area by the US Highway 59/Interstate 69 (IH 69) transportation corridor and runs parallel to Interstate 45 (IH 45).

Regional Context

East Fork San Jacinto River and its network of tributaries drain into the Lake Houston reservoir. Lake Houston's prominence as a drinking water source, recreational venue, and as an integral part of the complicated hydrology of the San Jacinto River Basin make the contributions from East Fork San Jacinto River and other tributaries especially important in a regional context.

Watershed Delineation

The East Fork San Jacinto River watershed was delineated using a combination of existing data, map review, and field observations. The primary watershed and subwatershed delineations were developed from National Hydrography Dataset Plus (NHD+) watershed layers, with minor adjustments to reflect conditions on the ground, segregate tributaries, and normalize subwatershed size. NHD+ data was compared with United States Geological Survey (USGS) Hydrologic Unit Code 12 and 10 data, and other local sources. Compared to aerials and known hydrologic boundaries, the NHD+ data was closest to expected actual drainage patterns in this system. Staff conducted map surveys using online mapping and limited field reconnaissance to confirm assumptions.

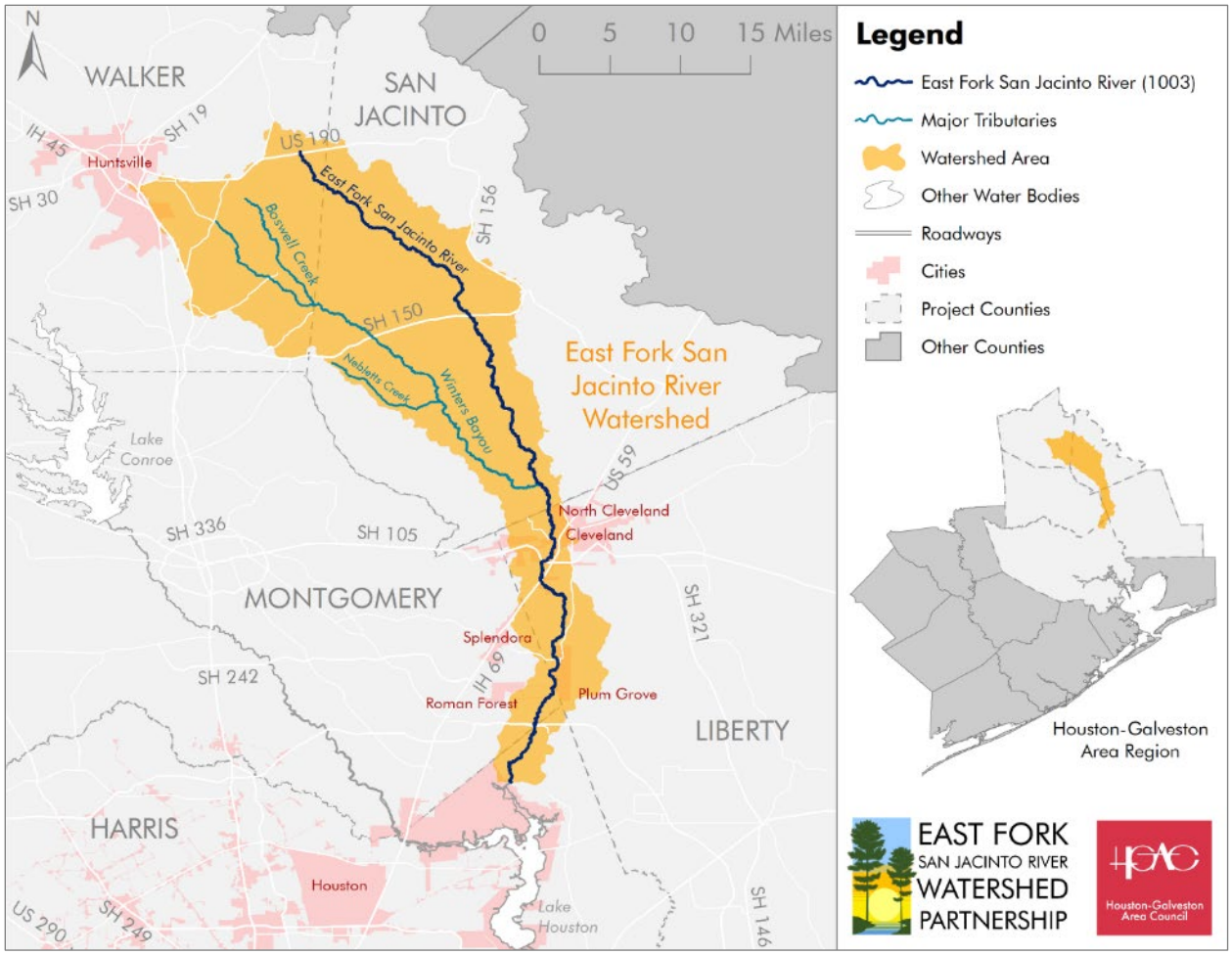


Figure 2. Regional context for the East Fork San Jacinto River watershed

Subwatersheds were further delineated from a selection of existing and continuing water quality monitoring stations to ensure the ability to evaluate these areas during the implementation of the WPP (**Figure 3**). Considerations for the selection of the stations were their ability to represent different areas of the watershed, the natural hydrologic elements of the watershed (*e.g.*, major tributaries), appreciable areas of developmental or land cover type, and general comparability in size. The resulting subwatersheds balance these interests, with the highest priority given to representation by ongoing monitoring stations at their terminal ends.

Stream Network and Drainage Area

The main channel of the East Fork San Jacinto River starts in the heavily forested areas of eastern Walker County. As it progresses south, the waterway grows in size. Once the main channel passes into more developed area south of SH 105, the waterway is a moderately sized creek in normal flow conditions. The stream network of the East Fork San Jacinto River watershed contains three primary tributaries (**Figure 4**). These are the unclassified

segments which are assessed by TCEQ and are the more prominent tributary systems in the watershed. They include:

- **Winters Bayou (1003A)** — Winters Bayou flows on the western side of the East Fork San Jacinto River watershed and is primarily characterized by more natural land types such as hay/pasture, varied types of forested land and wetlands.
- **Nebletts Creek (Segment 1003B)** — Nebletts Creek branches south of Winters Bayou just west of the bayou's confluence with East Fork San Jacinto River. It shares the same land cover types as Winters Bayou.
- **Boswell Creek (Segment 1003C)** — Boswell Creek branches north of Winters Bayou and is covered mainly in forested area.

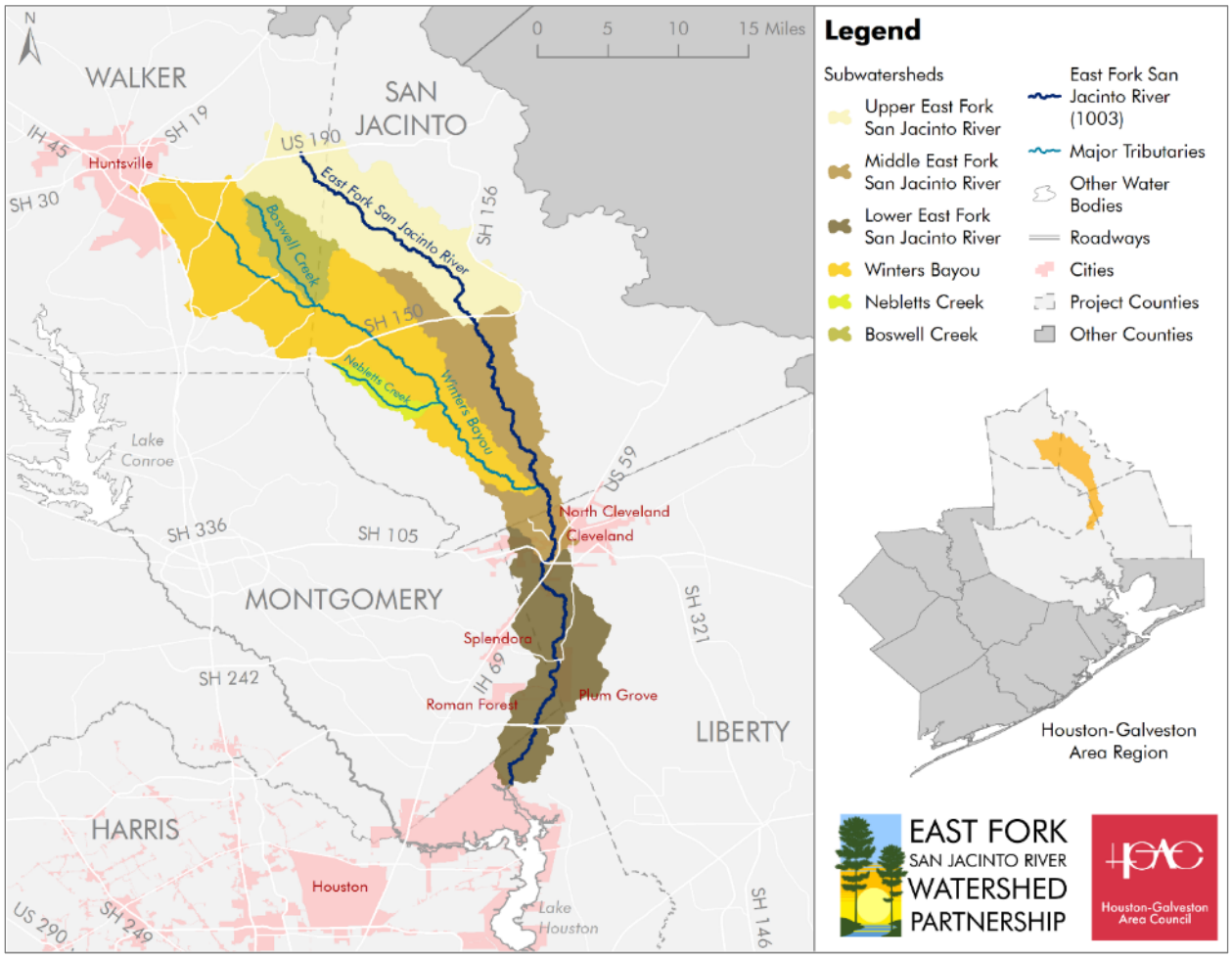


Figure 3. East Fork San Jacinto River subwatersheds

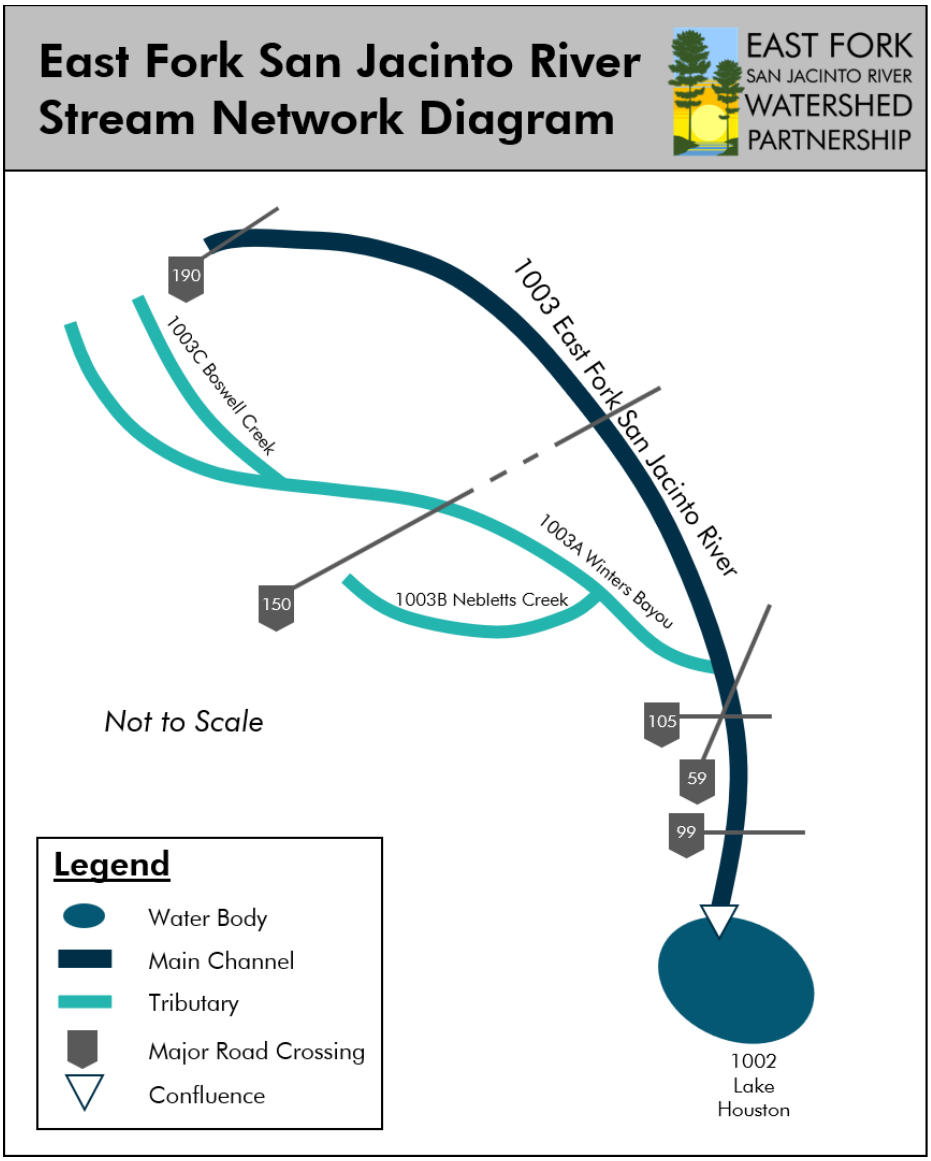


Figure 4. Stream network diagram

The full drainage area of the East Fork San Jacinto River watershed covers over 410 square miles (**Figure 5**). The drainage network includes both natural streams, modified waterways, and manmade drainage (channels and storm sewer systems) of varying size. Each of East Fork San Jacinto River's primary tributaries (Winters Bayou, Nebletts Creek, and Boswell Creek) are themselves networks of smaller tributaries and drainage conveyances.

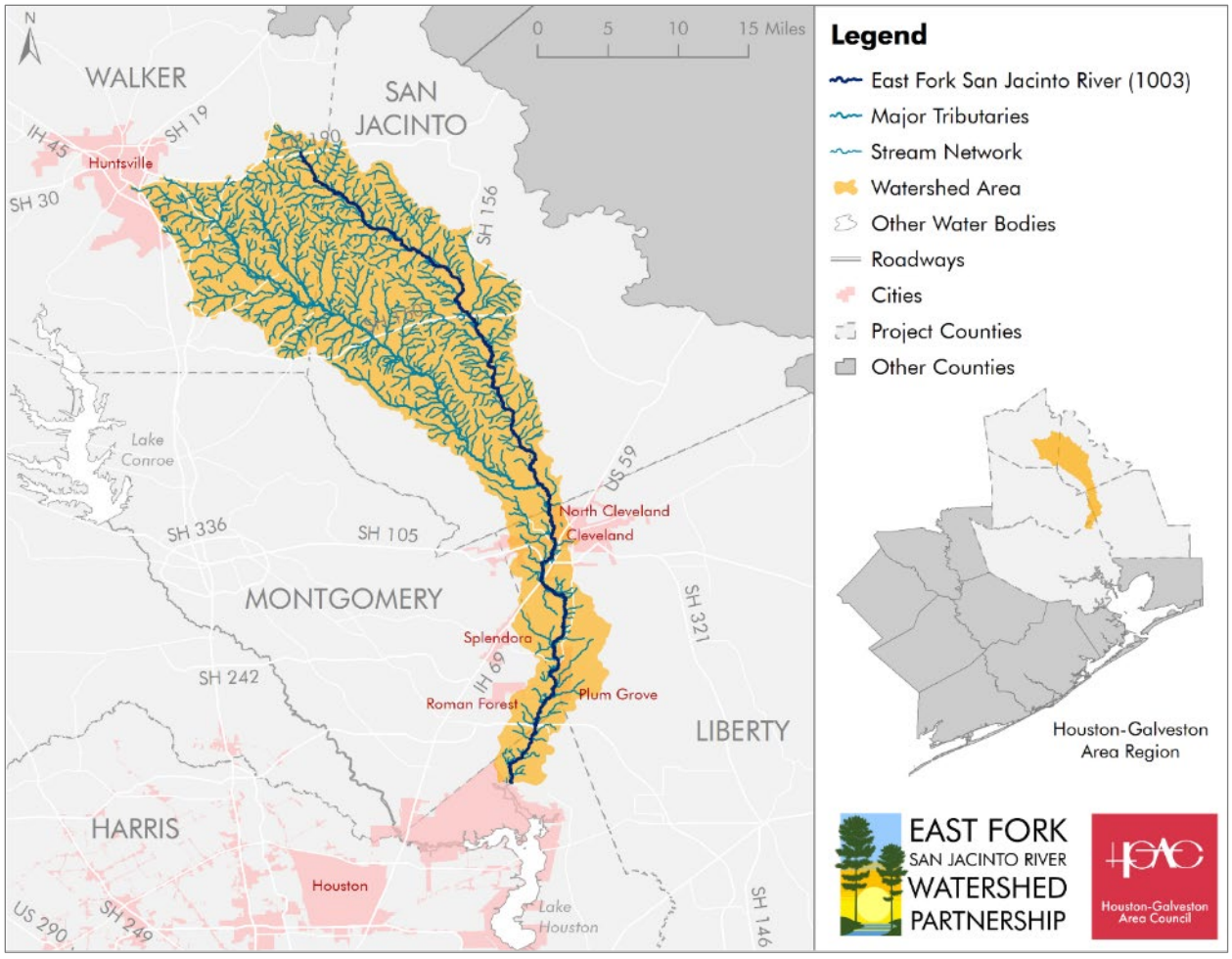


Figure 5. Hydrology in the East Fork San Jacinto River watershed

Political Geography

The watershed includes portions of Liberty County Commissioner Precincts 2 and 3, Harris County Commissioner Precinct 3, San Jacinto County Commissioner Precincts 1, 3 and 4, Montgomery County Commissioner Precinct 3, and Walker County Commissioner Precincts 2, 3 and 4. Representation at the national level includes United States House of Representatives Districts 2, 8, 17, and 36 (in addition to the United States Senate general representation). Representation at the state level includes Texas House of Representatives Districts 12,18, and 127; and Texas State Senate Districts 3, 4, and 5. In addition, the watershed overlaps the service area of a variety of other districts and authorities, including the San Jacinto River Authority, the Trinity River Authority, the Coastal Water Authority, the Harris County Flood Control District, and Harris County Flood Control District. Soil and Water Conservation Districts include those for Montgomery County, Harris County, Polk-San Jacinto County and Lower Trinity. Additionally, several other special purpose districts overlap with the watershed area.

Physical and Natural Characteristics

The physical aspects of watershed areas can impact how natural processes and effects of human development affect water quality.

Topography

Elevation generally decreases from northwest to southeast, and from headwaters toward the drainage pathways. There is a 161-meter difference between the highest and lowest points[9] of the watershed.

Climate

The climate of the area is categorized as humid subtropical, indicating it has winters cold enough to generate occasional freezing conditions. Average annual precipitation between 2006 and 2020 measured at the National Oceanic and Atmospheric Association station in Cleveland, Texas measured at 52.88 inches with the most rainfall occurring in the summer and the least occurring in the winter[10]. However, drought events can have appreciable effect on the area, as evidenced in the 2011 drought. Throughout this period, water elevations fell to record levels in downstream areas like Lake Houston—the reservoir into which East Fork San Jacinto River drains. Even though the watershed is not directly adjacent to the coast, the area is still well within the range of hurricanes and other large storms coming in from the Gulf of Mexico.

Soils

Fine-loamy soils[11] are found throughout the East Fork San Jacinto River watershed (**Figure 6**). Soils in the northern portion of the watershed tend to be more loamy and are especially fine along riparian areas. Very fine sediments are common south of Winters Bayou and in the riparian areas of the main stem just north of SH 150. South of SH 150 near Nebletts Creek, a high prevalence of clayey soils are found. Coarse-loamy sediments are more common south of the San Jacinto-Liberty county line. Erosion of soils is prominent in the alluvial sediments along the waterways.

[9] Based on USGS Digital Elevation Model 10-meter resolution spatial data.
[10] Accessed 11/3/2023 at: https://www.ncei.noaa.gov/access/us-climate-normals/#dataset=normals-annualseasonal&timeframe=15&location=TX&station=US1TXLR0013
[11] A key to the soil types represented in the map can be found at the link provided in this note. Data provided by: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Accessed on 11/3/2023 at: https://websoilsurvey.nrcs.usda.gov/. Soil survey dates and methods can differ from jurisdiction to jurisdiction and across time periods.

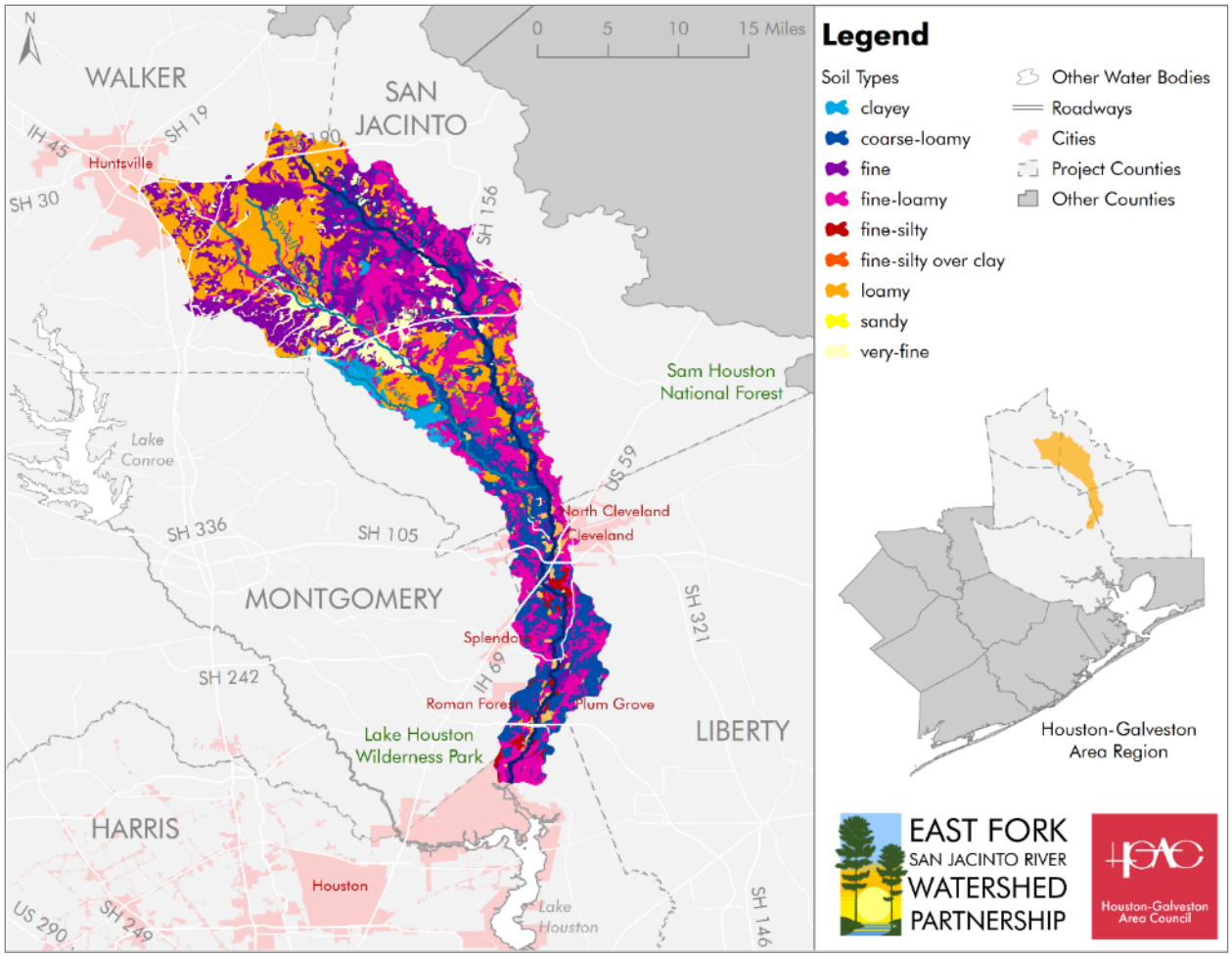


Figure 6. Soils in the East Fork San Jacinto River watershed

Habitat and Wildlife

The East Fork San Jacinto River watershed is fairly homogenous in that it only overlaps two designated ecoregions[12] (areas of similar climate, habitat, and landscape). The watershed is evenly split just north of the county line between San Jacinto and Liberty counties between the Southern Tertiary Uplands (EPA Level IV ecoregion 35e) in the north and the Flatwoods (EPA Level IV ecoregion 35f) in the south. Both of these designations fall under the broader South-Central Plains (EPA Level III ecoregion 35) designation.

This landscape hosts a diverse array of animal and plant species. Moderate winter temperatures and the location of the watershed in the Central Flyway for migratory birds support a dense and varied community of bird species year-round. Local bird species include wading birds (e.g., great blue heron, white ibis), a wide variety of passerine species, and several raptors (e.g., red-tailed hawk, bald eagle, barred owl). Typical mammal

[12] Based on EPA Level III (broad) and Level IV (more specific) Ecoregion data accessed on 11/3/2023 at: https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

species include white-tailed deer, Virginia opossum, raccoons, coyotes, eastern grey squirrels, striped skunks, nine-banded armadillos, and numerous species of rodents and bats. The watershed is also home to many common reptiles and amphibians, including *Nerodia* water snakes, red-eared slider turtles, and bullfrogs.

Of particular concern to the watershed are some of its invasive species. In addition to exotic plants (*e.g.*, Chinese tallow) and various invasive animals, feral hogs (*Sus scrofa*) are a growing issue for the Houston region and are present in the East Fork San Jacinto River watershed. Feral hogs threaten native wildlife species through direct competition for food and destruction of habitat. Large feral hog populations can cause damage on agricultural lands and are also a nuisance for suburban and exurban residential areas. Hogs tend to congregate in and around water bodies, causing damage to the riparian corridor and depositing fecal waste directly into the water body.

Land Cover and Development

The mixture of natural landscapes in the East Fork San Jacinto River watershed determines the density and transmission of pollutant sources, and considerations for implementing solutions.

Land Cover

In general, the watershed transitions gradually from undeveloped areas north of SH 105, to growing suburban/commercial areas in the southernmost portion of the watershed (**Figure 7**). Land cover in the watershed area is characterized by heavily wooded areas, especially in the portions of the watershed spanning Walker and San Jacinto counties. These areas are part of the Sam Houston National Forest. Pasture and woody wetlands are also common in these areas. The southern part of the watershed is more developed, especially in Liberty and Harris counties. Development is expected to expand as growing populations push north from the Houston area along the US Highway 59/IH 69 transportation corridor.

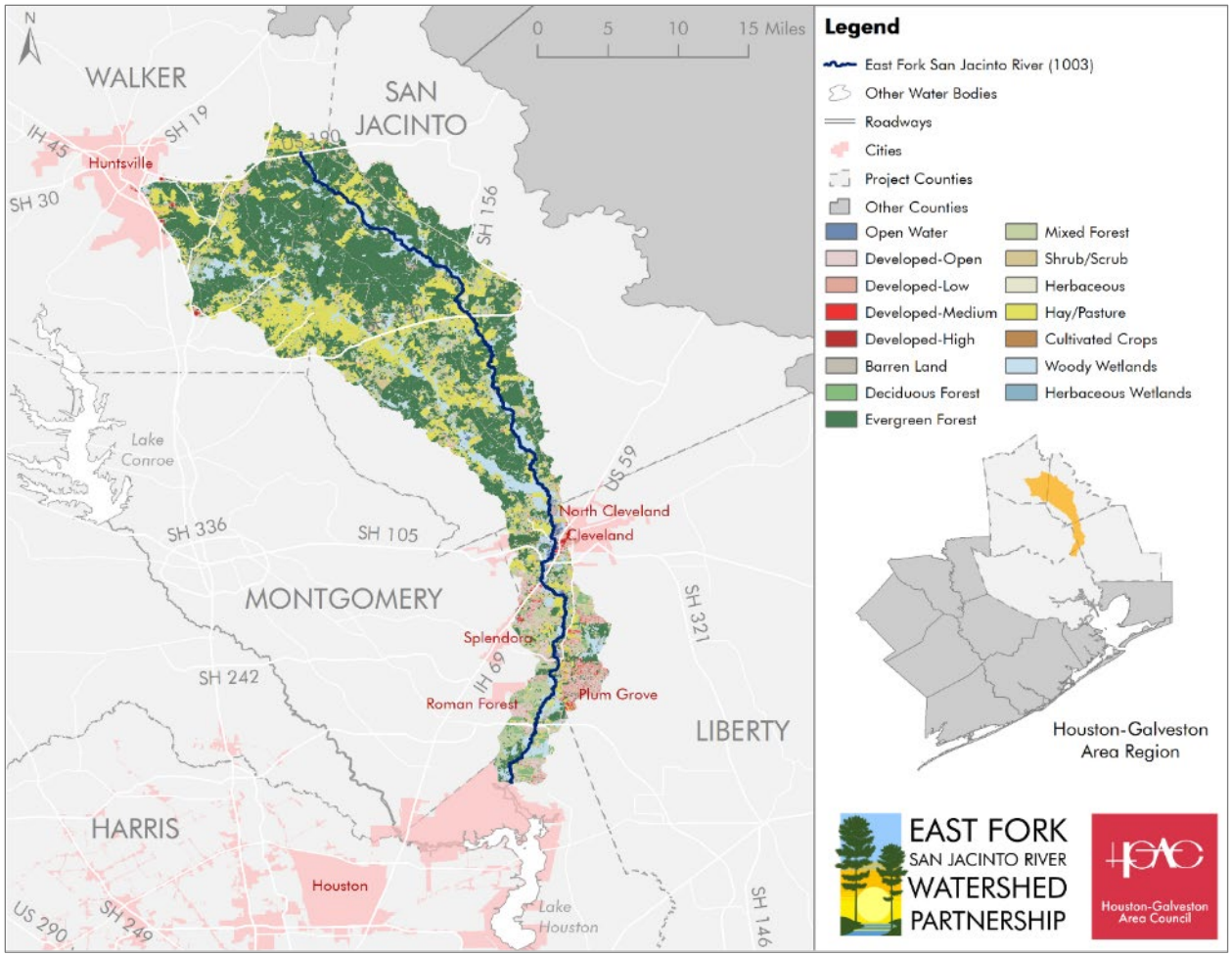


Figure 7. Land cover in the East Fork San Jacinto River watershed

Natural land uses make up the vast majority (~70%) of the total area of the watershed followed by agricultural uses (~19%). The approximate 11% of remaining area consists of developed areas (**Table 2**)[13]. The mix of land cover and uses in different areas of the watershed emphasizes the WPP focus on selecting locally-appropriate measures to address local challenges, identifying multiple areas in the watershed at which to monitor progress, and the need to coordinate with a broad array of partners throughout the watershed area.

[13] Data for this analysis represents 15-class data produced by H-GAC in 2020.

Table 2. Land cover as a percentage of watershed area

Land Cover Category	Percentage of Watershed Area
Open Water	0.83%
Developed - Open Space	7.24%
Developed - Low Intensity	3.00%
Developed - Medium Intensity	0.57%
Developed - High Intensity	0.15%
Barren Lands	0.42%
Deciduous Forest	1.27%
Evergreen Forest	43.54%
Mixed Forest	11.32%
Shrub/Scrub	0.62%
Herbaceous	0.92%
Hay/Pasture	18.64%
Cultivated Crops	0.02%
Woody Wetlands	11.41%
Emergent Herbaceous Wetlands	0.05%

Agriculture

Summary assessments below were derived from the United States Department of Agriculture (USDA) 2017 Census of Agriculture State and County profiles for Texas[14].

- **Harris County** – Harris County saw a 14% decrease in the number of farms, and an 8% decrease in the amount of land under production since 2012. Market value of sold products dropped by 22% in the same period. Most farms in the county are under 180 acres (92%) and many are under 50 acres (80%). However, there are several operations of 1,000 acres or larger. Current production value is heavily weighted toward crops (73%) as opposed to livestock (27%), but this is not reflected by total acreage for each type, with pastureland making up 62% of the total farmland, and cropland (24%) and other uses being smaller shares, proportionally. Only 5% of farmland is irrigated, and while agriculture is in overall decline in the county, over a third of the 3,106 producers are new and beginning. These numbers apply to the whole of the county and are not representative of the very small portion of Harris County overlapped by the watershed. Rather, this information is listed to provide context.

[14] Accessed on 11/3/2023 at: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Texas/

- **Liberty County** – Liberty County saw a 5% increase in the number of farms, but a 12% decrease in the amount of land under production since 2012. Market value of sold products decreased in this period by 14%. Like Harris County, most farms in Liberty County are under 180 acres (84%). Farmed land area is similarly weighted toward pastureland (47%), with cropland being a smaller share (27%). The share of sales for each type show that cropland represents 40% of sales value, and livestock makes up the remaining 60%. Only 2% of farmland is irrigated.

- **Montgomery County** – Montgomery County saw a 1% increase in the number of farms, but a 7% decrease in the amount of land under production since 2012. Market value of sold products increased by 8% in the same period. Most farms in the county are under 180 acres (90%) and many are under 50 acres (69%) Current production value is largely weighted (74%) toward livestock. Cattle are the predominant livestock product by value. Most farmers (66%) are new or beginning with a majority (63%) between the ages of 35 and 64.

- **San Jacinto County** – San Jacinto County saw a 1% decrease in the number of farms, and a 25% decrease in the amount of land under production since 2012. Market value of sold products decreased in this period by 16%. Most farms in Waller County are under 180 acres (89%). Farmed land area is weighted toward pastureland (53%), with almost equal shares of cropland and woodland (20% and 24% respectively). Crops represented 35% of sales and livestock made up the remaining 65%. Only 1% of farmland is irrigated.

- **Walker County** – Walker County saw an 8% decrease in the number of farms, and a 19% decrease in the amount of land under production since 2012. Market value of sold products decreased in this period by 2%. Like the rest of the project counties, most farms in Waller County are under 180 acres (86%). Farmed land area is mostly pastureland (55%), with woodland being the next largest category (27%). Crops yielded 57%of sales and livestock generated 43%.

Recreation

East Fork San Jacinto River is a popular destination for a variety of recreational activities Many of the prominent parks and natural areas[15] are adjacent to the creek system and are points of access for recreation (**Figure 8**).

[15] This map is not exhaustive of all parks in the watershed.

Among the most significant natural areas in the watershed is the Sam Houston National Forest[16]. The forest covers 163,037 acres across Montgomery, San Jacinto, and Walker counties. This area is not contiguous and is mixed in with privately owned farms and timberland. The forest is home to the 128 mile Lone Star hiking trail. Another prominent park overlapped by the watershed is Lake Houston Wilderness Park[17]. This park covers nearly 5,000 acres near New Caney, Texas. Over 20 miles of trails traverse the park. Both of these areas offer recreation opportunities such as camping, canoeing, fishing, and hunting.

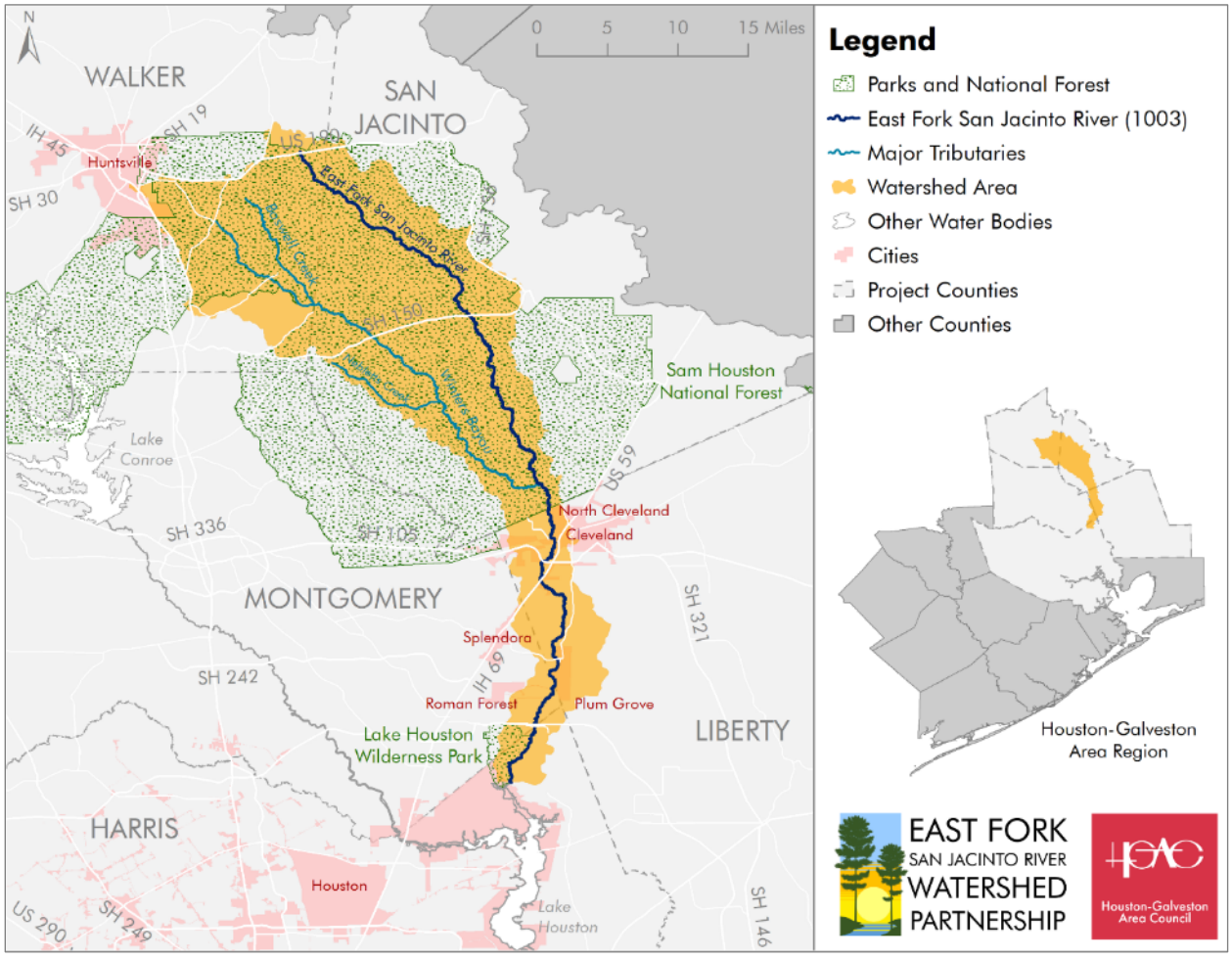


Figure 8. Parks and natural areas in the East Fork San Jacinto River watershed

Water Quality

For the State of Texas' routine water quality assessments of its water bodies, water quality parameters are strictly defined and tied to the uses we derive from a waterway (**Table 3**).

[16] For more information, see: https://www.fs.usda.gov/detail/texas/about-forest/districts/?cid=fswdev3_008443

[17] For more information, see: https://www.houstontx.gov/parks/lakehoustonpark.html

However, water quality for local stakeholders includes other factors specific to the values their community places on their local waterway, and they may have concerns not reflected in ambient water quality monitoring that range from other contaminants like trash to more qualitative concepts such as sense of place and aesthetic quality. This WPP recognizes that the defined water quality parameters discussed herein should be considered alongside other stakeholder concerns and valuations.

Water Quality Standards

For the lakes, creeks, streams, rivers, bays and bayous of Texas, water quality is evaluated based on SWQSs. Under the delegated authority of the CWA, TCEQ develops the SWQSs and is responsible for ensuring they are met. The intent of the standards is to establish explicit goals and limits to ensure Texas' surface waters continue to support recreation, drinking water supply, aquatic communities, and other established uses.

Table 3. Designated uses for water bodies

	The **aquatic life use** designation reflects the ability of the waterways to support aquatic ecosystems and habitat. Compliance with this use is determined by the availability of DO and an assessment of the diversity and health of existing ecological communities (fish, macrobenthics, and their habitat). High levels of chlorophyll-*a*, and elevated levels of nutrients, can indicate potential issues related to low DO.
	The **contact recreation use** designations indicate the waterway is used for recreational activities, such as swimming, that involve a greater chance of ingesting water. The basis of the SWQS for contact recreation standards is to protect public health. Ubiquitous fecal indicator bacteria organisms (*E. coli* and Enterococcus) are used as indicators of the potential contamination level from fecal pathogens. In freshwater systems like the East Fork San Jacinto River watershed, elevated levels of *E. coli* are a sign the waterway does not meet the SWQSs.
	The **public water supply use** designation indicates a waterway is used for public water supply. The assessment of compliance for this use is a measure of the suitability of the waterway to serve as a current or future drinking water source. A variety of criteria are used to evaluate this use, including temperature, total dissolved solids, DO, pH range, fecal indicator bacteria, chlorine, and sulfates levels.
	The **general use** designation reflects the overall health of the waterway as measured by criteria for temperature, pH, chloride, sulfate, and other parameters.

The vast network of surface water bodies is divided into segments, which are cohesive groupings of waterways and associated tributaries. The primary classified segment in the East Fork San Jacinto River watershed is Segment 1003 (East Fork San Jacinto River). Major tributaries or waterways of interest within these classified segments are delineated as

subordinate unclassified segments. Unclassified segments in this watershed include 1003A (Winters Bayou), 1003B (Nebletts Creek), and1003C (Boswell Creek). Other contributing waterways and drainage networks also contribute to the system but are either not designated as unclassified segments by TCEQ or are not actively assessed.

Surface water segments are further divided into assessment units (AUs), the fundamental targets for assessments that determine whether a water body is in compliance with applicable standards. AUs are designated as the segment number followed by the AU number (*e.g.*, 1003_01 for East Fork San Jacinto River, AU 1). AUs in the East Fork San Jacinto River system (**Table 4**; **Figure 9**) include:

Table 4. East Fork San Jacinto River segments and assessment units

Segment	Assessment Units
East Fork San Jacinto River - 1003	01, 02, and 03
Winters Bayou - 1003A	01
Nebletts Creek - 1003B	01
Boswell Creek - 1003C	01

Assessments are made based on data collected under the state's Clean Rivers Program (CRP) and other quality-assured data. TCEQ conducts assessments every two years for the state's water bodies, reviewing the previous seven years of data against the designated uses for the waterways. The results are included as part of TCEQ's 2022 Texas Integrated Report of Surface Water Quality (2022 Texas Integrated Report). The results of the assessments of the East Fork San Jacinto River AUs only reflect ambient surface water quality, not the quality of tap water provided by utilities in the watershed, which is not the focus of this WPP.

State of the Water

The water quality of the East Fork San Jacinto River system is affected by numerous factors, including human activities, natural processes, availability of rainfall, and releases and natural seepage from impoundments to which it is connected. Based on assessment of water quality data[18], many of the AUs in the watershed have existing water quality challenges. As development continues over the coming decades, additional sources of contamination may exacerbate these issues if no mitigating action is taken.

[18] For more information on detailed water quality assessments and modeling, refer to Section 3 of this document. For in-depth information on water quality trends in the watersheds, please refer to the *Water Quality Data Analysis Summary Report* available on the website for this WPP project at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf

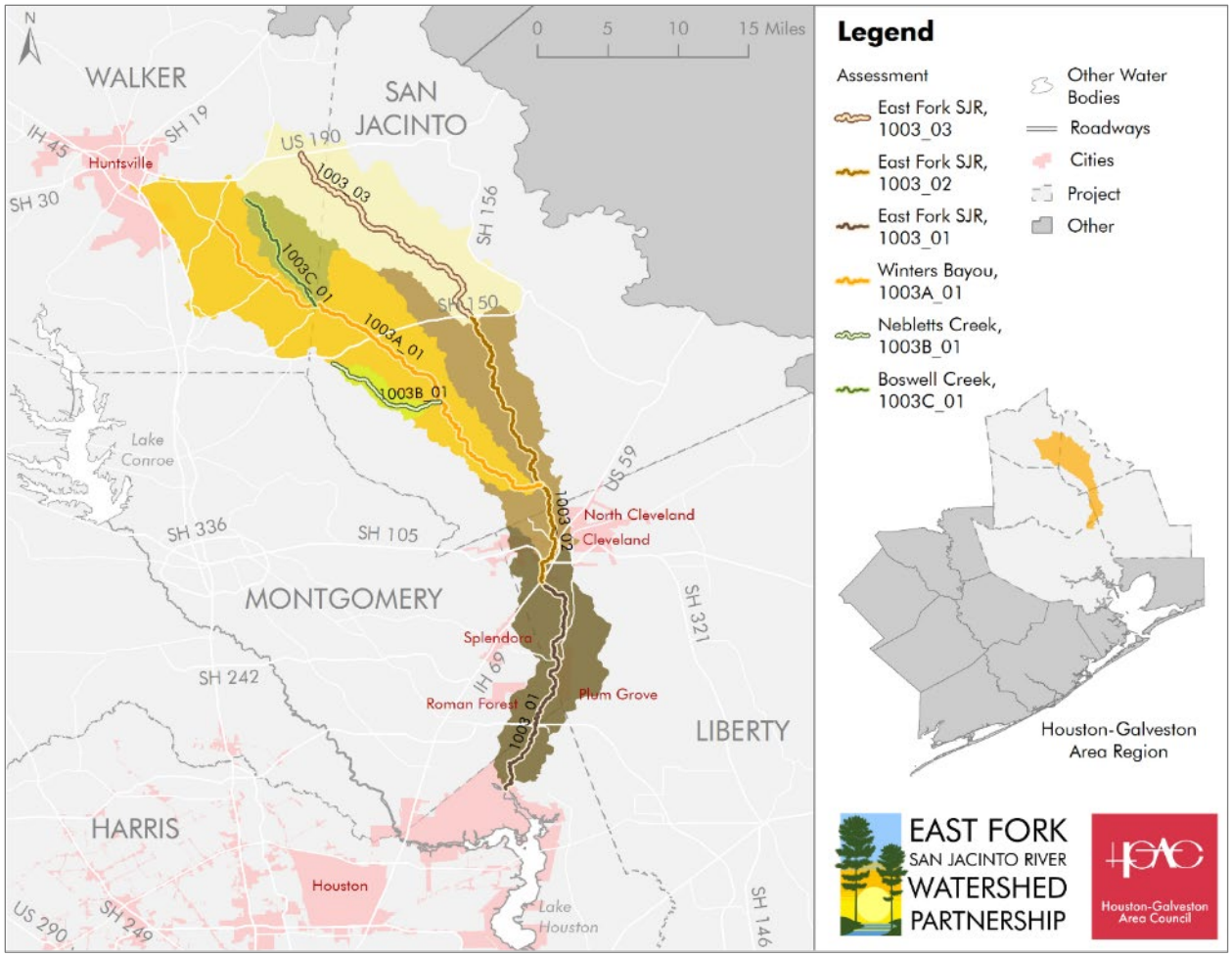


Figure 9. Segments and AUs in the East Fork San Jacinto River watershed

Impairments and Concerns

When a water body is unable to meet one or more of the SWQSs, it has an **impairment** for that standard. When an impairment may be imminent, or when substandard water quality conditions exist for a parameter that does not have an established numeric standard, the water body may be listed as having a **concern**. For example, water bodies are protected from excessive nutrient levels using screening levels. When concentrations of certain nutrients are above these screening levels, the water quality is characterized as a concern. Water quality in East Fork San Jacinto River and its tributaries is typical of challenges seen in other freshwater creeks and bayous in the area[19].

[19] References to assessments and water quality status refer, unless otherwise noted, to the 2022 Texas Integrated Report of Surface Water Quality, the most current report available at the time of publication.

According to recent versions of the Texas Integrated Report, current assessed water quality issues in East Fork San Jacinto River and its assessed tributaries include elevated levels of *E. coli* (**Table 5**). The contact recreation impairment exists across many of the watershed's AUs and is the primary focus of this WPP.

Table 5. Impairments and concerns in the East Fork San Jacinto River watershed, 2018-2022

Report Year	Assessment Units Impaired for *E. coli*	Assessment Units with Concerns for *E. coli*
2018	1003_01, 1003_02, 1003_03	1003A_01
2020	1003_01, 1003_02, 1003_03	1003A_01
2022	1003_01, 1003_02, 1003_03, 1003A_01	1003C_01

Other Concerns

While the primary focus of this WPP is to address water quality impairments and concerns, all water bodies have a range of issues that impact human and wildlife uses. The WPP model is inclusive of other stakeholder concerns as part of a broader effort to improve the waterway. During the development of this WPP, stakeholders identified several other issues as being secondary priorities for implementation activities.

Trash

Illegal dumping and ambient trash from stormwater are not reported by the stakeholders to be a widespread issue in the watershed, but implementation measures related to trash management are incorporated in this WPP as a precaution.

Flooding

While flood management is outside the scope of this WPP, changes to flow regimes or increased flooding can alter the impact of pollutant sources. These concerns are being included in this WPP based on their potential water quality impact, and the need to coordinate these efforts with the many flood mitigation projects underway or planned for the system.

Conservation of Natural Areas/Function

Using natural infrastructure to improve water quality, flood mitigation, maintain rural character, and protect natural landscapes and habitat was a standing concern among the stakeholders.

Section 3

Identifying Pollutant Sources

Photo Credit: Kendall Guidroz

Section 3. Identifying Pollutant Sources

The process of identifying, characterizing, and quantifying causes and sources of pollution in a watershed provides a rational basis for devising effective solutions to improve water quality. The Partnership used a variety of tools, combined with local knowledge and guidance, to investigate the water quality challenges facing the East Fork San Jacinto River watershed. The purpose of these efforts is to provide local stakeholders the information and context to make informed and effective decisions for their communities.

Investigation Methodology

The process of investigating causes and sources of pollution in the watershed used a series of successive steps to bridge the gap between the known existence of impairments and concerns, and the calculation of defensible estimations of causes and sources of pollution to meet the needs of the stakeholders[20].

Water Quality Goals

The applicability of each step to different pollutants/conditions of concern is based on the water quality goals established by the stakeholders (see Section 1) and is noted in parentheses for each step.

- **Water quality data analysis (all water quality issues)** — Project staff identified status and trends in ambient water quality monitoring data and discharge data from wastewater treatment plants. These analyses identify the extent and variability of water quality issues and highlight differences between areas in the watershed.
- **Source identification and feedback (all water quality issues)** — The Partnership used local knowledge, data from other efforts, field reconnaissance, and map analysis to identify potential sources. These steps help to shape subsequent analyses by focusing efforts on sources of priority in the watershed.
- **Source load modeling (fecal waste)** — H-GAC worked with the Partnership to estimate the potential amount of fecal waste/*E. coli* generated in the watershed using computer models guided by local knowledge and feedback. These efforts identified the potential total fecal loads, mix of sources responsible, and variation between different areas of the watershed.
- **Reduction/Improvement modeling (fecal waste, DO)** — H-GAC worked with the Partnership to estimate the amount of improvement needed to meet water quality standards for various areas in the waterway. Results were generated by computer

[20] More detailed information on the development of this investigation methodology and selection of models can be found in the Bacteria Modeling Report, located at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_4.3_bacteria_modeling_report_final.pdf

models using then-current water quality monitoring data. These processes generated the percent reduction for *E. coli* levels (see Section 4).

- **Source and improvement linkage (fecal waste)** — As the primary focus and sole impairment in the watershed, fecal indicator bacteria estimates were needed to establish numeric reduction goals for *E. coli*. This process applied the percent reduction targets from the improvement modeling to *E. coli* source load estimations to generate the amount of source load that needed to be reduced to achieve the water quality standard (see Section 4).
- **Coordinate with partner efforts (other concerns)** — Most specifically in the case of flood mitigation, the primary focus of developing recommendations for concerns outside the scope of this WPP was coordinating with partners.
- **Emphasize human wastewater as a priority** – While models may downplay the contribution of human wastewater, the stakeholders emphasized the greater risk human waste carries, the greater likelihood it is to be in proximity to our communities, and the potential for acute overflow events that do not reflect average daily loads.

Water Quality Analysis

Assessing water quality data sources is the first step in narrowing the search for the causes and sources of pollution. The Partnership reviewed analyses of 1) ambient water monitoring data, 2) volunteer water quality monitoring data, and 3) discharge monitoring reports (DMRs) and sanitary sewer overflow (SSO) data from wastewater treatment facilities. While these analyses are summarized here, greater detail on the methods and results can be found in the *Water Quality Data Analysis Summary Report*[21] prepared for this WPP. The primary goals of the analyses were to better understand water quality conditions, characterize the quality of wastewater contributions, and identify the availability of sufficient data for the models. The analyses focused on a five-year period of data to represent the most current conditions, but also relevant trends in recent years.

Ambient Water Quality Monitoring Data

Ambient water quality data are collected at over 400 sites in the 13-county Houston-Galveston region by H-GAC, local partners, and TCEQ as part of the Clean Rivers Program[22]. Most monitoring stations are sampled by CRP partners[23]. Waterways are

[21] Available on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf

[22] More information about this state-wide water quality monitoring program can be found at: https://www.tceq.texas.gov/waterquality/clean-rivers

[23] More information about the specific monitoring and programmatic details of the local CRP can be found at: https://www.h-gac.com/clean-rivers-program/information/

inherently dynamic systems, and water quality at any given time can vary greatly dependent on conditions at the time. However, a history of ambient water quality samples helps characterize the range of conditions that may be present in a waterway and is important for the identification of trends over time. The final determination of the regulatory status of each segment is based primarily on these ambient data. Goals and decisions for this WPP were established in part due to the regulatory status, and therefore ambient data is an important source of information for informing stakeholder decisions.

The East Fork San Jacinto River system is heavily monitored, with 14 active monitoring stations: seven on the main body, five on Winters Bayou (1003A), one on Nebletts Creek (1003B), and one on Boswell Creek (1003C; **Figure 10**; **Table 6**).

Table 6. CRP monitoring station locations in the East Fork San Jacinto River watershed

Station	Stream Segment	Assessment Unit
11235	East Fork San Jacinto River	1003_01
11236	East Fork San Jacinto River	1003_01
11237	East Fork San Jacinto River	1003_02
11238	East Fork San Jacinto River	1003_02
14242	East Fork San Jacinto River	1003_02
21939	East Fork San Jacinto River	1003_02
17431	East Fork San Jacinto River	1003_03
21417	Winters Bayou	1003A_01
21933	Winters Bayou	1003A_01
21935	Winters Bayou	1003A_01
21936	Winters Bayou	1003A_01
21937	Winters Bayou	1003A_01
21938	Nebletts Creek	1003B_01
21934	Boswell Creek	1003C_01

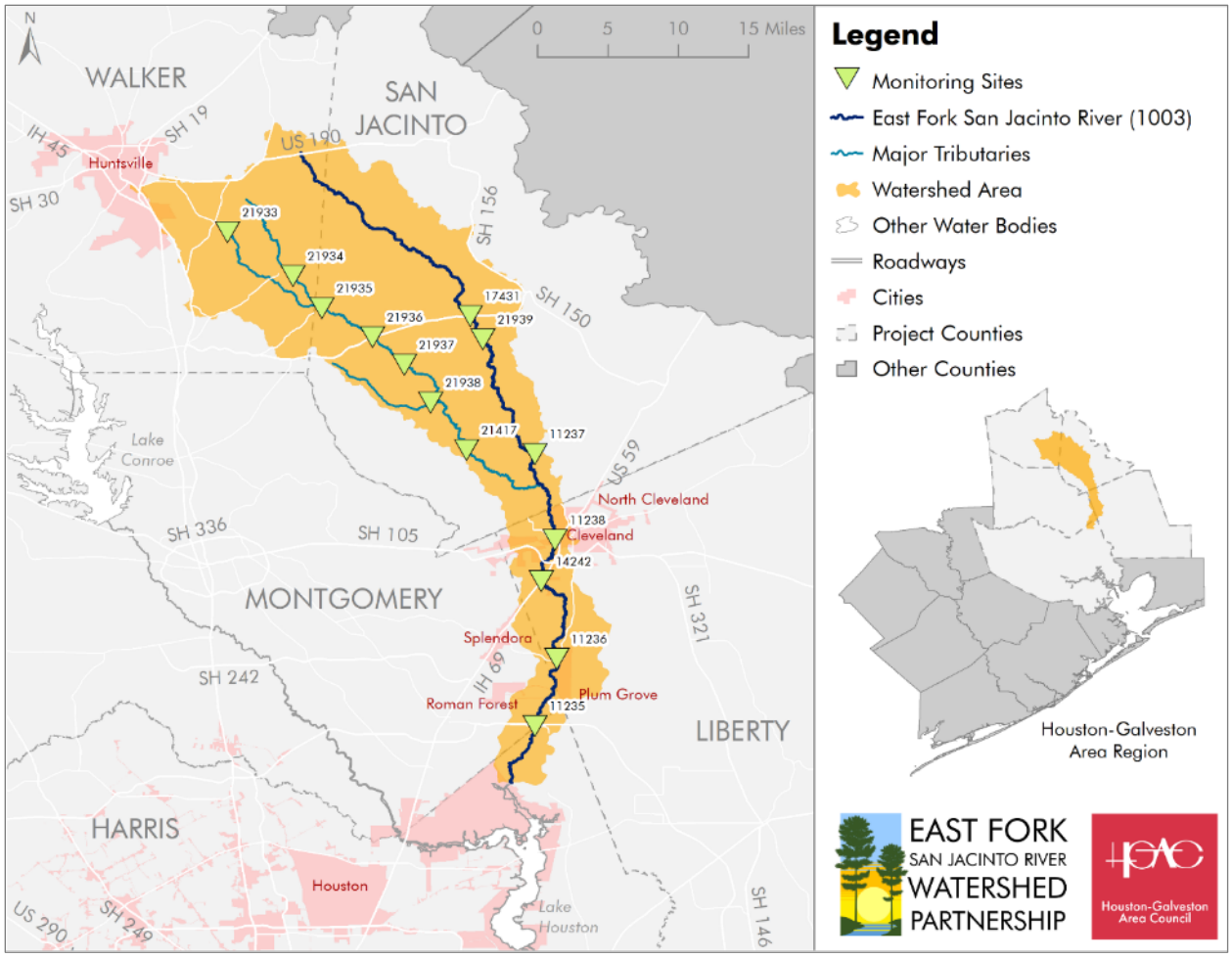


Figure 10. East Fork San Jacinto River watershed monitoring stations

Constituents of Concern

Routine ambient water quality monitoring under the CRP includes sampling for a suite of conventional, bacteriological, and field parameters. For this evaluation, a subset of those parameters most closely related to the goals of the WPP and characterization studies has been selected for in-depth analysis. The parameters reviewed were:

- *E. coli* — a bacterial indicator of the presence of fecal wastes, and an indicator of the safety of waterways for human recreation.
- DO (grab) — an indicator of the ability of the waterway to support aquatic life.
- Temperature — an indicator of a waterway's ability to hold oxygen, and a means for correlating other indicators to conditions in the waterways.
- pH — an indicator of the acidity or alkalinity of water, which may affect aquatic life and other uses.

- **Chlorophyll-*a* (Chl-*a*)** — an indicator of aquatic plant productivity and action, which can indicate areas in which algal blooms or elevated nutrient levels are present, and thus potentially depressed DO.
- **Nitrate (NO_3-N) and Nitrite (NO_2-N)** — a measure of nitrogenous compounds and indicator of nutrient levels (and thus potential DO impacts).
- **Ammonia Nitrogen (NH_3-N)** — a measure of specific nitrogenous compound that can impact aquatic life and is an indicator of nutrient levels and potentially of improperly treated sewage effluent.
- **Total Phosphorus (TP)** — an indicator of nutrient levels, especially in relation to potential for algal blooms and depressed DO in elevated levels.
- **Total Suspended Solids (TSS)** — a measure of the number of suspended particles in water that indicates the potential of light infiltration in the water column and the presence of particulate matter which *E. coli* may use as substrate.

The analyzed data covers 2011to 2021 to show a broad historic view. The primary questions this evaluation sought to answer relate to:

- The sufficiency of the data to characterize conditions,
- The spatial component of variations in water quality conditions,
- The extent of water quality issues, and
- Trends in water quality conditions, including any observable seasonal patterns.

H-GAC completed the assessment on the segment level, with attention to any unclassified tributaries which may be experiencing water quality issues.

Monitoring Analysis

A summary of ambient data represented as the geomean of each parameter for its period of record (2011 to 2021) is shown in **Table 7** below. This dataset is from TCEQ's Surface Water Quality Monitoring Information System and the period of record is designed to match that of the load duration curves mentioned in Section 4. These results are not directly comparable to that of the 2022 Texas Integrated Report which uses a different period of record (2013 to 2020) and assessment methodology for determination of Texas Surface Water Quality Standards attainment.

Table 7. Water quality monitoring geometric mean results by segment, 2011 to 2021

Parameter	Criteria	Unit	East Fork San Jacinto River, 1003	Winters Bayou, 1003A	Nebletts Creek, 1003B	Boswell Creek, 1003C
Temperature	NA	°C	*18.5*	*18.2*	*18.5*	*17.1*
DO, grab	Various	mg/L	7.2	6.3	8.6	6.9
pH	9 (high) 6.5(low)	NA	7.1	7.2	6.5	7.1
TSS	NA	mg/L	*16.9*	*13.5*	*5.1*	*36. 7*
Total Phosphorus	0.69	mg/L	0.1	0.1	0.1	0.1
Nitrate	1.95	mg/L	0.1	0.1	0.1	0.1
Nitrite	NA	mg/L	*0.1*	*0.1*	*0.1*	*0.1*
Nitrate and Nitrite	NA	mg/L	*0.1*	*0.1*	*No Data*	*No Data*
Ammonia Nitrogen	0.33	mg/L	0.1	0.1	0.1	0.2
E. coli	126	cfu/100mL	199.0	172.9	103.6	182.4

Note: Results shaded in dark gray indicate geomeans that exceed criteria or screening levels, while those shaded in light gray represent results that comply with criteria or screening levels. Italicized values indicate the data is not being compared to criteria or screening levels. This trend analysis does not reflect analysis or conclusions from the Texas Integrated Report.

Water Quality Parameter Trends

By examining all parameters collected from surface water samples in the East Fork San Jacinto River watershed and how measurements for those parameters have changed over time, statistically significant ($p < 0.0545$) trends in the data were determined. Of the ambient water quality parameters observed, geometric mean values for fecal indicator bacteria levels measured between 2011 and 2021 exceeded surface water quality standards in segments 1003, 1003A, and 1003C. No significant trends in *E. coli* over time were observed in any of the segments. Geometric means for nutrients such as total phosphorous, nitrate, nitrite, and ammonia nitrogen met the criteria in all segments. Though the trend analyses for nutrients generally did not yield significant results, nitrate measurements on segment 1003 and 1003A were observed to decrease significantly over time.

Relationship to Flow

Parameter measurements and their relationships to flow conditions were considered in this analysis. Further work on the relationship between flow and bacteria was completed as part of the model development explained in Section 4. According to

the results of the models, surface water in the East Fork San Jacinto River watershed is likely impacted by nonpoint source pollution. This is indicated by fecal indicator bacteria concentrations that are observed to increase with flow magnitude.

Ambient Data Analysis Summary

Of the ambient water quality parameters observed, geomean values for fecal indicator bacteria levels measured between 2011 and 2021 exceeded state water quality standards. Only Nebletts Creek (1003B) showed geomean values for *E. coli* within criteria levels. Unlike other water bodies in the Houston-Galveston Area region, nutrients do not seem to pose a challenge to water quality in the East Fork San Jacinto River Watershed. Likewise, levels of DO are well above the level of concern in all segments. Targeted assessment and application of best management practices could be expected to reduce or remove impairments and concerns in this watershed.

Stream Team Monitoring

While the WPP relies on quality assured data for trends analyses and model inputs, volunteer data provided by local Texas Stream Team (TST) monitors can be a valuable supplement to routine monitoring sites by providing hints at conditions in areas outside the existing data. One of the most valuable elements of TST data is the observational information from the volunteers. While there are currently no active TST sites in the East Fork San Jacinto River watershed, stakeholders have expressed interest in establishing a TST site to help identify WPP effectiveness going forward.

Wastewater Treatment Facility Discharge Data

Discharges from wastewater treatment facilities (WWTFs) are regulated by Texas Pollutant Discharge Elimination System (TPDES) permits from TCEQ which require stringent limits for effluent quality. Human waste can cause human illness, so identifying trends in permit exceedances for *E. coli* by WWTFs is important in understanding overall impacts to human health related to contaminated waterways. Additionally, effluent (especially if improperly treated) can be a source of nutrient or other precursors to depressed DO. At the time of this study, there are 10 permitted WWTFs with 11 outfalls in the East Fork San Jacinto River Watershed (**Figure 11**; **Appendix B**. Wastewater Treatment Facilities).

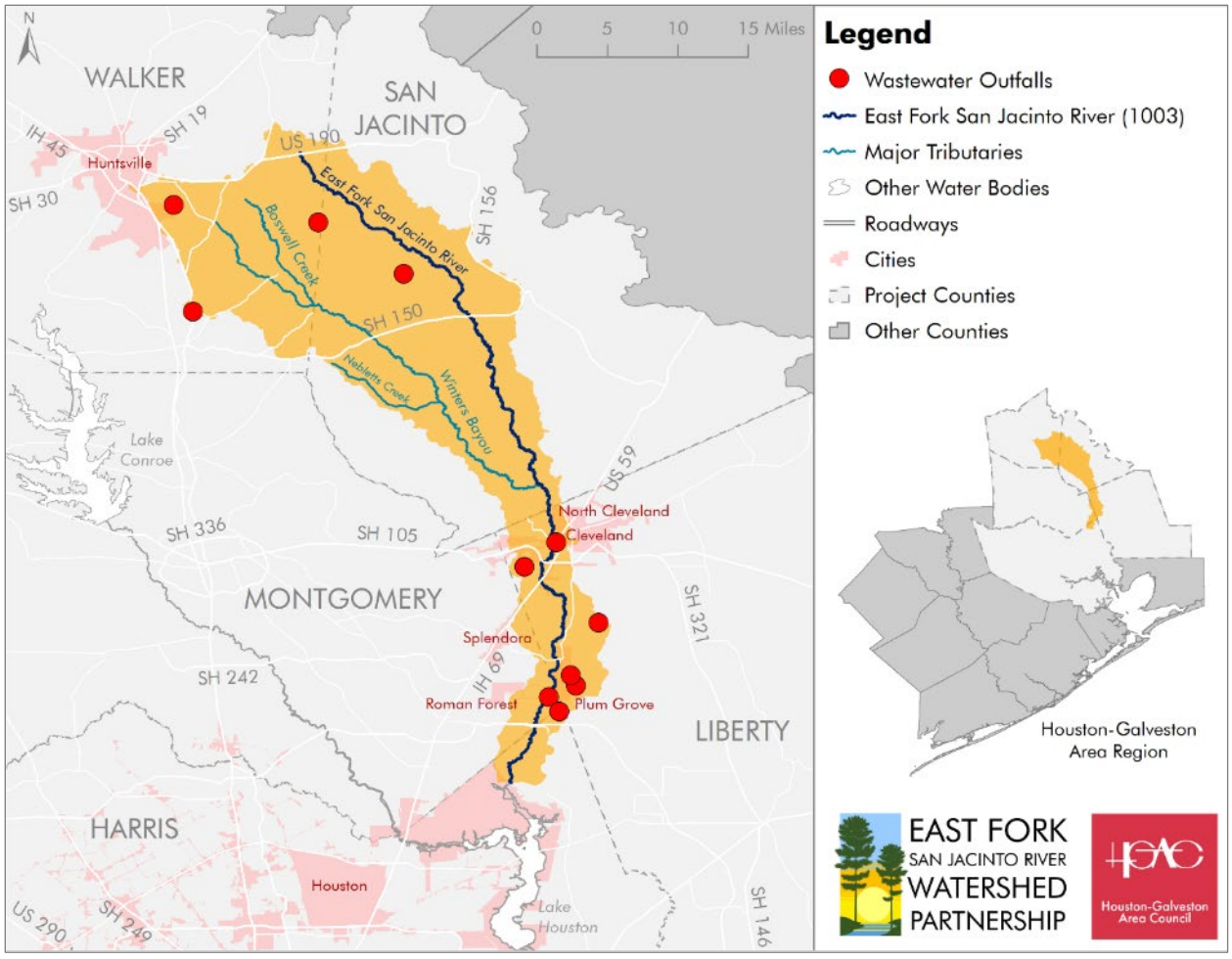


Figure 11. WWTF outfalls in the East Fork San Jacinto River watershed

Discharges from WWTFs are monitored on a regular basis (with a frequency dependent on facility size and other factors). The data from these required sampling events are submitted to (and compiled by) TCEQ as DMRs. As with any self-reported data, there is an expectation that some degree of uncertainty or variation from conditions may occur, but these DMRs are the most comprehensive data available for evaluating WWTFs in the watershed.

Project staff evaluated[24] DMRs from TCEQ reported between 2017 and 2021 by WWTF permit holders in the East Fork San Jacinto River watershed. Five parameters common to most WWTF permits were assessed including: *E. coli*, TSS, ammonia nitrogen (NH_3-N), DO, and five-day carbonaceous biochemical oxygen demand ($CBOD_5$). While some parameters are themselves constituents of concern, all are indicators of the presence or

[24] For more detail, see the Water Quality Data Analysis Summary Report on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf

potential presence of untreated/improperly treated waste[25]. The parameter evaluations were based on the regulatory permit limits specific to each facility, and consider the number of exceedances by each facility, in each year, in each segment, and as a percentage of the total samples.

E. coli

Effluent discharge from WWTFs is assessed for compliance with the TPDES permitted limits. For this analysis, DMR data were compared to TPDES permit limits for bacteria across segments, facility types, years, and seasons. The values for exceedances of geomean and single sample limits in **Table 8** were calculated for each facility depending on their specific permit limits. Several facilities in the watershed have more stringent bacteria limits than SWQS (e.g., 63 cfu/100mL) as required in a TMDL. However, when the WWTF bacteria loading was estimated in the SELECT process, an assumed effluent concentration of 126 cfu/100 mL was used for all facilities to get a high-end estimate for loading that the stakeholders felt was more appropriate. Exceedance statistics are summarized in **Table 8**.

Table 8. DMR bacteria exceedance statistics, 2017 to 2021

Parameter	Number of Facilities	Percent of Facilities	Percent of Reports
Facilities in DMR Dataset	10		
Facilities Reporting Bacteria	8		
Total Records	217		
Less than 1% Violations	6	75.0%	
1% to 5% Violations	2	25.0%	
5% to 10% Violations	0	0.0%	
10% to 25% Violations	0	0.0%	
Greater than 25% Violations	0	0.0%	
Exceedances of Geomean	1		0.4%
Exceedances of Single Grab	1		0.4%
Total Exceedances	2		0.9%

Note: Several facilities in the watershed have more stringent permit limits (e.g., 63 cfu/100mL) required in a TMDL. For DMR analyses, the actual permit limit for each facility was used.

Overall, the results of the analyses of DMR *E. coli* data indicated that the total number of exceedances reported was small relative to the total number of DMR reports submitted for the period of 2017 to 2021 (2 out of 217 records). Maximum

[25] In consideration of the nutrient loading capacity of the facilities, it should be noted that many nutrient parameters are not standard facility permit limits, and thus may not be tested. Based on review of correlations between nutrient parameters and flow for many stations, the analyses did show a likelihood of facilities as nutrient loading sources for non-permit limit parameters, particularly in effluent-dominated streams.

single grab values and geomean limits were each exceeded only once. Seasonality was not observed to be significant in shaping trends in bacteria concentrations. Plant age and size are also not believed to correlate in any way with the observed exceedances. While WWTFs may be appreciable contributions under certain conditions and in localized areas, the DMR analysis indicates that they are not likely a significant driver of segment bacteria impairments due to the comparatively few exceedances. However, due to the relatively higher risk of pathogens from human waste, and proximity to developed areas, WWTF exceedances are still a point of concern for stakeholders.

Dissolved Oxygen

DO levels in WWTF effluent help indicate the efficiency of treatment processes. DO is generally more stable in effluent than it can be in ambient conditions because it is less subject to natural processes and variation in insolation. DO is measured in milligrams per liter (mg/L), and the permit limits can vary based on the receiving water body and other factors. Unlike other contaminants, DO limits are based on a minimum, rather than maximum level, and represent a grab sample as opposed to a 24-hour monitoring event. Generally, permit limits for the data reviewed ranged between 4-6 mg/L. Evaluations for compliance with the permit limits were for all records, between years, and by season. Nine plants reported DO results during this period. The outcomes are summarized in **Table 9** below.

Table 9. DMR DO exceedance statistics, 2017 to 2021

Parameter	Number	Percent of Records
Facilities in DMR Dataset	10	
Facilities Reporting DO	9	
Total Records	367	
Total Exceedances	1	0.27%

Only one sample of 367 total reports fell below the minimum standard. After arranging the data temporally, no annual or seasonal trends were observed in the reported data. However, it is important to note that periodic impacts to DO levels may occur on a localized level but may not be well represented in this broad analysis. While the impacts of WWTFs on DO levels may not be a chronic or widespread issue in the watershed, an analysis of DO values reported in DMRs is still a critical component of this project especially as it pertains to identifying localized impacts.

Total Suspended Solids

To determine the efficiency of wastewater treatment in removing solids, TSS is evaluated. Bacteria use suspended particles as a protected growth medium and can therefore occur in greater concentrations when TSS is high. Additionally, TSS can be useful as an indicator that inefficient treatment may have led to other waste products (nutrients, *etc.*) being elevated in effluent. Permit limits for TSS include a concentration based (average) limit in mg/L and a total weight-based limit in pounds per day. Both average and maximum monitored results exist for most facilities. Evaluations for compliance with concentration and total weight permit limits were made for the overall dataset and for annual and seasonal data. The summary of reports made for TSS measurements, and the number of exceedances of the concentration and weight limits are presented in **Table 10** below.

Table 10. DMR TSS exceedance statistics, 2017 to 2021

Category	Number	Percent of Records
Facilities in DMR Dataset	10	
Facilities Reporting TSS	9	
Total Records	367	
Exceedances of Concentration	23	6.27%
Exceedances of Weight	2	0.55%
Total Exceedances	25	6.81%

The year with the most violations of both concentration and weight was 2019. These occurrences were observed after a year of no reported violations. In the following years (2020 and 2021), exceedances decreased back to the low levels observed in 2017. Of the four seasons, samples exceeding the concentration standard seem to be most prevalent during the summer and winter months. Exceedances of the weight standard were only observed during the spring. Though periodic, local impacts may not be captured by these results, water quality throughout the East Fork San Jacinto River watershed is unlikely to be impacted by TSS from WWTFs at the watershed level. A seasonal analysis showed that samples exceeding the concentration standard occurred with the highest frequency in winter and summer months, but the overall percentage of samples exceeding the standards compared to the total number of reports was negligibly small. Despite this, observing TSS in WWTF effluent is still worth considering when moving forward with best management practices for water quality. As mentioned previously, TSS is often correlated with nutrient and bacteria levels, and can be tracked as a measure of WWTF improvement.

Ammonia Nitrogen

Ammonia nitrogen is a component that indicates negative impacts to water quality due to nutrient loading. Further, it can be toxic to humans and wildlife. Deficiencies in wastewater treatment that lead to improperly treated sewage entering waterways can be indicated by elevated levels of ammonia nitrogen. Similar to TSS, concentration and weight measurements are used to assess compliance of ammonia nitrogen levels with permit limits. In **Table 11** below, the results of samples reported to be in exceedance of the limits as reported between 2017 and 2021 are summarized.

Table 11. DMR ammonia nitrogen exceedance statistics, 2017 to 2021

Category	Number	Percent of Records
Facilities in DMR Dataset	10	
Facilities Reporting Ammonia Nitrogen	9	
Total Records	367	
Exceedances of Concentration	25	6.81%
Exceedances of Weight	5	1.36%
Total Exceedances	30	8.17%

As seen with TSS, the most exceedances observed in one year occurred in 2019 after relatively low occurrences of exceedances in preceding years. When observed seasonally, exceedances of concentration and weight standards for ammonia nitrogen do seem to occur more frequently in the summer months. However, the total number of exceedances reported for ammonia nitrogen comprise less than 9% of the total reported values. This indicates that WWTFs are generally operating within permit limits and that ammonia inputs from WWTFs are not likely a chronic issue of importance for East Fork San Jacinto River waterways. Periodic, localized impacts may not be as apparent when using a broad scope analysis. Ammonia nitrogen may still have use as an indicator of WWTF efficiency much in the same way as TSS and will therefore continue to be considered for best management practices in the watershed.

Oxygen Demand

$CBOD_5$ measures the depletion of oxygen over time by biological processes and indicates the efficiency of treatment. It is not a pollutant itself but is informative of the water quality of effluent from WWTFs. In **Table 12** below, the exceedances of concentration and weight limits for $CBOD_5$ in relation to the total number of reported values are summarized.

Table 12. DMR $CBOD_5$ exceedance statistics, 2017 to 2021

Category	Number	Percent of Records
Facilities in DMR Dataset	10	
Facilities Reporting $CBOD_5$	9	
Total Records	367	
Exceedances of Concentration	6	1.64%
Exceedances of Weight	0	0.0%
Total Exceedances	6	1.64%

Annual exceedances were only observed in 2019 and 2020. Seasonally, there does seem to be a higher occurrence of exceedance in cooler spring and winter months. However, as with bacteria and DO, it should be noted that determining a trend from exceedance values occurring at such low frequencies might be misrepresentative of the overall dataset. From this analysis, it can be assumed that WWTFs are not likely a chronic source of poor CBOD5 values in the East Fork San Jacinto River watershed. As with previous analyses however, it should be noted that determining periodic and localized impacts may require further investigation.

Discharge Data Analysis Summary

Exceedances for all constituents compared to their permit limits were revealed in this analysis. However, plants in the East Fork San Jacinto River watershed were largely found to be in compliance with their permit limits for the majority of the period of study. It is unlikely that WWTFs are an appreciable source of contamination in the watershed on a chronic, wide-ranging scale. However, this broad analysis may underrepresent localized impacts of WWTF outfalls.

WWTFs may not be the largest source of bacteria, but effluent from these facilities has an inherently higher pathogenic potential than other sources due to the treatment of human waste. Additionally, unlike other sources of natural and diffuse fecal waste in the watersheds, WWTF effluent has both regulatory controls and voluntary measures by which improperly treated wastewater may be addressed. Given the nature of WWTF effluent as a human pollutant, and our direct ability to influence its character, WWTF bacteria should be considered as a potential focus for some best management practices. While other constituents (e.g., nutrients) are not necessarily any more harmful than other sources in the watershed, the principle of direct control of effluent applies to their consideration as well.

Sanitary Sewer Overflows

Though SSOs occur episodically, they represent a high-risk vector for bacteria contamination because they can have concentrations of bacteria several orders of magnitude higher than treated effluent. Untreated sewage can contain large volumes of raw fecal matter, making it a significant health risk where SSOs are sizeable and/or chronic issues. The causes of SSOs vary from human error to infiltration of rainwater into sewer pipes. Data used for these analyses is self-reported and may vary in quality. Even in the best of circumstances, the ability to accurately gauge SSO volumes or even occurrences in the field is limited by several factors. Actual SSO volumes and incidences are generally expected to be greater than reported due to these fundamental challenges. Known causes of SSOs were broken into four broad categories with several subcategories each, to reflect the breakdown in TCEQ's SSO database. It should be noted, however, that this categorization depends on the accuracy of the data reported by the utilities. Additionally, while a single cause is typically listed on the SSO report, many SSOs are caused by a combination of factors.

This study considered five years of TCEQ SSO violation data from 2017 to 2021. There were 22 SSO records from seven facilities considered for the watershed area. Of those, two plants had ≥ 5 SSOs, and of those two plants, only one had ≥ 10 SSOs. Number of SSOs generally corresponded to volume of SSOs.

The highest number of SSOs observed in one year occurred in 2019 as shown in **Table 13**. In terms of cause by number, the general category of weather-related issues accounted for 50.0% of the overall total, malfunctions and operational issues accounted for 40.9%, and 9.1% were listed as blockages.

Table 13. Number of annual SSO events

CAUSE	2017	2018	2019	2020	2021
Weather	**2**	**0**	**6**	**0**	**3**
Rain / Inflow / Infiltration	1		4		3
Hurricane	1		2		
Malfunctions	**4**	**0**	**1**	**3**	**1**
WWTF Operation or Equipment Malfunction	2			1	
Power Failure					
Lift Station Failure			1		
Collection System Structural Failure	1			1	1
Human Error	1			1	
Blockages	**0**	**0**	**1**	**1**	**0**
Blockage in Collection System-Other Cause				1	
Blockage in Collection System Due to Fats/Grease					
Blockage Due to Roots/Rags/Debris			1		
Unknown Cause	**0**	**0**	**0**	**0**	**0**
TOTAL	**6**	**0**	**8**	**4**	**4**

While numbering SSO events informs how frequently these overflows impact the watershed, volume of overflow is an indicator of the magnitude of impact. The results summarized in **Table 14** indicate that as with number of events, the highest annual volume of SSOs occurred in 2019. Of note, though 2017 had only the second highest total overflow volume reported over the five years of study, over 73% of the overflow volume was associated with a hurricane event (Hurricane Harvey). High flows associated with Tropical Storm Imelda in 2019 yielded over 84% of the annual SSO volume.

Table 14. Annual SSO events by volume (in gallons)

CAUSE	2017	2018	2019	2020	2021
Weather	**45,000**	**0**	**294,100**		**51,00**
Rain / Inflow / Infiltration	5,000		156,100		51,000
Hurricane	40,000		138,000		
Malfunctions	**9,300**	**0**	**54,000**	**10,600**	**1,000**
WWTF Operation or Equipment Malfunction	6,700			5,000	
Power Failure					
Lift Station Failure			54,000		
Collection System Structural Failure	2,500			4,800	1,000
Human Error	100			800	
Blockages	**0**	**0**	**150**	**100**	**0**
Blockage in Collection System-Other Cause				100	
Blockage in Collection System Due to Fats/Grease					
Blockage Due to Roots/Rags/Debris			150		
Unknown Cause	**0**	**0**	**0**	**0**	**0**
Total	**54,300**	**0**	**348,250**	**10,700**	**52,000**

Of the total volume of overflows reported from 2017 to 2021, weather was responsible for 83.8%. Malfunctions comprised 16.1% of the overall volume, and blockages led to the remaining 0.1%. These overall contributions are important to consider in a general sense for estimating impacts to the watershed area.

Report Data Analysis Summary

Of the seven plants that reported SSOs between 2017 and 2021, two had ≥ five SSOs, and only one plant had ≥ 10. The number of occurrences followed a similar pattern to that of overflow volume. There was not a strong annual or seasonal trend in number or volume of SSOs aside from the highest frequency and volume events occurring in 2019 in conjunction with Tropical Storm Imelda. In terms of general cause, weather accounted for the highest number of events and overflow volume respective to the other general categories of malfunctions, blockages, and unknown causes.

While this data is useful, it should be noted that it is also self-reported and may vary in quality. Overflow volumes and numbers of events may be greater than the values recorded in the report data. In addition, causes may be overgeneralized due to multiple factors ultimately resulting in SSOs.

In watersheds where bacteria loading is of particular concern, the impacts of SSOs are important to understand due to their concentrations of untreated human waste. These events pose a high risk to human health especially due to their proximity to urban populations. Further, despite their episodic occurrences, SSOs can be extreme loading sources in the sense of volume introduced in a short time frame. Though SSOs do not have the same potential to have chronic impacts on waterways as effluent from high volume WWTFs, for the aforementioned reasons, it is still critical to consider SSO management among the best management practices selected to improve water quality in the East Fork San Jacinto River watershed.

Summary of Water Quality Analyses

This review of water quality data is foundational for understanding and characterizing water quality concerns in the East Fork San Jacinto River watershed, and for informing subsequent stakeholder decisions. The analyses served to answer questions regarding the sufficiency of the data, the extent and severity of water quality trends, seasonality of water quality issues, and the potential impact of wastewater effluent and SSOs.

Data meeting the criteria for sufficiency were used to determine what constituents of water quality are of greatest concern and the extent to which their impacts have been observed throughout the area waterways. Results from the 2022 Texas Integrated Report for this watershed and the SWQM dataset from 2011 to 2021 identified high levels of the fecal indicator bacteria *E. coli* as the most pervasive impact to water quality.

Permitted wastewater effluent was unlikely to be a widespread or chronic water quality issue but requires further investigation on limited spatial scales and timeframes. However, understanding these discharges is still critical to the development of this project as WWTFs without permit limits for certain nutrients act as source loads—particularly in effluent-dominated streams. Further, as treatment facilities for human waste, improper treatment indicators identified in DMR analyses can have greater implications for risk to human health.

An analysis of SSO reports from the East Fork San Jacinto River watershed indicated that 28.6% of reporting plants experienced five or more SSO events between 2017 and 2021. Patterns in number of events were representative of patterns observed in magnitude of overflow volume. For both number of SSO events and volume of overflow, weather was the most common for the general cause categories. However, it is important to note that while only one cause is usually listed on the report, multiple compounding factors can lead to SSOs. Ultimately, causes listed in SSO reports are prone to a degree of subjectivity as opposed to more quantitative measurements. While the episodic overflow volumes reported during these events are relatively small compared to the scale of effluent produced

by WWTFs, SSO inputs are of particular concern due to the untreated nature of the sewage associated with them and the subsequent risk to human health.

As future growth projections indicate that increased development in the watershed is likely, the balance of pollutant sources and current hydrologic processes could be altered significantly in the coming years. These changes could result in further water quality impacts without intervention. Subsequent efforts should be made to identify causes and sources of the primary constituent of concern (indicator bacteria), and to characterize nutrient sources further to identify areas within the project watersheds most vulnerable to pollutant loadings and/or best suited for the implementation of management strategies.

Source Identification

Using the information generated through the water quality data analyses, the next step in characterizing pollution in the watershed was to evaluate potential causes and sources. The results of this source identification and prioritization process assisted the Partnership in understanding the range of potential sources and guided the subsequent modeling efforts that estimated the loads from fecal waste and nutrient sources. Fecal waste sources were the primary focus of these efforts.

Fecal Waste Source Identification

Waste from all warm-blooded animals is a potential source of *E. coli* contamination. *E. coli* are not necessarily themselves the source of potential health impacts; however, they signify the presence of fecal waste as well as a host of other pathogens associated with fecal waste. There is a wide array of potential fecal waste sources in the watershed. The potential mix of sources in a watershed can vary greatly in both spatial and seasonal contexts.

Source Survey

Characterizing fecal waste pollution in watersheds, and development of analyses to estimate potential loading, requires a consideration of potential sources. In any watershed with a mix of land uses, fecal waste can be produced by a broad mix of sources; this is especially true in a large, diverse watershed like East Fork San Jacinto River. The existence and location of some sources are known from existing data (e.g., WWTF outfalls), while many nonpoint sources need to be evaluated from a mix of literature values, land cover analysis, imagery and road reconnaissance, and a robust process of stakeholder review and feedback. As part of developing the source survey, the Partnership completed the following assessments:

- **Known Source Characterization** — Existing data was used to generate information on discrete (usually permitted) sources. Data sources included[26]:
    - WWTF outfall locations and DMRs (TCEQ outfall locations and DMR records)
    - Permitted on-site sewage facility (OSSF) locations (H-GAC proprietary data provided by local governments)
    - SSOs (TCEQ SSO database)
- **Land Cover Analysis** — Staff reviewed national land cover datasets and H-GAC proprietary land cover datasets to determine the mix of land cover types within the watershed, and within each subwatershed, in a spatial context. The watershed includes a mix of land cover types, so no sources were eliminated based on lack of land cover (*i.e.*, available habitat/use). Statistics and spatial coverage developed during this analysis were used as the basis of populating diffuse sources whose assumptions were tied to specific land cover types in modeling efforts.
- **Stakeholder Feedback** — Stakeholder engagement was a primary focus of the source survey. Local knowledge was a key aspect of understanding source composition in the area. Project staff engaged stakeholder consideration of sources through:
    - Direct discussion of sources at Partnership meetings
    - Direct discussion of sources at source-based Work Group meetings
    - One-on-one meetings with local stakeholders
    - One-on-one meetings with state and regional experts/agencies (*e.g.*, the Texas Parks and Wildlife Department (TPWD), TSSWCB, and others)

In general, stakeholder feedback upheld staff expectations of usual sources, and helped refine extent and scale of expected source contributions (*e.g.*, presence of deer in developed areas, hog activity levels, *etc.*). The ultimate selection of sources to include in the model was based on stakeholder decisions and affirmation of H-GAC's proposed modeling methodology, through the revision process.

Estimating *E. coli* Loads

Understanding the distribution and relative prominence of various sources of fecal waste is crucial to empowering stakeholders to make informed decisions about potential solutions. To quantify the potential number of fecal indicator bacteria being generated in the watershed, the Partnership used a combination of stakeholder knowledge and

[26] More information on data sources and quality objectives can be found in the project quality assurance project plan (QAPP), available online on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_eastforkmodelqapp_qtrak22-265.pdf

computer modeling. The goal was to identify how much *E. coli* was being generated by each source, and how those sources were distributed in the watershed.

Spatially Explicit Load Enrichment Calculation Tool

The Spatially Explicit Load Enrichment Calculation Tool (SELECT) is a Geographic Information System (GIS)-based analysis approach developed by the Spatial Sciences Laboratory and the Biological and Agricultural Engineering Department at Texas A&M University[27]. The intent of this tool is to estimate the total potential *E. coli* load in a watershed and to show the relative contributions of individual sources of fecal waste identified in the source survey. Additionally, SELECT adds a spatial component by evaluating the total contribution of subwatersheds, and the relative contribution of sources within each subwatershed. SELECT generates information regarding the total potential *E. coli* load generated in a watershed (or subwatershed) based on land use/land cover, known source locations (WWTF outfall locations, OSSFs, *etc.*), literature assumptions about nonpoint sources (pet ownership rates, wildlife population statistics, *etc.*) and feedback from stakeholders. The potential source load[28] estimates are not intended to represent the amount of *E. coli* actually transmitted to the water, as the model does not account for the natural processes that may reduce pollutants on their way to the water, or the relative proximity of sources to the waterway.

Project staff used an adapted SELECT approach to meet the specific data objectives of this project. The implementation of SELECT used for this modeling effort builds on the original tool by adding two modified components.

- **Buffer Approach** — The stock SELECT model assumes all *E. coli* generated within a watershed will have the same impact on instream loads. For example, loads generated 2 miles from a waterway are counted the same as equivalent loads generated within the riparian corridor. Realistically, loads generated adjacent to the waterways are more likely to contribute to instream conditions. However, SELECT does not provide a means by which to model fate and transport factors. In a situation in which a particular source is generally located farther from the waterway, it may be overrepresented compared to a source generally located adjacent to the waterway. For example, if OSSFs in a watershed produced 50 units of waste, but were generally located far from the water, while livestock in a waterway produced the same amount of waste, but generally in the riparian corridor, SELECT would treat these potential loads as equal. For stakeholders making decisions on prioritizing best management practices (BMPs) and sources, this

[27] Additional information about SELECT can be found at: http://ssl.tamu.edu/media/11291/select-aarin.pdf
[28] References to loads in this section, unless specifically stated otherwise, should be taken to refer to (potential) source loads, rather than instream loads. As indicated previously, SELECT does not generate instream loading estimates, just the potential source load prior to factors affecting the fate and transport of pollutants.

is a false equivalency. To strike a balance between project focus on simple but effective modeling and a desire to understand the potential impact of transmission, this implementation of SELECT differentiates between loads generated inside a buffer area surrounding waterways, and loads generated outside this area. The buffer approach assumes 100 percent of the waste generated within 300 feet of the waterway as being transmitted to the watershed without reduction. Outside of that buffer, only 25 percent of the waste is assumed to be transmitted to the waterway[29]. Sources that lack specific spatial locations (unlike permitted outfalls) are assumed to be distributed uniformly in appropriate land uses, inside and outside the buffer. For example, the total number of deer in the buffer is derived from multiplying the assumed density by the numbers of acres of appropriate land use within buffered areas. This approach is designed to provide a very general conception of the effect of distance from the waterway.

- **Future Projections** — The East Fork San Jacinto River watershed is forecasted to experience developmental change. Sources estimated based on data collected as of the year 2022[30] are expected to expand in the future. Therefore, *E. coli* reductions based on current conditions would be inadequate to meet future needs. This implementation of SELECT uses regional demographic projection data to estimate future conditions through 2050 in 5-year intervals[31]. Land use change is the primary driver for estimating changes in source contribution, and spatial distribution of loads[32].

Watershed conditions can change greatly from year to year based on rainfall patterns, agricultural activities, increased urbanization, and other landscape-scale factors. To

[29] Buffer percentages were based on previously approved WPPs and reviewed on multiple occasions with project stakeholders.

[30] References to "current" modeled conditions throughout this document refer to 2022 estimations, based on the available data at the time of the modeling effort.

[31] 2045 was chosen as a horizon year to coincide with the extent of the regional demographic model projections at the time and also in consideration of likely planning horizon for partner efforts and developmental projects.

[32] All future projections have some level of uncertainty that cannot be wholly controlled for. The H-GAC Regional Growth Forecast (http://www.h-gac.com/regional-growth-forecast/default.aspx) demographic model projections are widely used in the region and in similar WPPs, and thus considered the best available data for making these projections. Some wildlife sources have additional levels of uncertainty because the model assumes that change between land uses eliminates populations tied to the former land use. However, there is not adequate data or analytical approaches within the scope of this project to determine the potential that wildlife populations will change or consolidate by literature values alone. For example, the model assumes a set density of feral hogs per unit of area, populated in appropriate land cover types. Feral hog populations are assumed to stay static because there is insufficient data to make assumptions about rate of population growth. Additionally, if an area containing feral hogs converts to developed land cover, the hogs attributed to that area are eliminated from the calculations. In real conditions, this may instead lead hogs to consolidate in greater densities in remaining habitat up to some carrying capacity. This project acknowledges that uncertainty, and the stakeholders discussed potential methods to address it. However, no sufficient data sources or modeling methods within the scope of this project have been identified to account for wildlife population dynamics. Continual assessment of wildlife populations as a source is recommended in the adaptive management recommendations of the WPP to help overcome this uncertainty.

balance this inherent degree of variation and uncertainty, stakeholder feedback on sources, model assumptions, and results were used heavily through the generation of the analysis and its eventual use as a prioritization tool for selecting BMPs. The goal of the SELECT modeling in this WPP effort, other than the general characterization of source loading, is to aid in prioritizing which sources to address by showing their relative contributions and locations. The loads generated by SELECT are combined with reduction percentages derived from the models explained in Section 4 to generate source reduction loads. There is an inherent level of uncertainty in any modeling of a dynamic system, but the approach used in this WPP is balanced against the end use of the information to support stakeholder decisions.

The analysis design for this process includes four primary steps:

1) Development of a source survey using known locations/sources, suspected sources derived from projects in similar areas, and stakeholder feedback,
2) Stakeholder review of proposed sources and preliminary population/loading assumptions,
3) Implementation of the model and internal quality review, and
4) Stakeholder review of results and model revision as necessary (**Figure 12**).

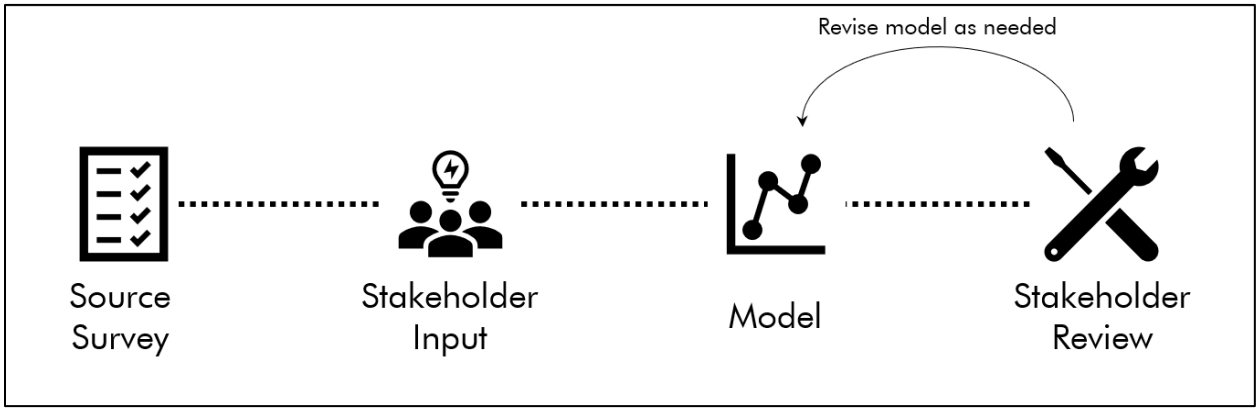


Figure 12. SELECT modeling process

The following subsections detail the sources modeled, including the data used and the feedback received from stakeholders. The maps indicate the relative distribution of source loads and populations, while the charts indicate the relative contribution of different sources. The loadings are given in numbers of billions of *E. coli* per day. The map for each specific source is not comparable to other sources; they show the relative distribution for a given source by color gradation, rather than color being tied to absolute load. The maps also reflect the use of the buffer approach. A 300-foot buffer around each waterway (appearing as a series of lines on the map) displays loading in these areas separate from the greater land area using the same color scale. Note that major waterways are

represented in blue for spatial reference. Colors associated with the loading value within the riparian buffer for each subwatershed are consistent but are partially obscured by the main channel vectors.

In viewing the maps, it is important to consider that they display both relative loading by area within a subwatershed (riparian areas versus areas outside the riparian) and between subwatersheds. Lastly the map coloration is based on relative load density (load per acre). Larger subwatersheds will have larger loads, all things being equal. Load density maps help equalize discrepancies in subwatershed size and make fair comparisons.

Wastewater Treatment Facilities

Wastewater utilities serve a number of communities throughout the watershed and occur in various sizes and capacities. For areas outside city boundaries, centralized waste treatment is most commonly managed by municipal utility districts and other districts. Discharge monitoring report data was available for 10 permitted WWTFs within the watershed and was incorporated into the SELECT model. Size of WWTFs vary greatly throughout the watershed and ranged between capacities of less than 0.1 MGD to 10 MGD.

WWTFs in the East Fork San Jacinto River watershed are not expected to be major contributors to fecal indicator bacteria loading. However, as the risks associated with human waste processed by WWTFs can be considerable in the event of improper treatment or other localized incidents, it is important to consider estimates of potential WWTF loadings in the overall SELECT model. These estimates are derived by multiplying the total discharge capacity of each facility by the state water quality standard for fecal bacteria. For future projections, models continued to estimate fecal bacteria loads at the state standard but adapted flow rates to reflect the projected increase in the number of households within service area boundaries. As many facilities discharge well below their maximum permitted rates, this results in a potential overestimation of fecal bacteria loading from this source. As noted previously, this method is still deemed appropriate for this watershed in order to account for exceedances or variations throughout daily discharges that could have greater impacts to public health.

Current WWTF loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 14**. As loads were estimated solely from outfall data within the riparian buffer, all spatial results are indicated within the buffer zone surrounding the watershed stream network (no data is available for the land area beyond the buffer). Color intensity indicates loading severity relative to

the other streams and may not be directly comparable between this modeled parameter and the remaining sources examined with SELECT analyses. Actual loading estimates by subwatershed are represented in **Table 15**. In **Figure 13**, forecasted total watershed loads from WWTFs are plotted in five-year increments through the year 2050.

Table 15. Wastewater facility outfalls and loadings in billion cfu/day by subwatershed

Subwatershed*	# of Outfalls	*E. coli* Load Estimate in Billion cfu/day	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	5	1.18	31%
Middle East Fork SJR (SW2)	2	1.56	41%
Upper East Fork SJR (SW3)	1	0.05	1%
Winters Bayou (SW4)	2	0.98	26%
Nebletts Creek (SW5)	0	--	--
Boswell Creek (SW6)	0	--	--
Total	**10**	**3.77**	**100%**

*See **Figure 3** for subwatershed names and location

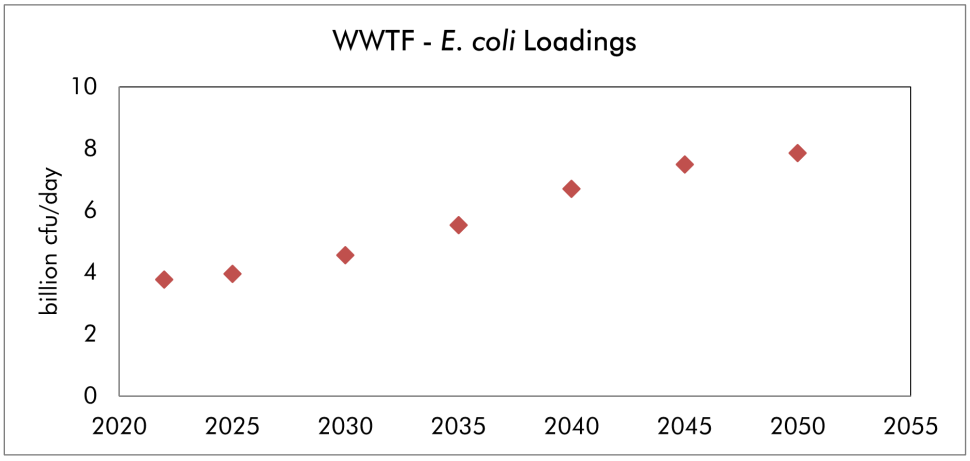


Figure 13. Future *E. coli* loadings from WWTFs

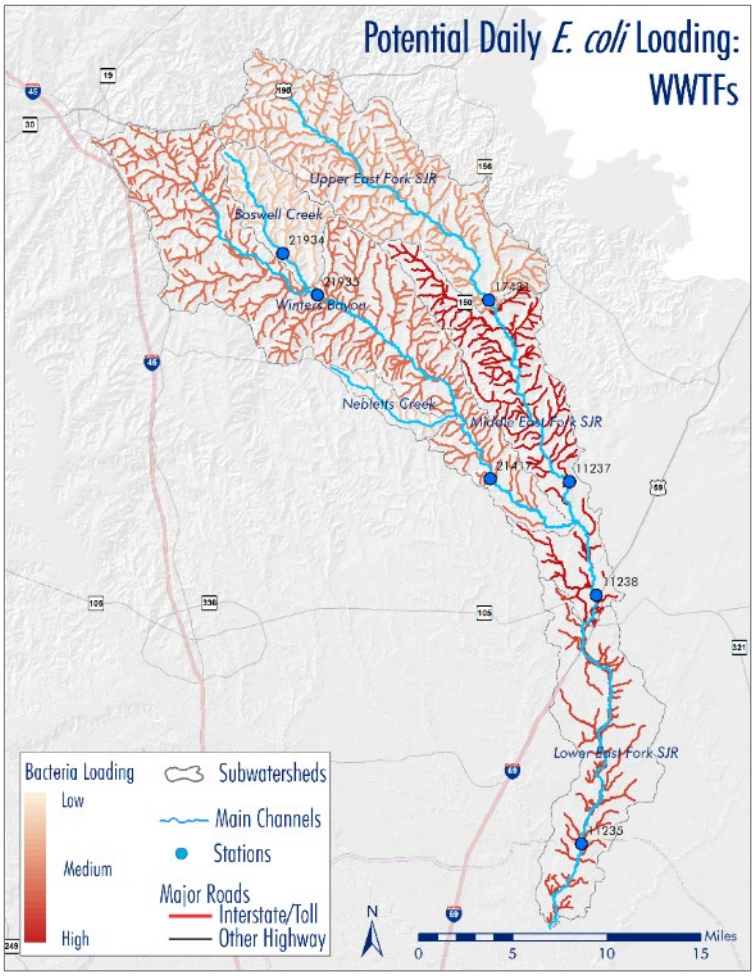


Figure 14. *E. coli* loadings from WWTFs by subwatershed

On-site Sewage Facilities

While centralized wastewater treatment is more common in developed areas, OSSFs are more likely to be used in parts of the watershed outside service area boundaries such as suburban and rural communities. OSSFs such as conventional and aerobic systems are an efficient and effective way to manage wastewater, however, aging or improperly maintained units run the risk of failing. Significant sources of fecal bacteria can be transmitted to waterways in the event of an OSSF failure.

Estimates of OSSF distribution throughout the East Fork San Jacinto River watershed were made using the spatial data of permitted OSSFs that were collected under a 604(b) agreement between H-GAC and TCEQ and quality assured under the auspices of that contract. Where portions of the watershed overlapped with areas outside the H-GAC region such as San Jacinto County, Texas State Data Center population projections were used. This dataset is not comprehensive as some data may be subject to insufficiencies such as a lack of geocoding. This uncertainty is

accounted for in the SELECT model through an estimation of any unrecorded or otherwise unpermitted OSSFs in the watershed area based on land use. Unpermitted OSSFs throughout the watershed were estimated by assessing the number of occupied parcels outside service area boundaries that were not indicated in the permitted OSSF database. Loading rates observed from improperly maintained and failed systems were used to estimate total load contribution from OSSFs. Literature values for OSSF failure rates in the watershed area range between 12 and 19%[33]. For the purposes of this report, a conservative estimate of 10% failure rate was applied to the combined total number of permitted OSSFs and unpermitted OSSFs indicated by the current dataset and for each of the five-year interval projections through 2050. This method has been used for watershed projects in nearby areas and was supported by local stakeholders. However, if more updated values for OSSF failure rates are determined throughout the project period, future evaluations of the WPP that take place as part of the adaptive management process will consider them.

Current OSSF loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 16**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 16**. In **Figure 15**, forecasted total watershed loads from OSSFs are plotted in five-year increments through the year 2050.

[33] See: https://www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf

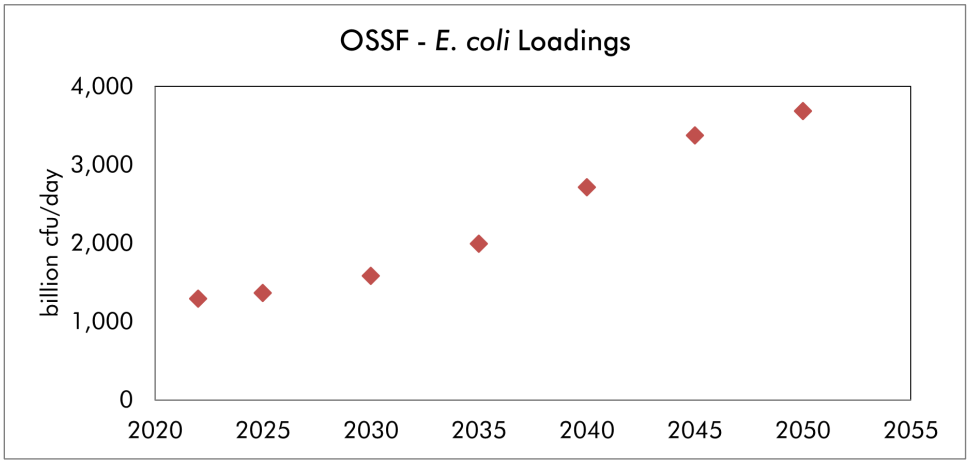


Figure 15. Future *E. coli* loadings from OSSFs

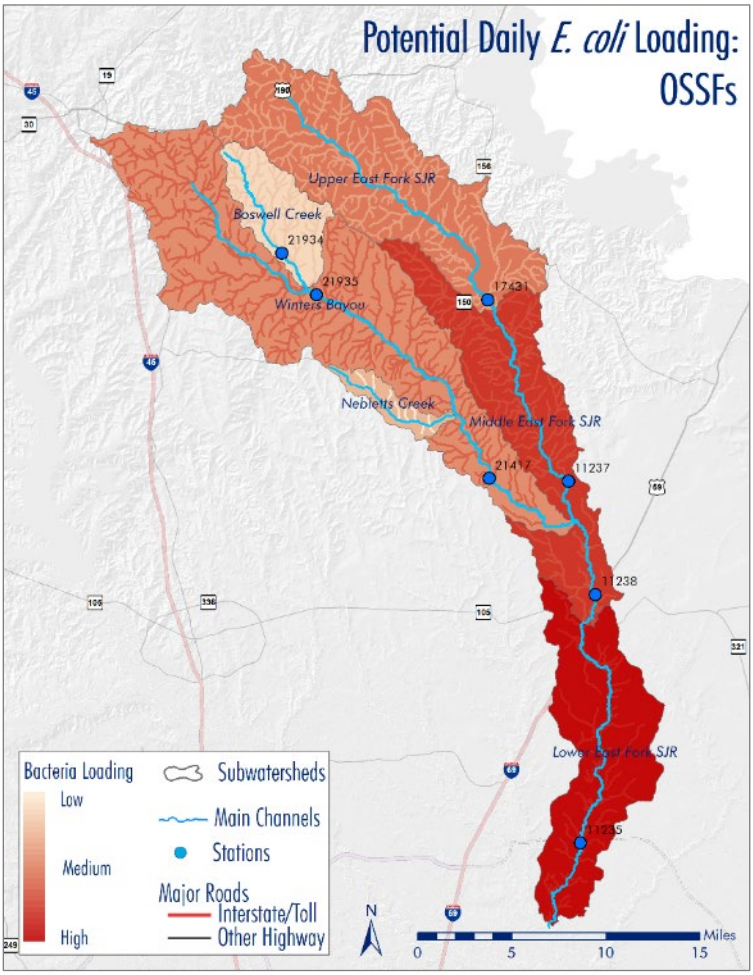


Figure 16. *E. coli* loadings from OSSFs by subwatershed

Table 16. OSSFs and loadings in billion cfu/day by subwatershed

Subwatershed	OSSFs Outside Buffer	OSSFs Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	6,560	667	608.44	247.46	63%
Middle East Fork SJR (SW2)	1,186	268	110.00	99.43	16%
Upper East Fork SJR (SW3)	758	140	70.30	51.94	9%
Winters Bayou (SW4)	604	244	56.02	90.52	11%
Nebletts Creek (SW5)	149	0	13.82	0.00	1%
Boswell Creek (SW6)	6	2	0.56	0.74	0%
TOTAL	**9,263**	**1,321**	**859.14**	**490.09**	**100%**

Pet Waste

Domestic and feral dog populations are significant contributors to fecal bacteria contamination in densely developed areas and are a common source of loading in the greater Houston region. Waste from other domestic pets (e.g., cats) is typically managed through collection in waste receptacles, whereas dog waste is more likely to be deposited directly into the environment.

For SELECT analysis, fecal bacteria loading from dog populations will be estimated by assessing pet ownership. Statistical data for Texas established by the American Veterinary Medical Association[34] of 0.6 dogs per household were used in SELECT models. This value was applied to current household data and future projections through 2050. Stakeholder insights on recent efforts to control pet waste including development of pet waste station infrastructure, and community use of waste bags, etc. already underway in the watershed. To account for this, the estimated load based on 0.6 dogs per household was further reduced by 20%. This method has been used in other WPP projects.

Current dog loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto

[34] For more information, see: https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx

River are represented in **Figure 18**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 17**. In **Figure 17**, forecasted total watershed loads from dogs are plotted in five-year increments through the year 2050.

Table 17. Dogs and loadings in billion cfu/day by subwatershed

Subwatershed	Dogs Outside Buffer	Dogs Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	4,840	412	2,419.80	824.40	62%
Middle East Fork SJR (SW2)	1,299	206	649.50	412.80	20%
Upper East Fork SJR (SW3)	455	84	227.40	168.00	8%
Winters Bayou (SW4)	362	146	181.20	292.80	9%
Nebletts Creek (SW5)	89	11	44.70	22.80	1%
Boswell Creek (SW6)	4	1	1.80	2.40	0%
Total	**7,049**	**860**	**3,524.40**	**1,723.20**	**100%**

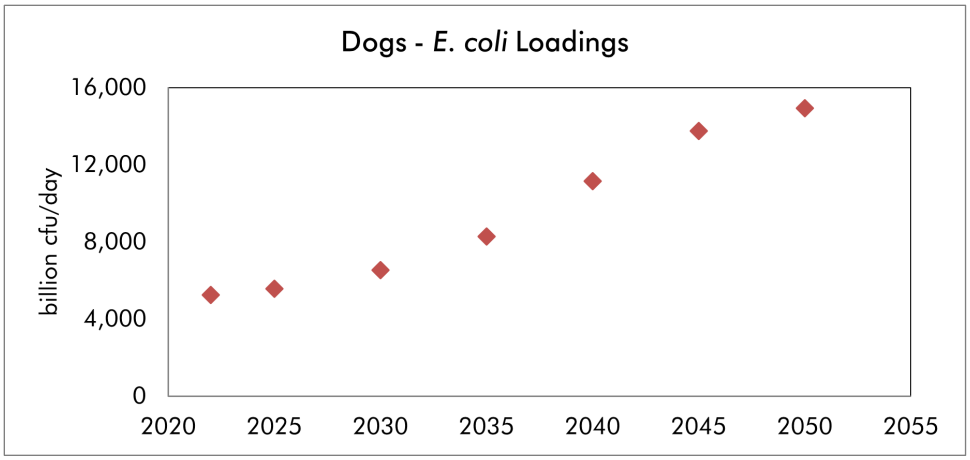


Figure 17. Future *E. coli* loadings from dogs

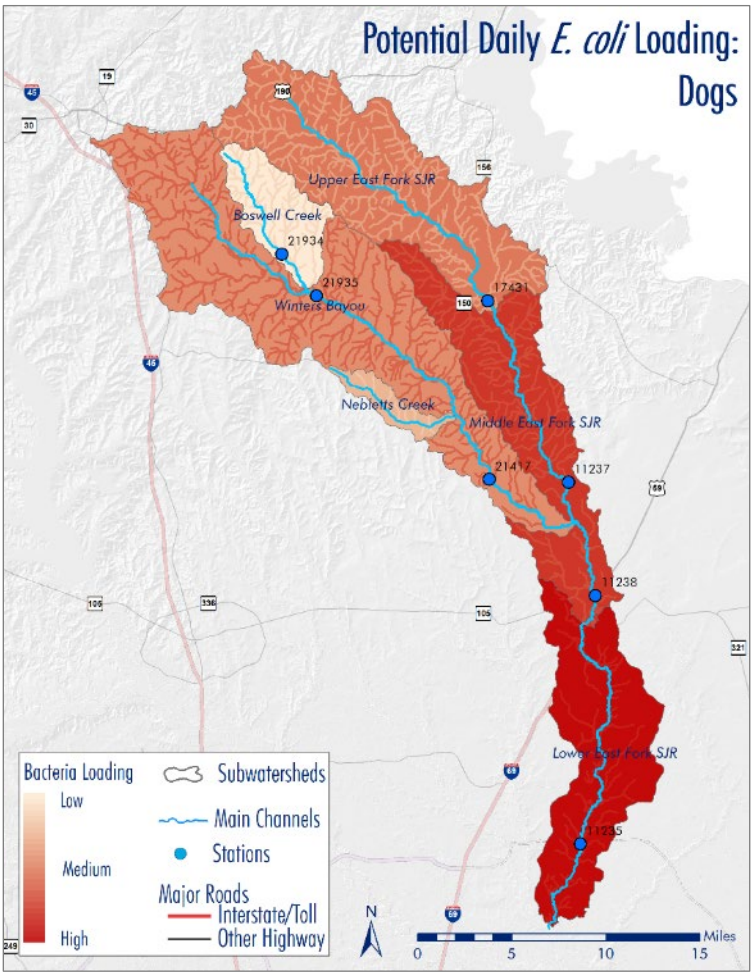


Figure 18. *E. coli* loadings from dogs by subwatershed

Cattle

Agricultural land, grassland, and pastures are most common in the western reaches of the watershed with smaller concentrated areas of these land cover types distributed throughout. National livestock populations including cattle were most recently assessed in a 2017 census by the United States Department of Agriculture. Census data are available by county and are not specific to the watershed area. To estimate cattle in the East Fork San Jacinto River watershed, a ratio of each county's portion of the watershed's acreage in appropriate land cover types to that of the respective county as a whole was applied to agricultural census data from each of the four counties. This approach ensures that the density of cattle in a county's applicable land cover acreage (grassland and pasture/hay) was the same as the density in the watershed's applicable land use acreage. After stakeholder review, this initial estimate was modified further to better reflect observed conditions. Stakeholders indicated that initial estimates distributing cattle populations solely in grassland and pasture/hay land cover areas were inaccurate due to an overestimation of the usage of those areas by cattle. To account for fallow lands or smaller parcels of pasture and grassland not grazed by herds, cattle population estimates were adjusted to 90% of the initial estimate in these land cover areas. Further, stakeholders noted that cattle occasionally use forest and shrubland especially when adjacent to waterways. This observation was reflected in the model by distributing 10% of the cattle population estimate into forested areas within the riparian buffer. Lastly, more updated estimates of daily cattle loading values were incorporated into the analysis[35]. Due to an adjustment from 5.4 billion cfu/day in the initial analysis to 11 billion cfu/day in the revision, livestock values shown here are much greater than those reported in the initial bacteria modeling estimate[36].

Current cattle loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 20**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 18**. In **Figure 19**, forecasted total

[35] See: Coffey et al., 2010 (https://www.sciencedirect.com/science/article/abs/pii/S0378377409002479), Coffey et al., 2013 (https://www.tandfonline.com/doi/abs/10.1080/10807039.2012.701983), and Iqbal and Hofstra, 2018 (https://www.tandfonline.com/doi/full/10.1080/10807039.2018.1487276)

[36] See: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_4.3_bacteria_modeling_report_final.pdf

watershed loads from cattle are plotted in five-year increments through the year 2050.

Table 18. Cattle and loadings in billion cfu/day by subwatershed

Subwatershed	Cattle Outside Buffer	Cattle Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	723	184	1,987.70	2,026.89	8%
Middle East Fork SJR (SW2)	1,081	424	2,973.47	4,660.75	14%
Upper East Fork SJR (SW3)	1,314	764	3,612.87	8,399.02	22%
Winters Bayou (SW4)	3,661	1,604	10,067.42	17,648.17	52%
Nebletts Creek (SW5)	107	28	293.84	312.22	1%
Boswell Creek (SW6)	147	129	404.63	1,419.98	3%
Total	**7,033**	**3,133**	**19,339.93**	**34,467.03**	**100%**

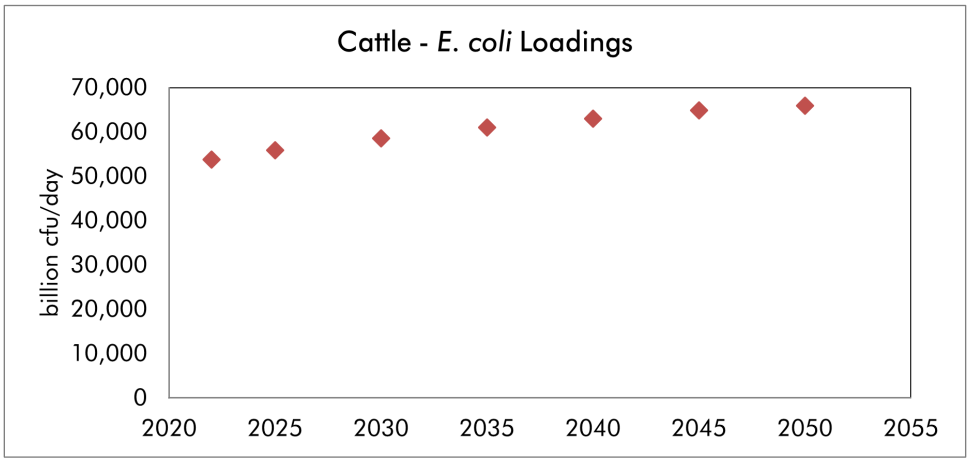


Figure 19. Future *E. coli* loadings from cattle

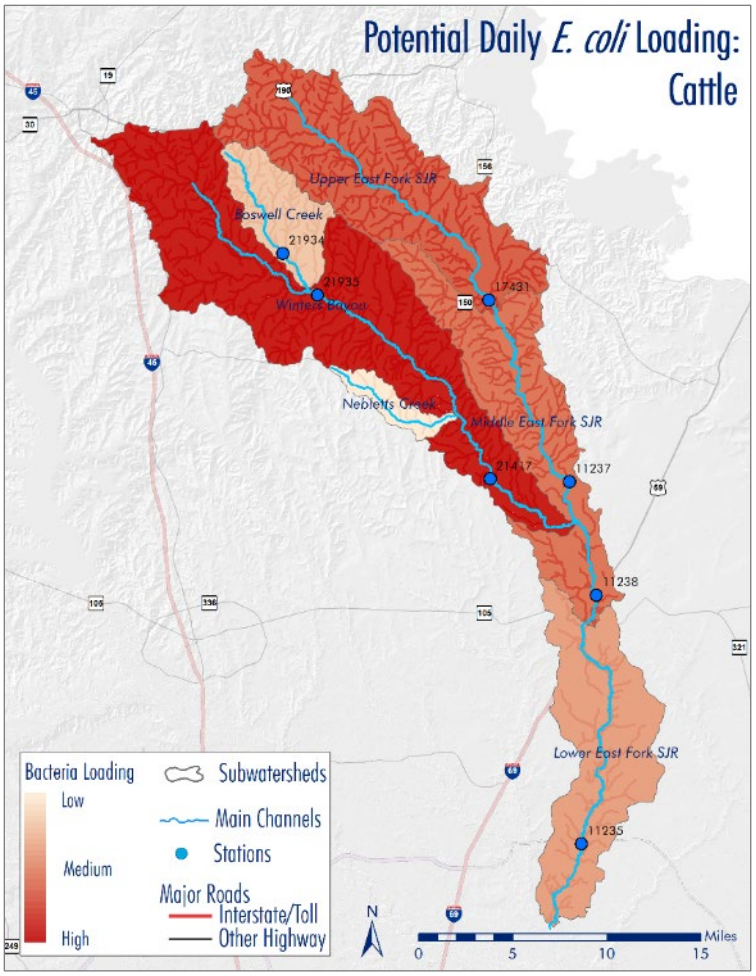


Figure 20. *E. coli* loadings from cattle by subwatershed

Horses

Similar to cattle, horse population estimates were calculated based on agricultural census data modified by the ratio of watershed area of relevant land use types to total county area. Based on stakeholder feedback, horse populations were similarly distributed 90% to pasture and grassland, and 10% to forested area within the riparian buffer. This method assesses only the horses designated for livestock use in the watershed. Horses owned for recreational purposes may not be well represented by these estimates.

Current horse loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 22**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 19**. In **Figure 21**, forecasted total

watershed loads from horses are plotted in five-year increments through the year 2050.

Table 19. Horses and loadings in billion cfu/day by subwatershed

Subwatershed	Horses Outside Buffer	Horses Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	68	17	3.56	20.41	17%
Middle East Fork SJR (SW2)	101	40	5.32	8.34	9%
Upper East Fork SJR (SW3)	123	72	38.14	15.03	37%
Winters Bayou (SW4)	343	150	18.02	31.59	34%
Nebletts Creek (SW5)	10	3	0.53	0.56	1%
Boswell Creek (SW6)	14	12	0.72	2.54	2%
Total	**659**	**294**	**66.29**	**78.47**	**100%**

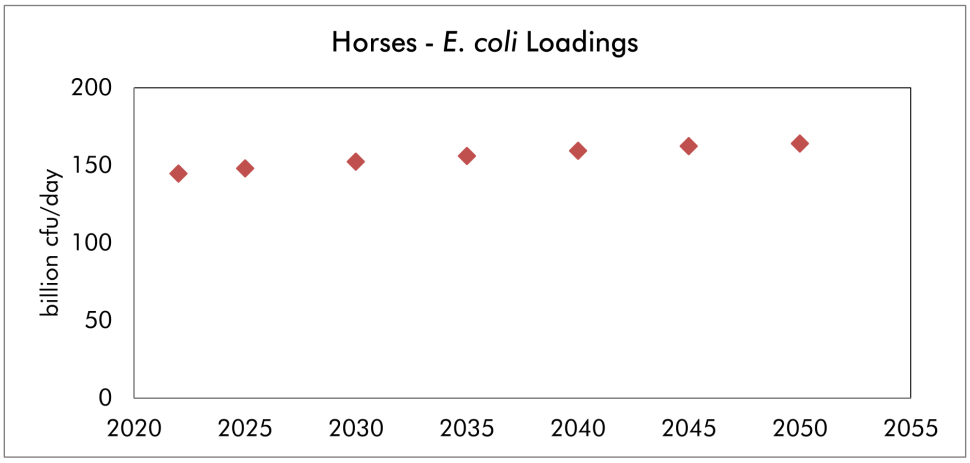


Figure 21. Future *E. coli* loadings from horses

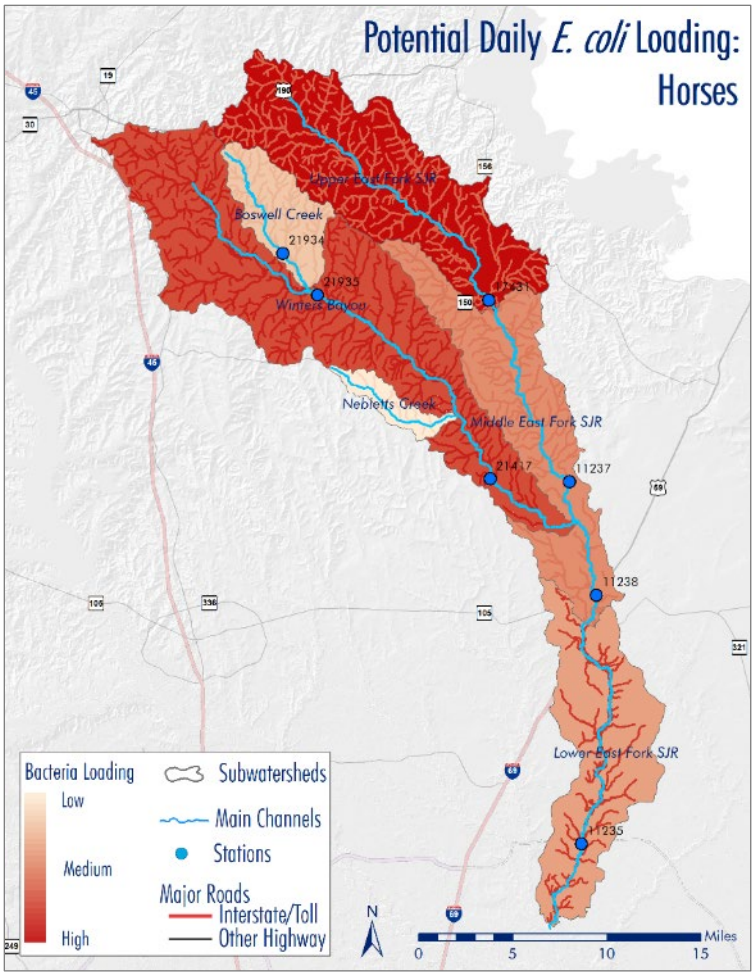


Figure 22. *E. coli* loadings from horses by subwatershed

Sheep and Goats

Sheep and goat populations represent a smaller portion of the livestock in the watershed, but still retain a presence in rural areas. Both animal populations are grouped into a single statistic in the agricultural census. To estimate the size of these populations, the same method used for cattle and horses was applied to agricultural census data for sheep and goats. Based on stakeholder feedback, sheep and goat populations were similarly distributed 90% to pasture and grassland, and 10% to forested area within the riparian buffer.

Current sheep and goat loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 24**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 20**. In **Figure 23**, forecasted

total watershed loads from sheep and goats are plotted in five-year increments through the year 2050.

Table 20. Sheep and goat loadings in billion cfu/day by subwatershed

Subwatershed	Sheep & Goats Outside Buffer	Sheep & Goats Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	83	21	186.18	189.85	8%
Middle East Fork SJR (SW2)	124	49	278.52	436.56	14%
Upper East Fork SJR (SW3)	150	87	338.41	786.71	22%
Winters Bayou (SW4)	419	184	942.99	1,653.05	52%
Nebletts Creek (SW5)	12	3	27.52	29.24	1%
Boswell Creek (SW6)	17	15	37.90	133.01	3%
Total	**805**	**359**	**1,811.52**	**3,228.42**	**100%**

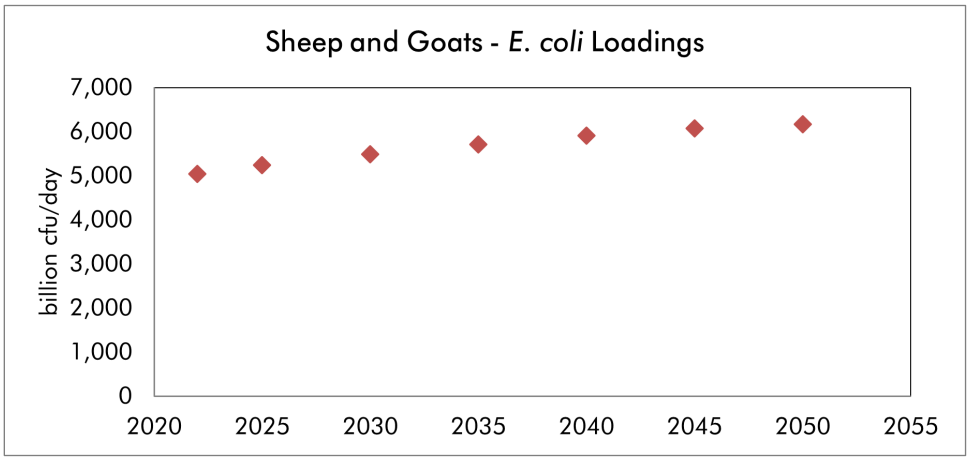


Figure 23. Future *E. coli* loadings from sheep and goats

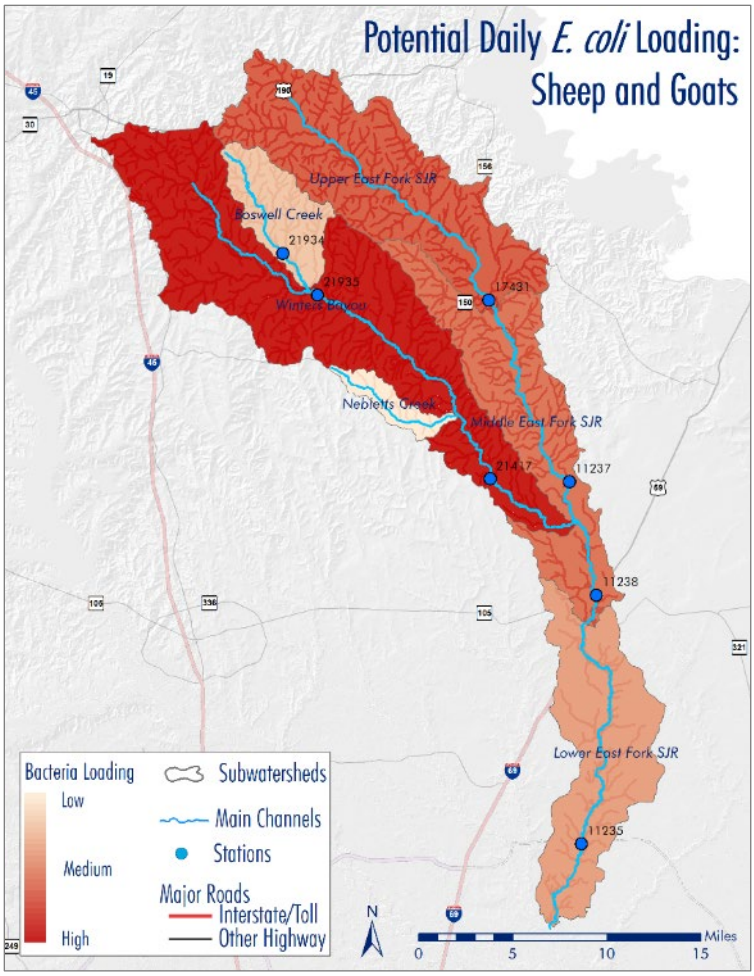


Figure 24. *E. coli* loadings from sheep and goats by subwatershed

Deer

Forests and open areas in the less developed areas of the watershed provide ample habitat area for white-tailed deer. However, deer are among the few species that are adaptable to the encroachment of developed areas. Loss of natural areas may lead deer to explore larger lots of suburban and light urban development as alternative habitat. Because of this, forested areas and open and low intensity developed areas were considered as possible deer habitat for the purposes of load estimation. To estimate deer populations and their associated fecal bacteria loading potential, Resource Management Unit population density data accessed from the Texas Parks and Wildlife Department assuming 1 deer for every 40.2 acres of forest, shrubland and open developed areas were used. In low intensity developed areas, deer density was assumed to be 1 deer for every 80.4 acres. After consulting with stakeholders, this lower density of 1 deer per 80.4 acres was applied in additional land cover areas including pasture and grassland, wetlands, and barren land. This change was made as stakeholders agreed that deer populations are most

concentrated in forested areas but noted seeing deer in areas also used by feral hog populations. Even with this updated approach, population dynamics are not well represented with respect to movements between land cover types and possible increases in density of natural areas after the built environment extends into previously undeveloped spaces.

Current deer loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 26**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 21**. In **Figure 25**, forecasted total watershed loads from deer are plotted in five-year increments through the year 2050.

Table 21. Deer and loadings in billion cfu/day by subwatershed

Subwatershed	Deer Outside Buffer	Deer Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	622	117	27.19	20.41	13%
Middle East Fork SJR (SW2)	642	217	28.07	37.96	17%
Upper East Fork SJR (SW3)	872	351	38.14	61.44	26%
Winters Bayou (SW4)	1,221	450	53.40	78.74	35%
Nebletts Creek (SW5)	89	22	3.91	3.93	2%
Boswell Creek (SW6)	241	98	10.56	17.06	7%
Total	**3,687**	**1,255**	**161.27**	**219.54**	**100%**

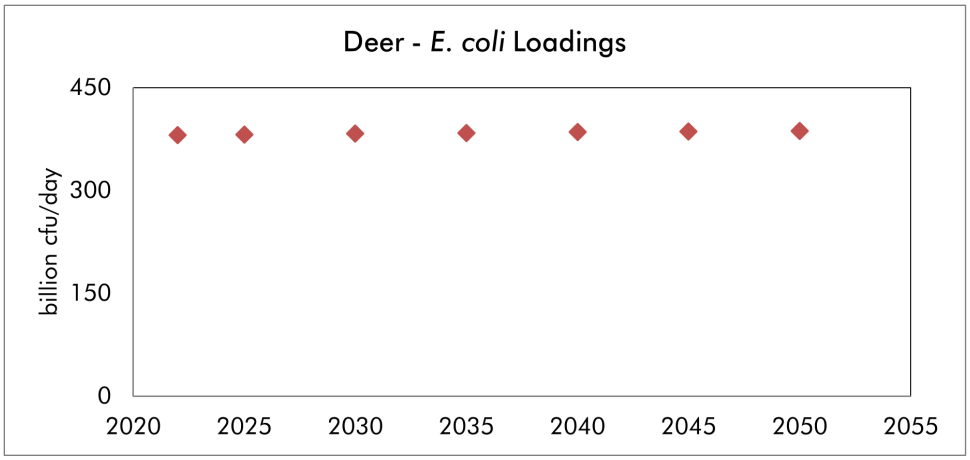


Figure 25. Future *E. coli* loadings from deer

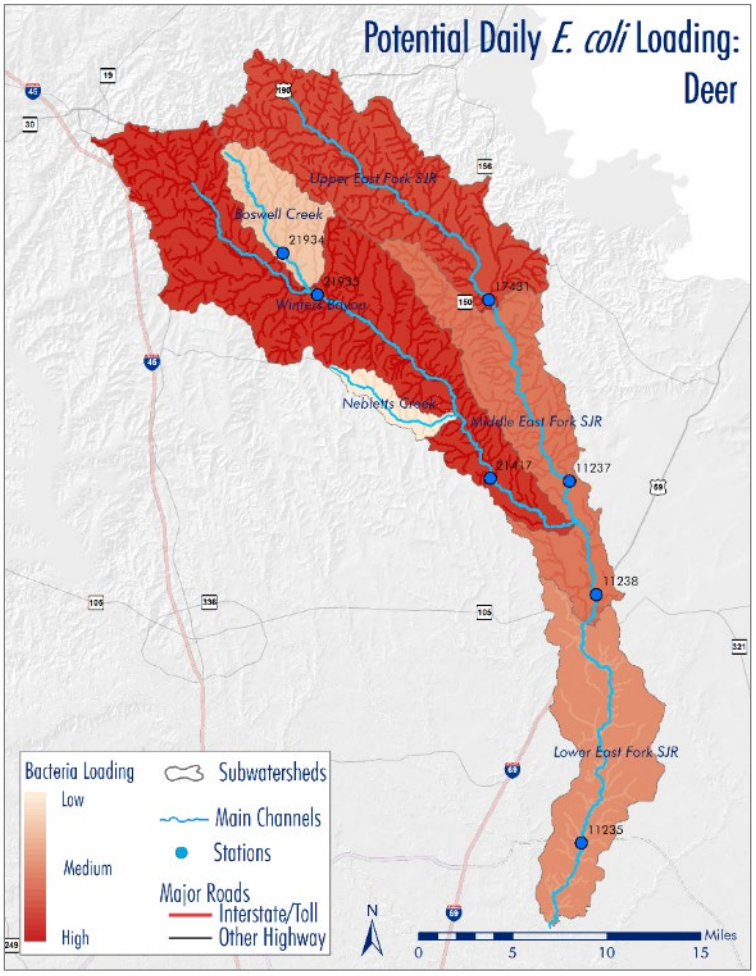


Figure 26. *E. coli* loadings from deer by subwatershed

Feral Hogs

In the Houston-Galveston region feral hogs (*Sus scrofa*) are an invasive species that negatively impact agriculture, wildlife species and their habitats, and human landscapes. Efforts to control feral hogs have been carried out by communities within the East Fork San Jacinto River watershed that have already recognized the environmental pressures associated with their populations. Feral hogs are of particular concern as carriers of diseases that can be dangerous to domestic livestock, pets, and humans. These animals are known to use land around waterways as shelter and transportation corridors between food resources and can generate large volumes of waste where they concentrate.

Though they occur in the highest densities along riparian corridors and other natural areas, feral hogs are pervasive and can be found in all land cover types aside from heavily developed areas and open water. Population density estimates used in the SELECT model for feral hog source loads referenced land cover types in the watershed area based on AgriLife literature values[37]. Though initial estimates accounted for hogs in all land cover areas excluding development and open water, stakeholder feedback about observed hog behaviors and migration in the watershed led to two important changes. First, hog densities were assumed to follow a gradient from heavy densities in more natural land cover type to lighter densities with increasing proximity to development. In **Table 22**, the specific allocation of hog population density based on stakeholder recommendations is described. Second, though no feral hog populations were assumed outside the riparian buffer in medium and high intensity developed areas, half of the lowest density estimate was applied within the riparian buffer in those land types.

[37] For more information, see: http://agrilife.org/feralhogs/files/2010/04/FeralHogPopulationGrwothDensityandHervestinTexasedited.pdf

Table 22. Feral hog population density by land cover type

Land Cover Type	Outside Buffer	Inside Buffer
Wetlands	16.4 hogs/ square mile	16.4 hogs/ square mile
Forest and Shrubland	16.4 hogs/ square mile	16.4 hogs/ square mile
Grassland	16.4 hogs/ square mile	16.4 hogs/ square mile
Pasture	12.7 hogs/ square mile	12.7 hogs/ square mile
Cultivated Cropland	12.7 hogs/ square mile	12.7 hogs/ square mile
Barren Land	12.7 hogs/ square mile	12.7 hogs/ square mile
Developed Open Space	8.9 hogs/ square mile	8.9 hogs/ square mile
Low Intensity Developed	8.9 hogs/ square mile	8.9 hogs/ square mile
Medium Intensity Developed	None	4.45 hogs/ square mile
High Intensity Developed	None	4.45 hogs/ square mile

Current feral hog loading distributions throughout the watershed as well as relative load contribution from each of the subwatersheds draining into East Fork San Jacinto River are represented in **Figure 28**. Color intensity of subwatershed areas indicates loading severity relative to the other subwatersheds and may not be directly comparable between this modeled parameter and others. Actual loading estimates by subwatershed are represented in **Table 23**. In **Figure 27**, forecasted total watershed loads from feral hogs are plotted in five-year increments through the year 2050.

Table 23. Feral hogs and loadings in billion cfu/day by subwatershed

Subwatershed	Feral Hogs Outside Buffer	Feral Hogs Within Buffer	*E. coli* Load Outside Buffer	*E. coli* Load Within Buffer	Subwatershed Percent of Total Load
Lower East Fork SJR (SW1)	731	156	1,004.83	857.94	13%
Middle East Fork SJR (SW2)	755	275	1,037.70	1,512.62	17%
Upper East Fork SJR (SW3)	988	431	1,358.03	2,371.82	25%
Winters Bayou (SW4)	1,453	581	1,997.87	3,195.20	36%
Nebletts Creek (SW5)	101	28	138.43	151.34	2%
Boswell Creek (SW6)	261	114	359.15	627.33	7%
Total	**4,289**	**1,585**	**5,896.01**	**8,716.25**	**100%**

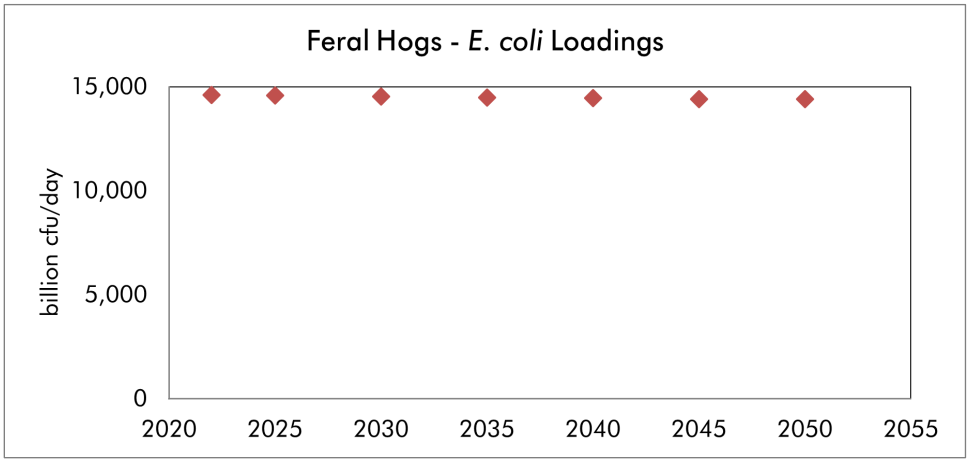


Figure 27. Future *E. coli* loadings from feral hogs

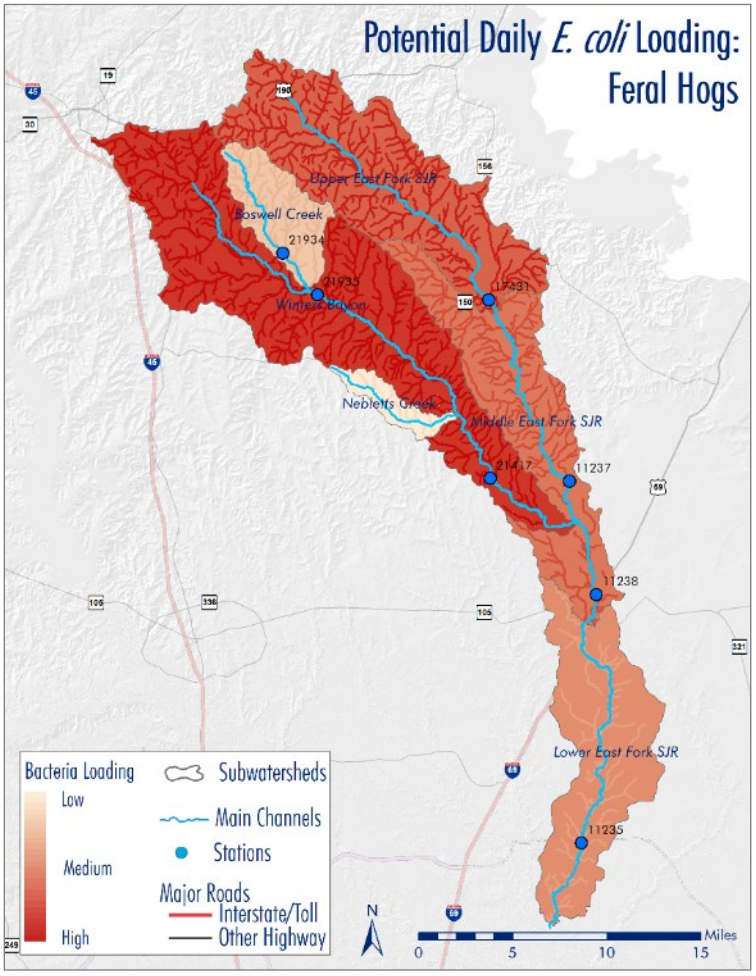


Figure 28. *E. coli* loadings from feral hogs by subwatershed

Other Sources of Fecal Waste

The primary other potential sources, and the reasons for not including them in the estimates are elaborated upon here. In general, sources which are not specifically included in the SELECT estimates are still potential targets of mitigation as part of the WPP, especially on a localized scale, depending on the source being discussed. While some of the wildlife populations discussed were not specifically modeled, their contributions are included in this project in the 10% other sources load estimate.

- SSOs

  Though SSOs occur episodically, they represent a high-risk vector for fecal bacteria contamination because they can have concentrations of fecal bacteria several orders of magnitude higher than treated effluent. Untreated sewage can contain large volumes of raw fecal waste, making it a significant health risk where SSOs are sizeable or chronic issues. Events are self-reported and may

vary in quality. Descriptions of frequencies, causes, durations, and volumes of SSOs may be subject to logistical inadequacies such as unknown duration of discharge, and inability to accurately gauge discharge volume. Actual SSO volumes and incidences are generally expected to be greater than reported due to these fundamental challenges.

After reviewing data compiled in SSO reports submitted by permit holders in the East Fork San Jacinto River watershed[38], SSO events were not found to follow any specific spatial, seasonal, or annual pattern. Weather related events accounted for the highest number of events and overflow volume respective to the other general categories of weather, blockages, and unknown causes. Frequency of SSOs generally corresponded to volume of SSOs.

Due to the episodic nature and spatial inconsistency of SSO events, fecal bacteria loads from these sources are not expected to have an appreciable long-term impact on the overall loading for the watershed and were excluded from SELECT model analysis. Though the estimations of SSO impacts in this watershed are not represented by SELECT models, they are no less important to consider in the overall assessment of fecal bacteria loading. The most extreme method of estimating fecal bacteria loads from SSOs would be to calculate loading based on EPA literature values[39] suggested for general causes related to each event multiplied by the highest observed volumes of discharge recorded for each cause. A more conservative method would be to calculate the average daily volume of discharge and use that as the multiplier for cause related load estimates. In other area watershed projects, stakeholders elected to refrain from the aforementioned calculations and treat SSOs as a separate, high-priority item for inclusion in the management strategies outlined in the WPP. SSO data regarding unique events impacting stream segments within the watershed area over the most recent five years of reports provided by TCEQ were used in these assessments. East Fork San Jacinto River watershed stakeholders elected to adopt this method as well.

- Human Waste – Direct Deposition
  In other watershed projects, potential impacts from unhoused communities and areas not serviced by centralized or localized wastewater treatment were

[38] For more detail, see the Water Quality Data Analysis Summary Report on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf
[39] As referenced at: https://www3.epa.gov/npdes/pubs/csossoRTC2004_AppendixH.pdf

considered. Based on stakeholder feedback, the populations represented by these groups were not found to be large enough to have appreciable impact.

- Land Deposition of Sewage Sludge
  In the event that improper use of manure spreading or violations of sludge application have occurred in the watershed area, action would be required to intervene and reduce the resulting fecal bacteria loading impacts. No such activity is known in the East Fork San Jacinto River watershed; however, these impacts would likely be addressed in best management practices for agricultural sources of pollution.

- Concentrated Animal Feeding Operations (CAFO)s
  No active CAFOs are in operation within the East Fork San Jacinto River watershed.

- Birds
  The greater Houston area is well known as part of the great Central Flyway migration path used by various bird populations. Many migratory bird species only utilize the land area for short periods of time while in transit, but migratory waterfowl and resident species represent longer-term populations, especially in coastal marshes. Similar watershed projects have evaluated the potential impact of waterfowl in terms of duration, potential fecal bacteria load, and other considerations, and found them to not be significant sources to be modeled. Colonial birds such as swallows have been identified by other watershed projects as potential sources of fecal bacteria load. Unfortunately, little or no data is available to characterize the impacts of fecal bacteria loading from colonial bird sources or to implicate colonial bird influenced fecal bacteria loading as a significant health risks to the watershed community. Beyond lack of data, relatively small fecal bacteria loads and health risks associated with bird waste compared to human sources further reduce the significance of bird waste impacts. General lack of management strategies available to deal with wild birds have limited the emphasis of this source as a meaningful component of management efforts in similar projects.

- Bats
  Though bats are present in the watershed area, only large colonies of these animals are estimated to have an appreciable impact on water quality. No known nesting sites of significant size or density have been indicated in the East Fork San Jacinto River watershed.

- Other Sources

Specific data for wildlife such as coyotes, opossums, rodents, wild cats, skunks, raccoons, and other mammals is not widely available. Similar watershed projects have recognized these wildlife animals as potentially appreciable contributors to fecal bacteria loads but lacked a reasonable method for quantifying their potential impacts. One method of improving understanding of wildlife impacts in the East Fork San Jacinto River watershed would be to implement fecal bacteria source tracking or assessments of genetic material found in waterways to identify species depositing fecal waste in and around streams. Data collected with this method in other watersheds showed that wildlife impacts are significant[40] and should be incorporated into fecal bacteria reduction strategies. As no such data is presently available for the watershed area of East Fork San Jacinto River, the understanding of wildlife species in this watershed will be largely informed by anecdotal information provided by stakeholders and general estimations decided by stakeholder input. In nearby watershed projects on Cypress Creek and Spring Creek, a novel approach assumed wildlife impacts to be equivalent to a conservative 10% of the other modeled loads assessed in the watershed. The value was generated by finding the total for all other sources in all subwatersheds, setting that total as 90% of the total load, and then assuming wildlife to be the other 10%. The stakeholders of the East Fork San Jacinto River watershed also elected to employ this method. However, to reflect the likelihood of loss of wildlife habitat as development expands in the watershed, stakeholders opted not to assume a consistent additional 10% contribution from wildlife in projections for 2025 onward. Rather, the 2022 10% calculated value was repeated in all subsequent projections. Stakeholders reviewed these results and agreed that other wildlife are an important component of bacteria loading in East Fork San Jacinto River but were reluctant to attribute a firm percentage to their influence. However, recognizing that other sources with little data for quantification estimates are at play in this watershed, stakeholders opted to retain this 10% addition to the total estimated load and refer to it more generally as other sources.

- Cats

  Domestic dogs are included in the SELECT model analysis as a concern of particular interest to the watershed due to the likelihood of improperly managed dog waste deposited outdoors making its way to streams via runoff. Domestic

[40] For example, bacteria source tracking completed by Texas A&M University for Attoyac Bayou showed *E. coli* from wildlife at greater than 50% of load across flow conditions (https://oaktrust.library.tamu.edu/handle/1969.1/152424) and a similar analysis (https://oaktrust.library.tamu.edu/handle/1969.1/149197) conducted for the Lampasas and Leon Rivers showed comparable results.

cat waste management is typically handled indoors and restricted to litter boxes. Therefore, pet wastes from cats were not estimated as part of this project. Feral cats, however, can be a local source when found in sufficiently dense urban populations, though very little data exists to quantify these impacts. Generally, impacts from feral cats may be accounted for in other loading assumptions such as diffuse urban stormwater or as part of the impacts from other wildlife.

- **Dumping**
  Illegal dumping is not typically a widespread or appreciable contributor to fecal bacteria loads in watersheds as these events occur locally or episodically. This factor will still be important for stakeholders to consider addressing in the WPP in terms of aesthetic and other regulatory issues.

Summary of *E. coli* Source Modeling Results

SELECT analyses indicated the highest loads from the total mix of modeled sources are concentrated in the Winters Bayou subwatershed because of pressures from agriculture and invasive feral hogs (**Table 24**). There is also a pronounced concentration of loading in the Lower East Fork San Jacinto River subwatershed associated with pressures related to development, including dog waste and OSSF discharge. Results shown in **Table 24** indicate the estimated current potential loads for all sources by subwatershed. Projected potential load in increments of five years by source are shown in **Table 25**. Assuming no additional action, changes in total load between 2022 and 2050 are shown in **Figure 29**. The year 2040, was set as an *E. coli* reduction milestone/target year and is therefore a different color than the other bars in the graph. Relative changes in source contributions between current and future conditions are shown in **Figure 30** and **Figure 31** respectively.

Without taking action to reduce fecal bacteria sources in the watershed, loads will continue to increase between 2022 and 2050. Noticeable changes in source load contributions between current conditions and those projected for 2050 involve decreased impacts from feral hogs relative to the expansion of sources associated with human development.

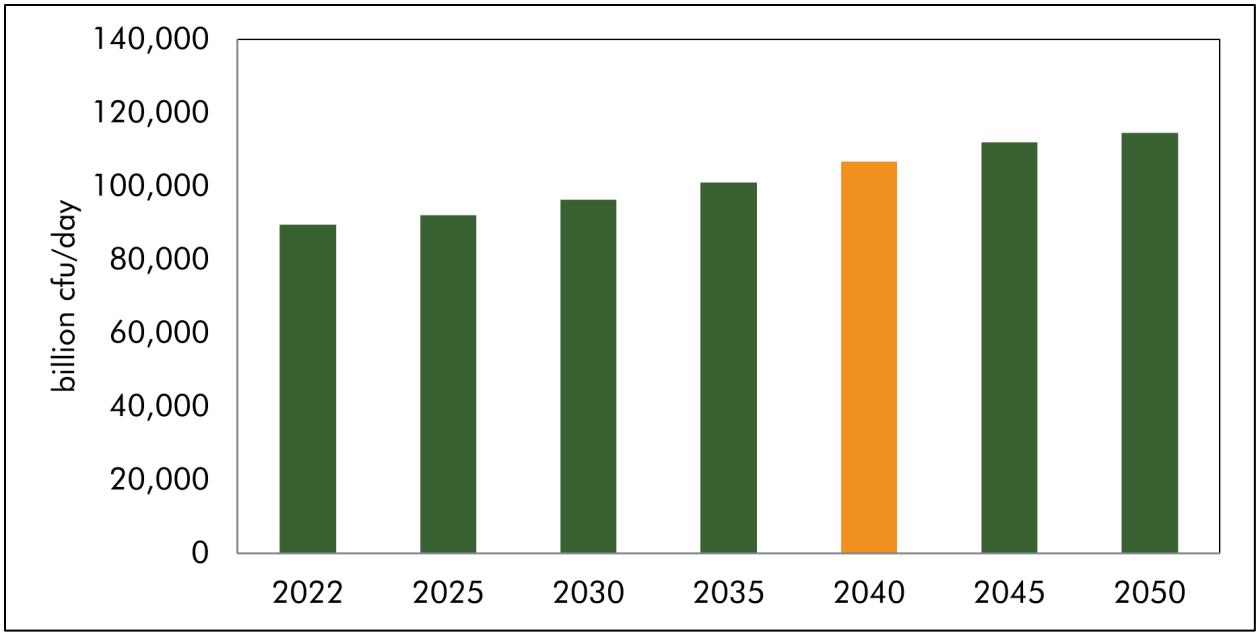


Figure 29. Potential total *E. coli* loads, with no action, 2022 to 2050

Table 24. Current *E. coli* loadings in billion cfu/day by source and subwatershed

Source	Lower East Fork SJR (SW1)	Middle East Fork SJR (SW2)	Upper East Fork SJR (SW3)	Winters Bayou (SW4)	Nebletts Creek (SW5)	Boswell Creek (SW6)	% Total Load
OSSFs	826.20	197.50	116.01	135.68	13.82	1.21	2%
WWTFs	1.18	1.56	0.05	0.98	0.00	0.00	0%
Dogs	3,244.20	1,062.30	395.40	474.00	67.50	4.20	6%
Cattle	4,014.60	7,634.21	12,011.89	27,715.59	606.06	1,824.61	60%
Horses	23.97	13.67	53.18	49.61	1.08	3.27	0%
Sheep & Goats	376.04	715.08	1,125.12	2,596.04	56.77	170.91	6%
Deer	47.60	66.03	99.58	132.14	7.83	27.63	0%
Other Sources	1,862.77	2,550.32	3,729.85	5,193.07	289.77	986.48	16%
Feral Hogs	1,155.17	1,360.07	1,947.90	4,033.01	115.87	335.37	10%
Total	**11,551.73**	**13,600.74**	**19,478.98**	**40,330.12**	**1,158.70**	**3,353.68**	**100%**

Table 25. *E. coli* loadings in billion cfu/day by source for all milestone years

Source	2022	2025	2030	2035	2040	2045	2050
OSSFs	1,290.42	1,368.13	1,585.78	1,992.10	2,714.63	3,380.01	3,685.21
WWTFs	3.77	3.95	4.56	5.52	6.71	7.49	7.86
Dogs	5,247.60	5,581.20	6,541.20	8,265.60	11,144.10	13,762.80	14,931.90
Cattle	53,806.96	55,931.68	58,619.53	60,994.68	63,037.11	64,823.72	65,864.98
Horses	144.78	148.16	152.33	156.01	159.38	162.33	163.96
Sheep/ Goats	5,039.95	5,238.96	5,490.73	5,713.20	5,904.51	6,071.86	6,169.39
Deer	380.82	381.75	382.80	383.82	385.00	386.24	386.55
Feral Hogs	14,612.26	14,569.80	14,522.72	14,481.30	14,445.77	14,414.28	14,395.12
Other Sources	8,947.39	8,947.39	8,947.39	8,947.39	8,947.39	8,947.39	8,947.39
	89,473.95	**92,171.02**	**96,247.04**	**100,939.62**	**106,744.60**	**111,956.12**	**114,552.36**

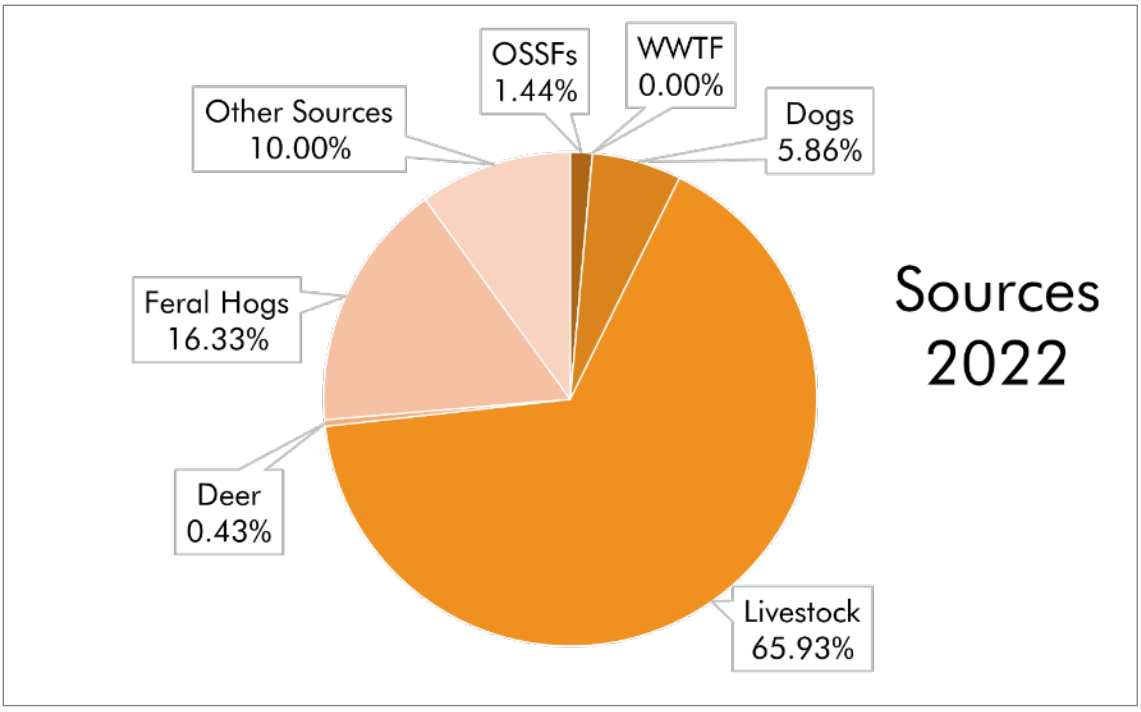


Figure 30. *E. coli* source profile, 2022

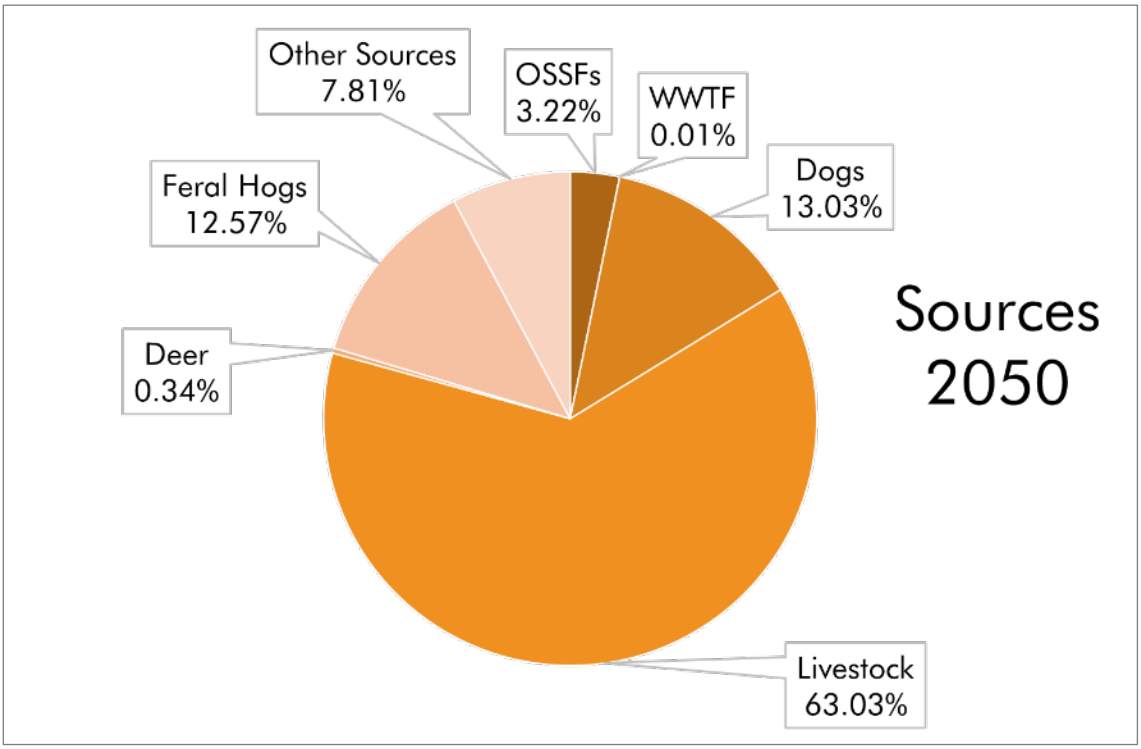


Figure 31. *E. coli* source profile, 2050

Implications of Fecal Waste Source Characterization Findings

The results of LDC and SELECT models generated for this report indicate different fecal bacteria reduction needs for different areas of the watershed dictated by a complex mix of sources which are predicted to shift in coming years. Among these sources, livestock waste was determined to be the dominant pollutant in both current and projected scenarios. The increasing loads highlight the need for intervention through the WPP and other means. Current water quality issues will be compounded by future loads, leading to degrading water quality through the planning period absent any effort to the contrary.

Uncertainty is present throughout the assumptions and methodologies of this modeling approach, as noted throughout this document. Project staff used the best available data and stakeholder feedback to minimize uncertainty wherever possible, but the results should be taken in the context of their use in characterizing fecal waste pollution on a broad scale, and for scaling and siting BMPs. For these purposes, the level of uncertainty and precision of the results was deemed to be acceptable by the stakeholders. Further refinement of results may be needed in the future considering changing conditions. While bacteria source tracking or other analyses quantifying host organism DNA instream were not a function of this project, it may be a consideration in the future to further characterize sources, identify location-specific challenges, and refine the linkage between source loads and instream conditions.

Other Concerns

No specific modeling was conducted for other stakeholder concerns such as flooding, or trash. However, stakeholder feedback was taken on problem areas, and project staff developed recommendations for coordinating with partner efforts and programs overlapping these concerns as part of the recommended solutions of this WPP.

Trash

While no sites of appreciable concern were designated by stakeholders, trash in the waterway was considered as a concern, especially in denser urban areas of the downstream watershed, where trash enters through stormwater and sheet flow. Project staff identified ongoing efforts in the watershed that would be important points of coordination, with the intent of including trash in water quality conversations, and vice versa.

Flooding

The potential use of natural infrastructure as supplement to flood mitigation projects, the conservation of open space, and the inclusion of water quality concerns in flood project design were all areas of needed coordination during the implementation of this WPP.

Section 4

Improving Water Quality

Photo Credit: Kendall Guidroz

Section 4. Improving Water Quality

The success of solutions recommended by this WPP will be due in large part to how well they are scaled and targeted to address the pollutant sources identified in Section 3. The Partnership conducted a water quality modeling effort[41] to determine the amount of improvement needed for *E. coli*. The purpose of this effort was to establish how much *E. coli* needed to be reduced to meet the SWQS. **Load duration curves** (LDCs) were used in combination with water quality data to determine these results. Based on these analyses, assessments of land cover and pollution sources, and the locations of points at which future compliance would be measured, different attainment areas were identified within the total watershed. Unique improvement goals were generated specific to the magnitude and composition of pollutant sources estimated for each attainment area.

Load Duration Curves for *E. coli*

Pollutants can enter the water body from discrete sources or from nonpoint sources in different flow conditions. The amount of water flowing through a water body can affect concentrations of pollutants. LDCs use observed water quality data (see Section 3) to indicate the difference between observed levels of pollutants in a waterway, and the levels at which the applicable water quality standards would be met. The difference then becomes the basis for improvement goals.

The LDC approach uses flow data from a stream gauge or other source to create a flow duration curve. These curves indicate what percentage of days the flow of water meets certain flow levels (*e.g.*, a certain waterway may meet its base flow 100% of the time, but its highest peak flows only 5% of the time). Based on the numeric criteria for a water quality standard, a maximum allowable load of pollutant is calculated for all flow conditions. Lastly, monitoring data for the pollutant are multiplied by flows to produce a load duration curve, which shows how the actual load of a pollutant in the water changes in different flow situations (an example LDC is shown in **Figure 32**). More importantly, the curve indicates under what flow conditions, and by how much, the observed pollutant levels exceed the allowable load. Areas in which the load duration curve line exceeds the maximum allowable load curve line indicate that the standard is not being met in those flow conditions. If the areas of exceedance are primarily in high flow conditions, it is likely that nonpoint sources are most prominent. If areas of exceedance are instead primarily in the low flow conditions, point sources are more likely suspects. In situations where there is a mix of flow conditions related to exceedances, or in which contaminants exceed the

[41] For greater detail on the modeling for *E. coli* discussed in this section, please refer to the Bacteria Modeling Report on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_4.3_bacteria_modeling_report_final.pdf

allowable limit in all conditions, a mix of point and nonpoint sources is likely. The amount in which the observed loads exceed the allowable loads is the basis for developing improvement goals.

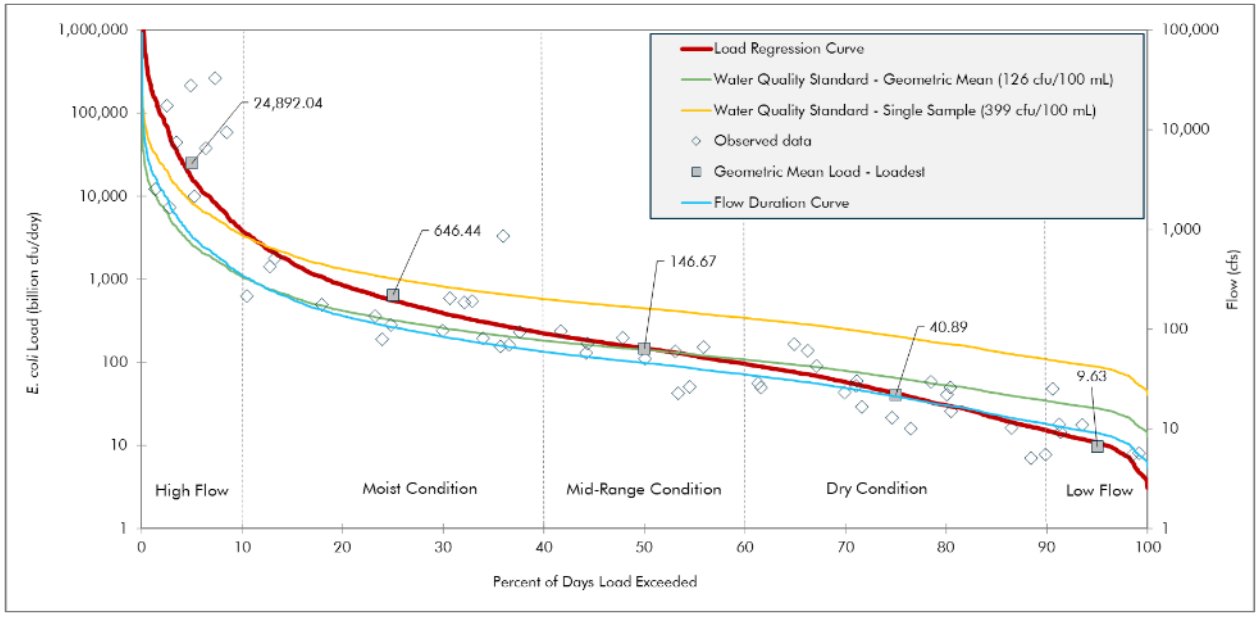


Figure 32. Example of a load duration curve for *E. coli*

Data Development

Project staff developed LDCs for *E. coli* at several monitoring stations throughout the East Fork San Jacinto River watershed. The purpose of the LDCs was to identify which flow conditions demonstrated exceedances, and to generate goals for *E. coli* reduction.

Site Selection

Site selection for LDCs was based on support for a mix of considerations, including known water quality conditions[42], the need for long-term assessment of progress toward the water quality standard, projected needs for BMP siting decisions, and stakeholder input.

- *Known Water Quality Conditions* — Based on a review of historical ambient water quality trends, wastewater treatment facility discharge monitoring reports, and sanitary sewer overflow information, water quality in the project watershed indicated that conditions in the assessed tributaries and main channel both had a degree of variability and potential for continued exceedance. A single station would not be representative of the variability of conditions based on the water

[42] For more information, see the Water Quality Data Analysis Summary Report on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf

quality review. Therefore, several LDC locations were chosen to represent varying conditions along the waterway. One station on each AU with an impairment or concern was selected to assess water quality throughout the watershed. This design allows for a greater degree of scrutiny of geographic variability of loads in the watershed, and an ability to target reductions more precisely. Evaluating several areas independently ensures area-specific problems would not be lost when diluted by a larger waterway, and that end results reflect variability of conditions throughout the waterway.

- *Long Term Assessment Considerations* — To ensure sufficient periods of record and continued data availability, LDC locations were drawn from existing CRP monitoring stations that have been monitored for at least 10 years and are planned to provide ongoing data. Availability of corresponding long-term streamflow data from USGS gage sites was also considered for site selection. Data from CRP stations and associated USGS gages (**Table 26**, **Figure 33**) selected for LDC analysis include:
    - **East Fork San Jacinto River (Lower)** – This area is represented by Station 11235 (East Fork San Jacinto River at FM 1485) and stream flow was assessed from USGS gage 08070200.
    - **East Fork San Jacinto River (Middle)** – This area is represented by at Station 11238 (East Fork San Jacinto River at SH 105) and USGS gage 08070000 was used to measure flow.
    - **East Fork San Jacinto River (Upper)** – This area is represented by Station 17431 (East Fork San Jacinto River at SH 150). This station is not represented by a USGS gage, but because it occurs on the same water body as a gaged station (11238), stream flow was estimated by applying a drainage area ratio. To do this, the drainage area of 11238 was compared to that of 17431 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 11238. The resulting values were used as daily flow values for 17431.
    - **Winters Bayou Creek** – Ambient data for this area are represented by Station 21417 (Winters Bayou at Tony Tap Road near Cleveland) Station 21417 occurs after the confluence with Nebletts Creek but before the confluence with the East Fork San Jacinto River. This station is not represented by a USGS gage. Because 21417 occurs on a separate water body from the nearest USGS gaged station (11238), a linear regression method was applied. Instantaneous flows measured during quarterly sampling events at 21417 were compared to daily mean flow measured at 11238 to develop a linear regression equation. This equation was applied to daily mean flows from 11238 to estimate daily flows at 21417.

- **Boswell Creek** – Ambient data were collected from Station 21934 (Boswell Creek at Four Notch Road). As with Station 17431 in SW3, stream flow data were assessed by applying a drainage area ratio to the regression values from 21417. The drainage area ratio was used in this case as opposed to the regression method due to the limited record of instantaneous flow data available at this station.

- *BMP Siting Requirements* — As discussed previously, LDCs were chosen in part to reflect geographic variability. A greater number of LDC locations is beneficial to compare with modeling results to scale and site solutions (*i.e.*, solution requirements can be refined to the subwatershed level based on the specific reduction needs of the LDC assessment area in which the subwatershed falls).
- *Stakeholder Input* — Project staff built the aforementioned considerations into a set of LDC locations, which were reviewed with stakeholders in the preliminary meetings of the East Fork San Jacinto River Watershed Partnership.

Table 26. LDC site information

LDC Site	CRP Station	USGS Gage	Assessed Area	Number of *E. coli* Samples
East Fork San Jacinto River at FM 1485	11235	08070200	Subwatershed 1	59
East Fork San Jacinto River at SH 105	11238	08070000	Subwatershed 2	58
East Fork San Jacinto River at SH 150	17431	No Gage	Subwatershed 3	33
Winters Bayou at Tony Tap Road near Cleveland	21417	No Gage	Subwatershed 4	31
Boswell Creek at Four Notch Road	21934	No Gage	Subwatershed 5	17

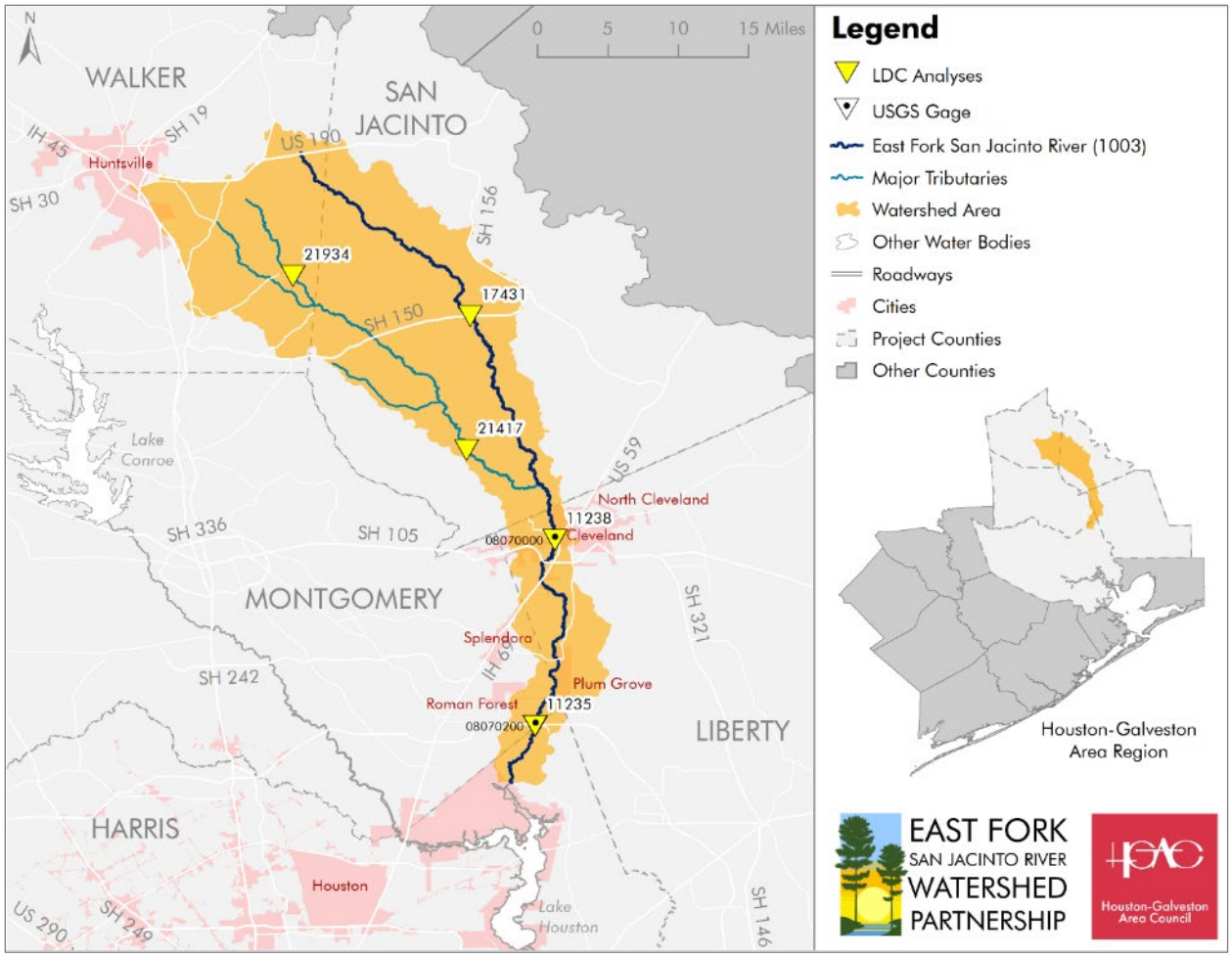


Figure 33. LDC sites

Quality Assurance

Quality-assured ambient water quality results from CRP monitoring were available for all six stations. All stations on the East Fork of the San Jacinto River have at least 10 years of data available and range from 33 to 59 samples for *E. coli* (**Table 26**). Regular sampling on the tributaries to the East Fork of the San Jacinto River, Winters Bayou and Boswell Creek, have begun in more recent years, therefore, the dataset is more limited. However, an analysis of these waterbodies will provide a more complete understanding of bacteria loading throughout the watershed. For *E. coli*, both single sample and geomean values were evaluated against their respective criteria, but only geomean values were used in the process of assessing reductions for this modeling effort.

In addition to ambient water quality data, streamflow data is also required (with continuous flow data being preferable) to produce LDCs. Two of the East Fork San Jacinto River watershed LDC sites (11235 and 11238) have corresponding USGS

gages. For Stations 17431, the drainage area of gaged Station 11238 was compared to that of 17431 to determine a ratio to use as a multiplier for daily mean stream gage measurements taken at 11238. This process has been used in previous watershed-based plans and meets the quality objectives of the project. Similarly, no USGS gage data is available for Station 21417 on Winters Bayou. Because 21417 occurs on a separate water body from the nearest USGS gaged station (11238), a linear regression method was applied. Instantaneous flows measured during quarterly sampling events at 21417 were compared to daily mean flow measured at 11238 to develop a linear regression equation. Lastly, estimations for stream flow data at Station 21934 on Boswell Creek were assessed by applying a drainage area ratio to the regression values from 21417. The drainage area ratio was used in this case as opposed to the regression method due to the limited record of instantaneous flow data available at this station. These processes were reviewed internally and with project stakeholders and found to be sufficient for the quality objectives of the project.

Load Duration Curve Implementation

Both the requisite flow and constituent sample data was sufficient to develop LDCs for all locations and will likely continue to support future revisions and the adaptive management process of evaluating WPP success. Results of the LDC analyses were reviewed internally and with project stakeholders. No issues with the data development and implementation were identified based on quality assurance review and feedback. Full profiles for each LDC site are included in the Bacteria Modeling Report[43].

Load Duration Curve Analysis Summary

Results of LDC analyses for East Fork San Jacinto River have been reviewed internally and subjected to stakeholder analysis. H-GAC staff discussed these results with stakeholders at partnership meetings and in more focused, one-on-one conversations. Stakeholder support and positive feedback support confidence in the estimated levels of fecal bacteria loadings and reduction targets for the East Fork San Jacinto River watershed.

LDC analyses of fecal bacteria loads at all sites throughout the watershed indicated a need for considerable reductions in high flow and moist conditions (**Table 27**). Reduction needs at lower levels of flow varied among sites. Sites on the East Fork of the San Jacinto River (11235, 11238, and 17431) require reductions for a wider range of flow levels (high flows through mid-range conditions and occasionally dry conditions) compared to those in the

[43] For more information, please refer to the Bacteria Modeling Report on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_4.3_bacteria_modeling_report_final.pdf

watershed areas of the tributaries (21417 and 21934; reductions only required in high flow and moist conditions). Low flow conditions are within range of the standard at all sites.

Table 27. Summary of LDC results

LDC Location	Area Represented	Findings
Lower East Fork San Jacinto River (11235)	Segment 1003; Subwatershed 1	The results of LDC analyses for Station 11235 indicate a need for moderate reductions in fecal bacteria loading at high flow, moist, mid-range, and dry conditions. *E. coli* geomean loads expressed in billion colony forming units per day (cfu/day) were higher at higher levels of flow and implicate nonpoint sources as the greater pressure in this subwatershed area.
Middle East Fork San Jacinto River (11238)	Segment 1003; Subwatershed 2	The results of LDC analyses for Station 11238 indicate that fecal bacteria require reduction in high flows, moist, and mid-range conditions. Comparative to Station 11235, reduction levels at Station 11238 were comparable in high flow and moist conditions. *E. coli* geomean loads at mid-range were lower than at 11235 and were within state standard range in both dry and low flow conditions.
Upper East Fork San Jacinto River (17431)	Segment 1003; Subwatershed 3	The results of LDC analyses for Station 17431 are more in line with the analysis conducted on 11235 in that reductions in fecal bacteria are recommended for all flow conditions excluding low flow.
Winters Bayou (21417)	Segment 1003A; Subwatershed 4	The results of LDC analyses for Station 21714 differ from those observed in the East Fork of the San Jacinto River in that *E. coli* reductions are only required in high flow and moist conditions. This indicates that nonpoint sources of fecal bacteria loading are of greater concern at this site.
Boswell Creek (21934)	Segment 1003C; Subwatershed 5	The results of LDC analyses for Station 21934 more closely resembled those of Station 21417 with exceedances of the *E. coli* water quality standard observed only in periods of high flow and in moist conditions.

Improvement Goals for *E. coli*

The LDCs provided the basis for setting improvement goals for *E. coli* in the form of percentage reductions of instream loading.

Attainment Areas

In developing improvement goals, the Partnership considered whether a single, watershed-wide goal for *E. coli* was appropriate. Based on the varied character of the watershed, and to provide for better monitoring of project progress, the Partnership elected to set separate goals for distinct areas in the watershed.

In both LDC and SELECT model results, different fecal bacteria source pressures are indicated in different areas of the watershed. To streamline the process of determining load reduction targets while recognizing different loading pressures affecting different areas of the watershed, project staff recommend using attainment areas as the base level target

areas for determining fecal bacteria reductions. Attainment areas are groupings of similar geographical areas such as subwatersheds which share similar characteristics including land cover or pollutant loading pressures. The East Fork San Jacinto subwatersheds were grouped into three attainment areas (**Figure 34**). The respective stream segments and watershed areas for station 21417 and 21934, along with those of Nebletts Creek, were grouped together into an attainment area because of the similarities in model results and land cover and to differentiate the tributary portion of the watershed from the subwatersheds representing the East Fork of the San Jacinto River. The "East Fork San Jacinto River Tributaries" attainment area will be represented by Station 21417 due to its location (furthest downstream) and data record. The Lower East Fork San Jacinto River subwatershed is unique due to the large percentage of developed land cover in this area. This subwatershed will comprise a separate attainment area represented by data from Station 11235. The remaining subwatersheds (Middle and Upper East Fork San Jacinto River) will be grouped into a final attainment area due to similarities in LDC model results and land cover. The representative station for this "Upper East Fork San Jacinto River" attainment area will be Station 11238. The monitoring stations and their associated LDCs and improvement goals for these three areas will be the primary focus of measuring water quality achievements under the WPP.

E. coli Source Load Reduction Goals

With the establishment of the three primary attainment areas, the Partnership developed specific *E. coli* reduction targets for current and target year (2040) conditions. The first step was to identify a single improvement goal based on the LDCs for each attainment area.

The design for generating single target reductions for each attainment area[44] was based on a compromise between the worst-case scenario (*i.e.*, equating the reduction need to the **highest** possible reduction need in any flow category) and the least conservative approach (*i.e.*, equating the reduction to the **average** reduction needed based on all flow conditions). H-GAC proposed, and the stakeholders affirmed, a moderate approach in which reduction targets would be established based on a weighted average of the flow conditions in which reductions were needed, for each attainment area.

[44] As opposed to the modeled reduction values for each flow category.

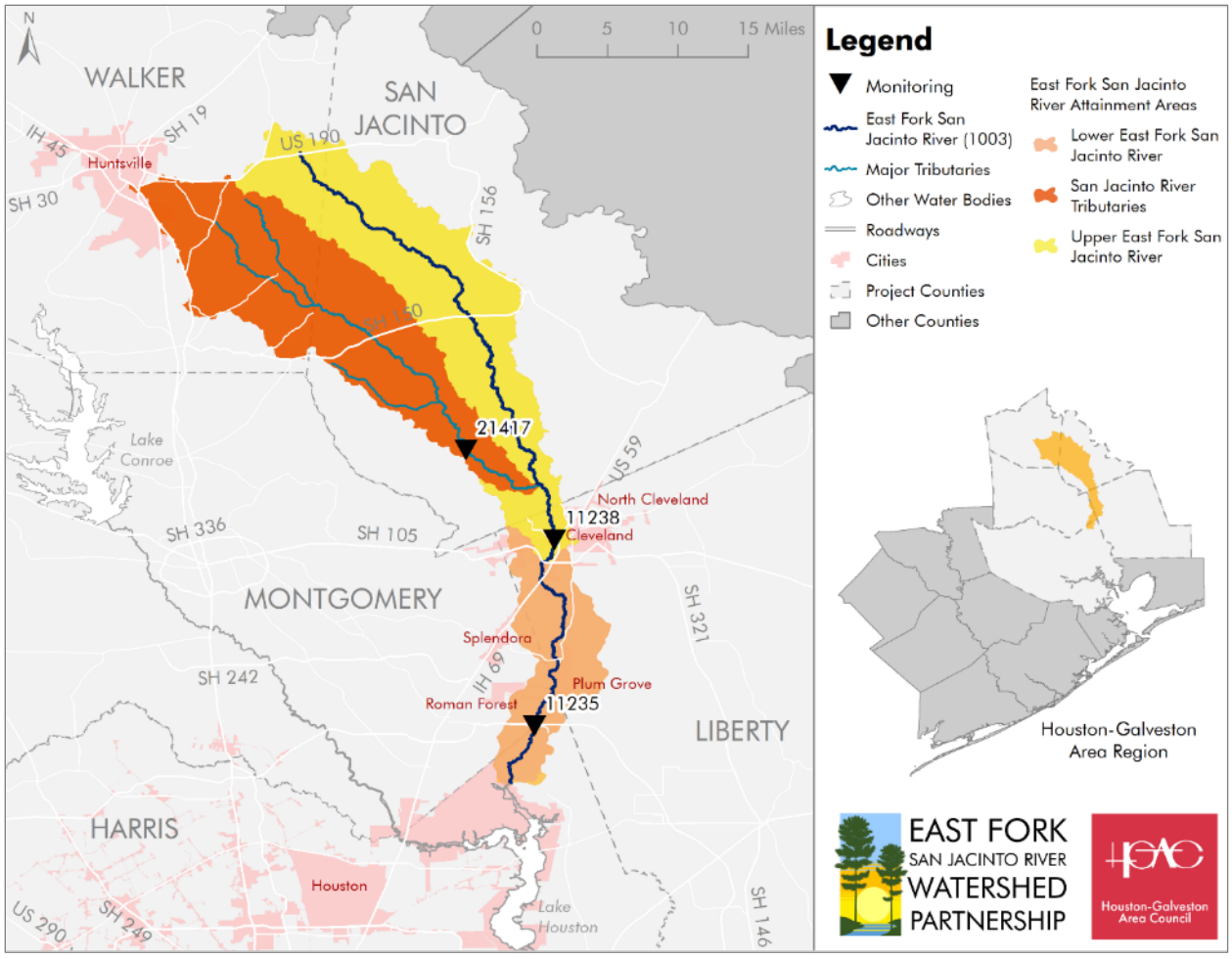


Figure 34. East Fork San Jacinto River watershed attainment areas

The equation below demonstrates the calculation used to determine this average, where *W* represents the weighting factor (percent of flows) at high flow (*h*), moist (*m*), mid-range (*mr*), dry (*d*), and low flow (*l*) conditions, and *R* represents the reduction value required at each rate of flow.

$$\text{Weighted Average Reduction} = \frac{WHRH + WMRM + WMRRMR + WDRD + WLRL}{WH + WM + WMR + WD + WL}$$

For example, 11235 is the farthest downstream station in the attainment area of the lower East Fork San Jacinto River and was used to represent the area as shown in **Table 28**. At the high flow category which represents the top 10% of flows, an *E. coli* reduction of 83% is recommended. *E. coli* observed in the next 30% of flows (moist conditions) require a reduction of 56% and *E. coli* observed in the following 20% of flows (mid-range conditions) require a 31% reduction. Finally, *E. coli* observed in dry conditions comprising the following 30% of flows only require a 1% reduction. Low flow conditions are not factored into this

calculation as no reductions were indicated by the LDC model. The calculation for the weighted average reduction for Station 11314 is shown below:

$$\text{Weighted Average Reduction} = \frac{(10\times 83)+(30\times 56)+(20\times 31)+(30\times 1)}{10+\ 30+\ 20+30}$$

$$\text{Weighted Average Reduction} = \frac{830+1{,}680+620+30}{90}$$

$$\text{Weighted Average Reduction} = \frac{3{,}160}{90} = 35.1$$

This calculation was also used to determine the weighted average fecal bacteria reduction needed at Station 11238 which was selected as the best representative station in the upper East Fork San Jacinto attainment area, and Station 21417 which represents the attainment area for the tributaries of the East Fork San Jacinto River. Only weighting factors and reduction targets from high, moist, and mid-range flows were considered for Station 11238 as no reductions were indicated by the LDC model at dry and low flow conditions. For the same reason, only high and moist conditions were used in the weighted average reduction target calculation for station 21417. The resulting value is shown in **Table 28**.

Table 28. *E. coli* load reduction goals by percentage of load

Attainment Area	LDC Station	Subwatersheds	Weighted Average *E. coli* Reduction Target
Lower East Fork San Jacinto River	11235	1	35%
Upper East Fork San Jacinto River	11238	2 and 3	38%
East Fork San Jacinto River Tributaries	21417	4, 5, and 6	36%

Model Linkage

SELECT was used to generate potential source loads and characterize the source profile. The percent reduction improvement goals developed under the LDCs were applied directly to the source loads to generate the source load reduction targets. This process was developed with H-GAC and TCEQ project staff and reviewed and accepted by the stakeholders. No granular fate and transport modeling was completed for this project. Instead, the linkage relies on the assumption of a linear relationship between source loads and instream conditions. The percent reduction from the LDCs, rather than an absolute number of *E. coli* to reduce, is used for the linkage.

With the model linkage established, calculating *E. coli* reduction targets required that the stakeholders consider two other primary questions: 1) what milestone year would reduction

targets be based on; and 2) how would source load reductions be spread out among the fecal waste sources?

Milestone Year

WPPs typically are written to be executed over a 5 to 15-year period. The existing projections developed during the SELECT analyses allowed the stakeholders to target any of the five-year milestone dates between 2022 and 2050. However, the further out the projections went, the greater the uncertainty. In deciding on a target milestone year, the stakeholders balanced the need to set near term, achievable goals within a period of relative certainty, and the need to account for the amount of future growth projected for the watershed. A 5-year plan would not adequately address the appreciable increase in loads through 2050, whereas a more long-term plan would have to rely on less certain predictions[45]. The Partnership and project staff agreed to target the year 2040, allowing a long-term focus to account for watershed change, while focusing on meaningful interim action. For a WPP approved in 2024, this would represent a 16-year plan life.

Allocating Reductions

The mix of sources present in the watershed, and the shift of relative contribution through 2050, posed a challenge for allocating how reduction targets would be met. Stakeholders considered several options, including: 1) targeting all sources proportional to their contribution (*e.g.*, if in 2040, source X made up 30% of the total load, then 30% of the reduction value would be met by addressing that source.); 2) allocating reduction subjectively based on potential solutions; and 3) allocating reduction based on current relative contribution (rather than 2040). Project staff proposed the first option as an initial guide for the calculation of reduction targets, with the understanding that the WPP would stress opportunistic implementation in addition to adaptive management strategies that will be most feasible in the short term. The proportional allocation was modeled for the whole watershed, subwatersheds, and attainment area groupings, with the proposed allocations to focus on the attainment areas. Stakeholders affirmed the proposal.

Based on these decisions, project staff generated reduction targets for each attainment area, subwatershed, and source. Overall reduction targets for each of the attainment areas and the linkage of the reduction target percentages to the source loadings were used to generate the target source load reductions for estimations as of the year 2022, and for the 2040 milestone year (**Table 29**). The load reductions needed by source for each of the two attainment areas, were also determined for conditions in 2040 (**Table 30**; **Table 31**;**Table 32**).

[45] This should not be taken to indicate a failure of the modeling methodology, but a reflection of the potential for unaccountable change the further out a model is used to predict conditions.

Table 29. 2022 and 2040 source load reduction targets

Attainment Area	Sub-watersheds	Weighted Average *E. coli* Reduction Target	2022 Total Source Load in Billion cfu/day[46]	2022 Source Load Reduction Target in Billion cfu/day	Incremental Load, 2022 to 2040 in Billion cfu/day[47]	2040 Total Source Load Reduction Target in Billion cfu/day[48]
Lower East Fork San Jacinto River	1	35%	7,821.74	2,737.61	7,737.36	10,474.97
Upper East Fork San Jacinto River	2 and 3	38%	15,293.54	5,811.55	1,029.77	6,841.31
East Fork San Jacinto River Tributaries	4, 5, and 6	36%	18,206.81	6,554.45	2,774.56	9,329.01

[46] Current source load is generated by summing the source loads for the subwatersheds within the attainment area.

[47] The incremental load represents the difference between the 2040 load and the 2022 load. See the next footnote for explanation of its use in generating 2040 source reduction load target.

[48] The 2040 reduction target is generated by through the equation $C_r+(F_l-C_l)$; where C_r= current source reduction load, F_l = future total source load, and C_l = current total source load. In essence, the incremental load generated between 2022 and 2040 is added to whatever existing reduction load exists in 2022. This approach is used because LDCs cannot estimate future reduction percentages, and because it is assumed the waterway will not have additional assimilative capacity in 2040.

Table 30. Load reduction targets by source, Lower East Fork San Jacinto River attainment area, 2040

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	11.92%	1,291.63
WWTFs	0.02%	2.31
Dogs	48.39%	5,243.44
Cattle	21.03%	2,279.05
Horses	0.13%	13.89
Sheep and Goats	1.97%	213.47
Deer	0.25%	27.71
Other Sources	6.30%	682.36
Feral Hogs	9.99%	1,082.4
Total	**100.00%**	**10,836.26**

Table 31. Load reduction targets by source, Upper East Fork San Jacinto River attainment area, 2040

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	1.00%	150.36
WWTFs	0.01%	0.77
Dogs	4.59%	695.4
Cattle	61.26%	9,275.56
Horses	0.19%	29.31
Sheep and Goats	5.74%	868.82
Deer	0.47%	71.31
Other Sources	9.28%	1,404.89
Feral Hogs	17.46%	2,644.01
Total	**100.00%**	**15,140.43**

Table 32. Load reduction targets by source, East Fork San Jacinto River Tributaries attainment area, 2040

Source	% Total Load, 2040	Proportion of 2040 Load Reduction Target in Billion cfu/day
OSSFs	0.34%	79.32
WWTFs	0.00%	0.45
Dogs	1.19%	287.24
Cattle	70.78%	17,024.05
Horses	0.13%	30.47
Sheep and Goats	6.63%	1,594.59
Deer	0.32%	77.59
Other Sources	8.50%	2,044.54
Feral Hogs	12.11%	2,912.42
Total	**100.00%**	**24,050.67**

Representative Units and Scaling Implementation

To determine what the source load reduction targets meant in terms of the scaling of solutions, representative units were used. Representative units simplify the conceptualization of load reduction targets by converting load values in cfu/day to practical units. The total number of units that would need to be addressed in each attainment area in 2040 was calculated by dividing the target load reductions by the per-unit *E. coli* load of each source (*e.g.*, one representative unit for pet waste is equal to the daily *E. coli* load produced by one dog) (**Table 33**). The per-unit *E. coli* loads from each source are largely adapted from Teague et al., 2009[49] with the exception of cattle which were revised to reflect more recent estimations (See Section 3). All units are rounded up to the nearest whole unit. In SELECT analyses using the buffer approach, the instream load contributed by each source varies by proximity to the waterway. However, when calculating representative units, no spatial distinction was made. This conservative method of converting target load reductions to representative units could over-represent reductions to be made in areas outside the buffer.

Table 33. Representative units to address by 2040, Lower East Fork San Jacinto River attainment area

Source	Representative Unit	Representative Unit Daily Load (billion cfu/day)	Units to Address by 2040
OSSFs	1 failing OSSF	3.71	348
WWTFs	1 million gallons of effluent	4.77	NA[50] (0)
Dogs	(waste of) 1 dog	2.50	2,388[51] (2,097)
Cattle	(waste of) 1 cow	11.00	207
Horses	(waste of) 1 horse	0.21	NA (66)
Sheep & Goats	(waste of) 1 sheep or goat	9.00	24
Deer	(waste of) 1 deer	0.18	NA (158)
Feral Hogs	(waste of) 1 feral hog	4.45	243

[49] See: https://ssl.tamu.edu/media/11291/select-aarin.pdf

[50] WWTF, horse, and deer units to address are shown as NA as the Partnership elected to over-convert reductions in other sources given the negligible impact of WWTF and horse waste on instream loading, and a lack of viable reduction solutions for deer waste. The numbers in parentheses represent the number of units that would have needed to be reduced if the Partnership had not chosen this course.

[51] Dog waste unit numbers are increased to cover WWTF, horse, deer, and other sources reduction loads in both the Lower East Fork San Jacinto River attainment area per stakeholder preference. Because there is no representative unit for other sources, that reduction value is not shown. Equivalent reduction values for dogs are added to the total representative units. The number in parentheses represents the number of dogs required to be addressed if WWTF, horse, deer, and other sources loads were not converted into equivalent values.

Table 34. Representative units to address by 2040, Upper East Fork San Jacinto River attainment area

Source	Representative Unit	Representative Unit Daily Load (billion cfu/day)	Units to Address by 2040
OSSFs	1 failing OSSF	3.71	41
WWTFs	1 million gallons of effluent	4.77	NA[52] (0)
Dogs	(waste of) 1 dog	2.50	278
Cattle	(waste of) 1 cow	11.00	843
Horses	(waste of) 1 horse	0.21	NA (140)
Sheep & Goats	(waste of) 1 sheep or goat	9.00	97
Deer	(waste of) 1 deer	0.18	NA (407)
Feral Hogs	(waste of) 1 feral hog	4.45	933[53](594)

Table 35. Representative units to address by 2040, East Fork San Jacinto River Tributaries attainment area

Source	Representative Unit	Representative Unit Daily Load (billion cfu/day)	Units to Address by 2040
OSSFs	1 failing OSSF	3.71	21
WWTFs	1 million gallons of effluent	4.77	NA[54] (0)
Dogs	(waste of) 1 dog	2.50	115
Cattle	(waste of) 1 cow	11.00	1,548
Horses	(waste of) 1 horse	0.21	NA (145)
Sheep & Goats	(waste of) 1 sheep or goat	9.00	177
Deer	(waste of) 1 deer	0.18	NA (443)
Feral Hogs	(waste of) 1 feral hog	4.45	1,138[55](654)

Because the other sources as a category do not have a representative unit, they are not included in this table. Reduction targets for WWTFs, horses, deer, and other sources were converted into equivalent dog waste in the Lower East Fork San Jacinto River attainment area and feral hog waste in the Upper East Fork San Jacinto River and East Fork San Jacinto River Tributaries attainment areas to account for negligible instream loads expected from WWTFs and horse waste in addition to stakeholder preference in not selecting specific

[52] See Footnote 50.
[53] Dog waste unit numbers are increased to cover WWTF, horse, deer, and safety margin reduction loads in both the headwaters and downstream attainment areas per stakeholder preference. Because there is no representative unit for the safety margin, that reduction value is not shown. Equivalent reduction values for dogs in the headwaters and downstream are added to the total representative units. The number in parentheses represents the number of dogs required to be addressed if WWTF, horse, deer, and Safety Margin loads were not converted into equivalent values.
[54] See Footnote 50.
[55] See Footnote 53.

solutions to target deer and wildlife. While WWTFs and horses are not estimated to contribute significantly to bacteria loading in the East Fork San Jacinto River watershed, they will still be considered a focus of implementation, education and outreach, and continued monitoring.

The solutions for livestock are based on the implementation of TSSWCB Water Quality Management Plans (WQMPs) and similar conservation plans through USDA Natural Resources Conservation Service (NRCS). Section 5 provides details on these solutions. To translate the number of livestock units to address into number of plans, project staff worked with TSSWCB and the local Soil and Water Conservation Districts (SWCDs) in this and previous projects to develop an assumed average number of livestock units (50) to be served by each plan. The number of plans is then derived by dividing the number of livestock units by the average units per plan and rounding up to the nearest whole representative plan (**Table 36**). The actual load reduction value for each plan will differ depending on the mix of livestock involved (given their different representative unit loading values).

Table 36. Agricultural plans needed to address livestock loads by 2040

Attainment Area	Total Livestock Units to Address	Total Plans
Lower East Fork San Jacinto River	231	5
Upper East Fork San Jacinto River	940	19
East Fork San Jacinto River Tributaries	1,725	34

Source Load Reduction Summary

Forecasted increases in *E. coli* loads highlight the need for intervention through the WPP and other means. Current water quality issues will be compounded by future loads, leading to degrading water quality through the planning period absent any effort to the contrary.

Uncertainty is present throughout the assumptions and methodologies of this modeling approach, as noted throughout this document. Project staff used the best available data and stakeholder feedback to minimize uncertainty wherever possible, but the results should be taken in the context of their use in characterizing fecal waste pollution on a broad scale, and for scaling and siting BMPs. For these purposes, the level of uncertainty and precision of the results was deemed to be acceptable by the stakeholders. Further refinement of results may be needed in the future in light of changing conditions.

Section 5

Recommended Solutions

Photo Credit: Kendall Guidroz

Section 5. Recommended Solutions

Sources of pollution in the East Fork San Jacinto River watershed are widespread, diverse, and expected to increase in the future. Without intervention, water quality will likely continue to degrade. Identifying a path forward that details a comprehensive approach for addressing these water quality issues is a necessary step in linking stakeholder concerns to achievable results. While the situation is challenging, potential solutions exist that can be implemented on a voluntary basis and in a cost-efficient manner.

This WPP is designed to establish a clear link between the causes and sources of contamination, and the solutions identified and scaled to address them. Section 3 quantified the sources that contribute to water quality impairments and Section 4 identified the *E. coli* reductions and DO improvements needed to meet the Partnership's water quality goals. This Section details the voluntary solutions identified and prioritized by the stakeholders and discusses the financial and technical resources needed to implement them. Section 6 links these activities to corresponding education and outreach elements, Section 7 details the timeline and milestones associated with implementation, and Section 8 provides a path forward to evaluate their success.

Identifying Solutions

As detailed in Section 1, the stakeholders established six guiding principles for the recommendations of the WPP. The stakeholders emphasized: 1) recognizing the uniqueness of the areas in the system; 2) making decisions locally; 3) using voluntary solutions; 4) utilizing proven strategies; 5) coordinating with flood mitigation, conservation, and other adjacent activities occurring in the watershed; and 6) incorporating a strong education and outreach campaign. This focus provided a framework for identifying a set of feasible solutions in line with community priorities. These considerations shaped the discussion of potential solutions and the ultimate selection processes.

Stakeholders reviewed a wide range of potential solutions, starting with those identified in existing projects[56] and ongoing local efforts[57]. The diversity of pollutant sources in the watershed required that stakeholders consider an equally wide range of potential solutions sufficient to address each source[58] in proportion to the prominence of the source. This palette of potential solutions served as a starting point for local customization and

[56] Including previous WPPs and TMDL I-Plans conducted in other watersheds, as well as the I-Plan for the Bacteria Implementation Group, under whose auspices the East Fork San Jacinto River TMDL project now rests.

[57] Including planned or potential activities of local government partners like the Harris County Precincts and Harris County Flood Control District; NGOs like the Bayou Land Conservancy; regional efforts like USACE studies; private developers, and others.

[58] Deer, migratory birds, and other wildlife for which no feasible solutions existed were not considered under this process, based on stakeholder feedback or regulatory restriction.

development of area-specific actions. Recommendations were discussed at multiple meetings of the Partnership. In the interim, the topic-specific Work Groups refined ideas and added expertise in the form of recommendations to the Partnership for further discussion. The discussions focused primarily on solutions to reduce fecal waste loads, with the assumption that most of the fecal waste solutions proposed would also benefit other water quality goals. However, the Partnership discussed some solutions specific to other concerns. After several rounds of discussion and one-on-one meetings with specific partners, the Partnership formed the set of recommended solutions described herein. Both ongoing projects and new efforts are reflected.

This list of solutions is built around the understanding that the WPP operates on a process of adaptive management that will add or remove solutions based on efficacy, funding levels, changing conditions, or opportunities.

Solution Prioritization

The prioritization of solutions was a primary discussion point for the stakeholders. Funding limitations were a key concern for some structural solutions. In general, the stakeholders favored enhancement or supplementation of existing efforts before the addition of new elements. High priority was placed on solutions that:

- Had potential funding sources;
- Served multiple benefits (*e.g.*, vegetative riparian buffers that reduce the transmission of *E. coli* and nutrients while also slowing storm flows and reducing hydrologic impacts of runoff);
- Were already proven programs with sustaining support from agencies or other organizations;
- Involved or emphasized voluntary conservation;
- Were related to or supplemental to flood mitigation efforts;
- Had a strong outreach and education component or tie-in; and
- Were focused on areas most adjacent to the water.

These priorities are reflected in both the set of recommended solutions, as well as the priorities for their implementation, as discussed later in this section.

Recommended Solutions

In developing solutions, the stakeholders considered the purpose of the solution, the scope of its implementation, the responsible parties[59], the period in which it would be

[59] Throughout this section, references to categories (Counties, Districts) are made unless a specific party is named.

implemented[60], the contaminants addressed, its status as either an existing or new effort, the technical and financial resources needed for implementation, and its potential for reducing *E. coli*. The solutions will be implemented together, or in phases, such that they cumulatively address the *E. coli* reduction goals for each source. Estimated costs reflect the period through 2040. The solutions identified in this section are for direct structural or programmatic elements. Solutions related to education and outreach for each source category are highlighted in Section 6. While solutions are intended to be implemented in all appropriate subwatersheds, proportional to the load from the subwatersheds, specific focus areas are indicated for each source category. Focus areas identify the subwatersheds for which a set of solutions is most applicable. For all solutions the Partnership, as an ongoing point of coordination facilitated by H-GAC or a successor agency, is assumed to be a supporting party, though the level of support will differ based on the solution. Additional information on potential funding mechanisms is included as **Appendix D**.

[60] The period represented for each solution is the timeframe within the implementation window between an assumed approval in 2024 and the target year of 2040. Many solutions will likely continue to be implemented as ongoing efforts or as needed to maintain water quality after that point.

Wastewater Treatment Facilities and Sanitary Sewer Overflows

WWTFs in the watershed are generally able to meet their bacteria limits, with few exceedances, but enhancements to structural and operational elements and a focus on addressing SSOs can reduce these sources of human fecal pathogens. Based on established jurisdictions for WWTF operation and SSOs, the responsibilities for these recommendations will largely fall to the local utilities and special districts, who provide the overwhelming amount of sanitary sewer service in the watershed. Many of these MUDs, utility districts, water control and improvement districts, private utilities, and other entities are actively engaged in these efforts and have had noteworthy success. Across the watershed, priority is placed on aging systems, smaller systems with less oversight, systems with chronic issues, economically disadvantaged areas, or facilities located in floodplains vulnerable to storm events.

Despite the relatively low daily load from WWTFs and SSOs, these sources are being considered a high priority because of their proximity to developed areas, and the relatively high risk of human waste. The primary focus of WWTF and SSO solutions are continuation and enhancement of utility operations. Supplemental support from the Partnership, or additional activities beyond normal operations emphasize information sharing, funding identification, and prioritization.

These recommendations are in supplement to the existing day-to-day operations of the WWTFs in the area. The following solutions were identified by the stakeholders for WWTFs and SSOs:

- WWTF 1 — Address problem facilities and consider regionalization
- WWTF 2 — Recommend increased testing
- SSO 1 — Remediate Infrastructure

Educational elements related to WWTFs and SSOs are expanded on in Section 6. Due to the variety of operations in the watershed, cost estimates for these solutions vary widely or are future costs that cannot be predicted. However, the primary focus of funding in this section is existing utility funding resources as augmented with support from the Partnership in identifying and pursuing additional funds. More information about funding sources is available in **Appendix D**.

WWTF 1 – Address Aging Facilities; Consider Regionalization

Purpose: To increase oversight of facilities with discharge violations, and potentially consolidate operations where appropriate to increase economies of scale and phase out outdated treatment infrastructure.

Description: The Partnership will work with local authorized agents and interested utilities to promote remediation of facilities or processes in which exceedances are occurring or likely to occur. This may happen through: routine or augmented investment by the utilities; support from the coordinating entity of the Partnership in identifying or pursuing additional funding resources; or action or recommendation from the counties regarding regionalizing problem, undersized, or aging facilities and infrastructure. No specific problem facilities were identified in the watershed characterization, but as systems age, problem areas may arise.

Priority Area(s): Watershed-wide

Responsible Parties	Period	Contaminant(s) Addressed	Status
Utilities; Cities; Utility District Operators; Counties	Ongoing-2040	Bacteria	Extends existing management; potential enhancement to existing operations

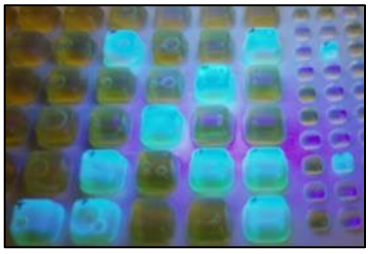
Technical and Financial Resources Needed	Estimated Costs and Funding
The technical resources needed to fulfill these recommendations are sufficient utility staff to address system elements, and Partnership support for funding identification. Financial resources needed for this recommendation are highly variable, but include utility staff time costs, and infrastructure costs as warranted.	Costs involved with WWTP rehabilitation or regionalization are highly variable and not estimated individually here. Funding sources potentially include tax or utility revenue, TWDB loans or grants or other applicable grant programs (USDA Rural Utilities Service, *etc.*).

Bacteria Reduction Capability

This activity directly reduces bacteria and additional concerns such as nutrients stemming from poorly treated effluent. Because there is not a significant pattern of exceedance existing already among watershed WWTFs, future reductions cannot be quantified as they will be dependent on the future state of infrastructure. The primary reduction potential for this task is as a preventative measure.

WWTF 2 – Recommend Increased Testing

Purpose: To increase oversight of certain facilities and enhance nutrients data through increased voluntary testing.



Description: The Partnership will recommend additional bacteria testing to local utilities that do not have daily testing requirements in their TPDES permit. The intent of the increased voluntary testing is to expand the ability to identify operations that would benefit from additional resources. Infrequent testing may mask issues, especially in smaller facilities with less consistent loading. The Partnership also recommends that utilities consider voluntary testing, as appropriate, for a wider suite of nutrients, such as total phosphorus and nitrogenous compounds. This data would help establish the potential impacts of effluent on nutrient loading to the waterway and potentially help prepare facilities for future permit changes, including future statewide additions of other nutrient criteria by TCEQ.

Priority Area(s): Watershed-wide

Responsible Parties	Period	Contaminant(s) Addressed	Status
Utilities; Partnership	Ongoing-2040	Bacteria	Extends existing functions

Technical and Financial Resources Needed	Estimated Costs and Funding
The technical resources needed to fulfill these recommendations are sufficient utility staff to handle increased voluntary testing. Financial resources needed for this recommendation are the incremental costs of sampling, dependent on the frequencies and constituents involved.	Testing costs are highly variable by the frequency of testing and costs specific to the individual entity involved. Funding sources are expected to be tax or utility revenues of the utility.

Bacteria Reduction Capability

This activity does not directly reduce bacteria; it provides information for decision-makers to address current or future operations to directly reduce pollutants.

SSO 1 – Remediate Infrastructure

Purpose: To physically remediate collection system SSOs through rehabilitation and preventative maintenance.

Description: Utilities will continue to identify and address areas in collection systems prone to SSOs and consider structural and operation changes that will reduce SSOs, including:

- prioritizing rehabilitation of problem elements/areas
- considering additional funding for rehabilitation where appropriate
- pursuing additional grant or loan funding to expand resources for rehabilitation

No specific problem areas were identified by stakeholders, but as systems age, problem areas may arise.

Priority Area(s): Watershed-wide with particular focus on Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
Utilities	Ongoing-2040	Bacteria	Enhance existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources for remediating SSOs include sufficient staff capacity for investigating problem areas and implementing capital projects or operational adjustments. For grant projects, staff grant administration capacity would be needed. Financial resources for remediating SSOs are typically borne by utilities directly, through rate revenue or *ad valorem* tax revenue. Potential supplemental funding sources include Texas Water Development Board (TWDB) Clean Water State Revolving Fund loans or grants, funding from resiliency-based funding sources from federal agencies as listed in Appendix D, and traditional commercial loan or bond opportunities. Costs are highly variable depending on the size, age, and type of infrastructure and the nature of the causative factor for SSO problem areas. Resources needed include maintaining adequate staff capacity, equipment to conduct inspections and supplement operations, and cost of rehabilitation and contractor services. Residents are responsible for maintenance and repair of their private line connections.	Estimated costs for addressing SSOs are highly variable depending on the extent of the issues, size of the system, and nature of the fix. Example costs from other regional WPPs include mid-sized cities who spend $1,000,000-$5,000,000/year on addressing aging collection system infrastructure. The distributed nature of service in the watershed means costs per utility are likely lower than this estimate, but in conglomerate amount to appreciable investment. Funding sources include tax or utility revenue and loans/grants from TWDB or other programs.

Bacteria Reduction Capability

This activity is expected to reduce SSO activity at chronic locations. Efficiency is variable depending on extent of the local problem and nature of implementation. The primary benefit is expected to be localized, but significant in those localities based on the relatively high risk of untreated sewage. While the total volume of SSO flow that will be reduced cannot be projected, the reduction efficiency is 100% for each gallon of effluent not released.

On-site Sewage Facilities

Failing OSSFs are a priority source due to high risks to human health associated with untreated human waste, and their increasing share of total load by 2040. The general intent of the stakeholders was to prioritize failing systems that are unlikely to be addressed otherwise, attempt to prevent future failures through education and outreach to the community and licensed professionals, and direct intervention to economically disadvantaged households through programs such as the Supplemental Environmental Program (SEP)[61]. SEP funding is being provided by both TCEQ and the Harris County District Attorney's Office. In order to qualify, homeowners with failing OSSFs must reside in an eligible county, and have a combined income below 80% of the median for the county.

These solutions are in addition to the existing requirements of watershed counties, including mandatory maintenance contracts for systems and other authorized agents, and the enforcement thereof. It should be recognized that county and authorized agent efforts are the primary foundation for all other efforts. The following supplementary solutions were identified by the stakeholders:

- OSSF 1 — Remediate failing OSSFs (repair, replace, pump, decommission)
- OSSF 2 — Convert OSSFs to sanitary sewer where appropriate
- OSSF 3 — Improve and update spatial data to identify priority areas

Educational elements (*e.g.*, homeowner workshops) are included in the discussion of education and outreach activities in Section 6.

Actual implementation will be opportunistic and will seek to emphasize priorities noted in each OSSF solution. Proposed siting of OSSF projects within the watershed to be implemented by 2040 is shown in **Table 37**.

Table 37. Proposed siting for OSSF solutions to be implemented by 2040

Attainment Area	Units to Address
Lower East Fork San Jacinto River	348
Upper East Fork San Jacinto River	41
East Fork San Jacinto River Tributaries	21

[61] H-GAC's SEP is used to remediate, repair, pump, or decommission OSSFs for homeowners making less than 80% of the Area Median Income.

OSSF 1 – Remediate Failing OSSFs

Purpose: Reduce bacteria and nutrient contributions from failing OSSFs through physical remediation.

Description: H-GAC will work with watershed counties and OSSF owners to inspect and remediate failing systems through pumping, repair, replacement, or abandonment/conversion to sanitary sewer. H-GAC will use SEP, CWA §319(h), or other grant funding to address priority systems. Authorized agents will work with homeowners to enforce existing requirements concerning OSSF function and inspection. In remediation efforts, priority will be given to failing systems near the waterways.

Priority Area(s): Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
H-GAC; Homeowners; Counties (enforcement); Utilities (for conversion projects)	Ongoing-2040	Bacteria	Expansion of existing efforts (e.g., H-GAC OSSF SEP, residential maintenance)

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resource needs include data on OSSF locations from H-GAC's regional OSSF database, the counties, local utilities/special districts, who may also provide violation information as appropriate. Actual remediation conducted by H-GAC, the homeowner, or another party; enforcement and referrals will be provided by the other responsible parties. Inspection will be conducted as needed by authorized entities based on existing ordinance or other authority. Financial resources required include H-GAC staff time to manage remediation contracts, other parties' staff time in enforcement, and funding for the remediation. Staff time is variable and is not included in cost estimates. Homeowners are expected to provide most of the funding, with other sources supplementing routine maintenance and replacement costs.	Estimated costs are an average[62] of $5,500 per unit, with a total cost of $8,030,000 for 1,460 systems. Funding Sources include routine homeowner maintenance costs, as supplemented by H-GAC SEP and other grant programs (CWA §319(h), etc.).

Bacteria Reduction Capability

Remediating failing OSSFs is assumed to remove 100% of their daily load. Full implementation of this solution will meet the bacteria reduction goal for OSSFs by 2040.

[62] Average cost numbers were based on a review of OSSF work completed under other projects and approved WPPs in the area, including pump outs, repairs, replacements, and related costs. The range of potential costs for all services mentioned runs from several hundred dollars for a pump out to over $10,000 for replacement of a new system in some areas.

OSSF 2 – Convert to Sanitary Sewer

Purpose: Convert old and/or failing OSSFs to sanitary sewer service where available and appropriate.

Description: Local partners, in coordinating with funding sources like H-GAC's SEP for OSSF remediation, will focus on identifying and pursuing opportunities to convert OSSFs within service area boundaries to sanitary sewer service. Cities will consider promoting or requiring conversion of areas within existing or annexed boundaries. Priority should be given to failing systems, and this recommendation only applies where sanitary service is available/feasible.

Priority Area(s): Properties in subwatersheds with existing sanitary sewer systems

Responsible Parties	Period	Contaminant(s) Addressed	Status
H-GAC; Counties; Special Districts; Utilities; Homeowners	Ongoing-2040	Bacteria	Expansion of existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources include available staff at local governments, H-GAC, and watershed counties to promote and/or process conversion projects. Homeowners or funders will need to have, or contract for, personnel skilled in this specific type of construction. Financial resources include the cost to permit the service connection, construct the service line, and pump/decommission the OSSF. It is expected that a good number of conversions may result in abandoned OSSFs as development of master-planned communities displaces existing residences.	Estimated costs of converting a residence to sewer service are $3,000-$5,000. No specific number of OSSFs is slated for this specific action (see OSSF 2). Funding sources include expected routine costs from homeowner, as supplemented by H-GAC SEP or CWA §319(h) grant funding.

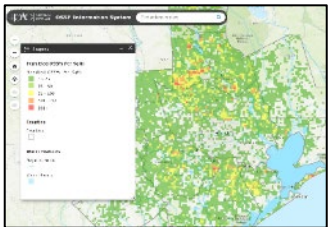
Bacteria Reduction Capability

This solution is expected to provide 100% removal rate by actively converting systems to alternate service.

OSSF 3 – Improve Spatial Data

Purpose: Inform decisions about prioritizing OSSF remediation.

Description: H-GAC will work with watershed counties and other local partners to continue to collect spatial data on OSSF locations as part of H-GAC's existing OSSF spatial database[63]. The partners will update and improve designations for priority remediation areas based on the data and other factors (e.g., growth, developmental trends).



Priority Area(s): H-GAC region and San Jacinto County

Responsible Parties	Period	Contaminant(s) Addressed	Status
H-GAC; Counties; Special Districts; Utilities	Ongoing-2040	Bacteria	Expansion of existing efforts (e.g., H-GAC OSSF database)

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources include existing staff capacity at H-GAC and partner agencies. H-GAC currently maintains the database as part of a CWA Section 604(b) grant project with TCEQ. No additional technical resources are needed for this aspect of the task. Financial resources needed include staff time from local partners to continue to submit and review OSSF data, and to coordinate with H-GAC on maintaining and updating priority areas for H-GAC SEP and other funding in the watershed. Specific focus will be given to economically disadvantaged households and OSSFs in riparian or flood-prone areas.	Estimated costs include existing funding of staff time which is variable depending on workload for this element. Funding sources are the ongoing H-GAC CWA §604(b) grant and local partner staff time.

Bacteria Reduction Capability

This solution does not directly reduce fecal waste pollution but is designed to better inform other solutions (OSSF 1 and OSSF 2; OSSF homeowner workshops) to enhance their effectiveness.

[63] Available for review online at: http://datalab.h-gac.com/ossf/

Stormwater

Stormwater runoff from populated areas with large amounts of impervious cover can contribute pollutants from a variety of sources that often reach waterways through storm sewers without filtration. While urban stormwater is not an original source, but a conveyance for sources, several solutions exist to mitigate its impacts.

The primary means for addressing these sources in most of the urban areas of the watershed are the Municipal Separate Storm Sewer System (MS4) permits through TCEQ's General Permit (TXR040000). The permits require stormwater utilities to address sources of pollutants they may discharge to impaired waterways[64]. The recommendations of this WPP are designed to supplement rather than supplant the existing efforts of the MS4s in the watershed[65]. MS4 activities are likely to have the most impact on bacteria levels in the downstream area. In addition to MS4 permit activities, the stakeholders recommended:

- Urban Stormwater 1 — Install stormwater inlet markers
- Urban Stormwater 2 — Investigate drainage channels for illicit discharges
- Urban Stormwater 3 — Promote low impact development

Points of focus of this category include education and outreach activities, as reflected in Section 6. Implementation will target the urbanized portions of the watershed. These recommendations are in addition to the general recommendation by the stakeholders that infrastructure should be properly maintained. For both Urban Stormwater 1 and Urban Stormwater 2, the Partnership recommends that the investigation program and inlet installation program both include reporting of damaged infrastructure as a standard operating procedure. This will help ensure utilities or other property owners are aware of infrastructure problems and can work effectively to address them, which produces both water quality and flood mitigation benefits to the community. It should be noted that targeted monitoring that is complementary to Urban Stormwater 2 is a recommendation for the broader Bacteria Implementation Group[66] (BIG) area, and active projects are currently underway which may serve as valuable models for this watershed. All efforts under this category will be coordinated to the greatest extent possible with efforts occurring as part of the BIG.

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[64] More information on the permits can be found at: https://www.tceq.texas.gov/permitting/stormwater

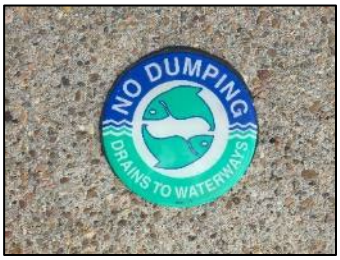
[65] No funding other than that from the MS4 permittees themselves is expected to be applied to activities specific to their permit activities. Any mention of funding sources in the solutions identified for this subsection is intended in reference to activities above and beyond permit requirements.

[66] The BIG is an ongoing TMDL effort addressing fecal indicator bacteria for a number of segments in the H-GAC region, including East Fork San Jacinto River. The WPP provides a more specific focus on East Fork San Jacinto River, considers additional pollutants and stakeholder concerns, and makes watershed-specific recommendations, but is working in conjunction with the broader BIG effort to reduce fecal contamination in local waterways. Learn more at: https://www.h-gac.com/bacteria-implementation-group

Urban Stormwater 1 – Install Stormwater Inlet Markers

Purpose: To increase public visibility of stormwater drains as vectors for pollution.

Description: This solution involves installation of stormwater inlet markers, where appropriate for local governments, special districts, homeowners' associations (HOAs), and neighborhoods. Local organizations (e.g., The Harris County Flood Control District's Stormwater Inlet Marking program[67]) have existing programs for this purpose. This solution reflects partners' intent to continue or expand programs. Inlet markers will be installed based on the requirements of the specific jurisdictions. The intent is to utilize this as a project to engage local volunteers in coordination with outreach efforts.



Priority Area(s): Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
Local Governments; Special Districts; HOAs; Local Volunteers	Ongoing-2040	Bacteria, Trash	New or expanded effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources include staff capacity to train volunteers and manage installation programs. This capacity already exists in the watershed. Financial resources include costs of staff time in installation or managing volunteers, and the costs of the inlet markers. Potential sources include existing programs, local government/organization funding, CWA §319(h) grant funding, neighborhood HOA funding, or private foundation funding.	Estimated costs include the markers themselves (average of $5 or less when bought in bulk), and time in installation (which will vary dependent on whether staff or volunteers are involved). Total costs depend on the extent of the implementation. Funding sources include existing programs, utility revenues, or non-governmental organization (NGO) partner funds.

Bacteria Reduction Capability

This activity is expected to have an indirect impact on bacteria and trash by providing structural outreach to residents. No specific reduction efficiency is assumed.

[67] Harris County maintains a Stormwater Inlet Marking program. More details can be found at: https://www.cleanwaterways.org/swim/

Urban Stormwater 2 – Investigate Drainage Channels

Purpose: To identify and reduce illicit discharges in drainage areas with high bacterial loads.

Description: This solution involves targeted reconnaissance of waterway and drainage channels by H-GAC or partner agency staff on foot to identify broken infrastructure, illicit discharges, or other pollutant sources. Illicit discharge detection is a minimum control measure for MS4 permits, but targeted reconnaissance based on high bacterial loads and coordination of follow-up to anything found would be efforts above and beyond permit requirements. The models for this recommendation are similar to TCEQ/Galveston Bay Estuary Program (GBEP) projects[68] identifying high bacteria load streams in the Houston urban area. This effort can be paired with monitoring activities.

Priority Area(s): I-45 corridor, urbanized areas, downstream attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
H-GAC; Non-Profit Organizations; Local Governments	Early; Ongoing - 2040	Bacteria, Trash	New or expanded effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources include staff capacity in investigation of water and drainage channels. Enforcement data and knowledge from the counties and other jurisdictions would aid in choosing sites and channels. Financial resources include costs of staff time and travel expenses. Staff time would likely be only an incremental addition above a base cost for watershed facilitation in implementation by H-GAC or another lead agency (Section 6).	Estimated costs include hourly costs of $40-50 for staff time and overhead. Total costs depend on scale of effort. A $20,000 project could fund 200-300 hours of field investigation and follow-up. Funding sources include grants (CWA §319(h), GBEP, etc.), collaborations with MS4s, or existing partner resources.

Bacteria Reduction Capability

This activity is expected to have an indirect impact on bacteria and trash by identifying potential sources, which would then be referred to responsible enforcement jurisdictions.

[68] The Top 5/Least 5 project, among others, was a GBEP and H-GAC partnership project to detect potential sources of contamination in highly contaminated waterways, and those close to meeting the standard. The project was successful in identifying sources for several waterways in excess of MS4 permit requirements in the area, through targeted monitoring and reconnaissance.

Urban Stormwater 3 – Promote Low Impact Development

Purpose: To reduce pollutants in stormwater flows through infrastructure that mimics or improves on natural hydrology.

Description: This solution involves promoting and implementing low impact development (LID) design and green infrastructure to filter, slow, and increase infiltration of stormwater runoff. H-GAC and local partners will promote LID through providing model materials on our website, coordinating with local and regional LID projects, and including LID as part of broader discussions of MS4 permits and new development. Local partners may elect to use LID practices in new institutional development (government buildings, parks, *etc.*) Focus areas for this solution are in areas of new development.

Priority Area(s): New developments, Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
H-GAC; Local Governments; Special Districts; Developers	Ongoing-2040	Bacteria, Trash	New or expanded effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources include staff capacity to facilitate discussions for promotion and staff capacity among local partners to implement LID projects. Financial resources of promotion include costs of staff time in developing and disseminating LID materials and coordinating discussion. Financial costs of implementing include the engineering, staff, and structural costs of each project which will vary widely by type and scale.	Cost estimates for promotion are included in the general duties of a watershed coordinator (see Section 7), and do not represent appreciable additional costs. Costs for implementation are dependent on the projects undertaken by local partners. Funding sources include local government revenues with potential grant supplement (CWA §319(h), *etc.*)

Bacteria Reduction Capability

This activity is expected to have a direct impact on bacteria and trash by providing structural barriers. However, reduction capacity is dependent on the practices used. No reduction is assumed specifically for this activity in the WPP.

Pet Waste

Waste from both pet and feral dogs is a substantial source of bacteria and nutrients in the East Fork San Jacinto River watershed, especially in the more densely developed areas. The general focus of the recommended solutions is to enhance existing pet waste reduction efforts, install new structural elements, and promote spay/neuter programs to reduce unwanted populations. The implementation of these tasks is designed to focus on making pet waste reduction easy and visible to dog owners, especially in public places. In light of this, stakeholders recommended the following solutions:

- Pet Waste 1 — Install pet waste stations in local areas
- Pet Waste 2 — Add dog parks or dog areas in public places
- Pet Waste 3 — Hold spay/neuter clinics to reduce feral populations
- Pet Waste 4 — Increase enforcement of pet waste rules and ordinances

The focus of implementation for these solutions will be on public areas with high traffic from pet owners, including parks, trails, and large multi-family complexes. The priority areas are the urban centers and regional park areas, especially the developed portions of Subwatershed 1 adjacent to waterways. The recommendations are in supplement to existing pet ordinance enforcement by local governments and existing structural elements (pet waste stations, *etc.*). Grouping multiple stations at single locations increases ease of use and visibility.

The Partnership's goal is to address dog waste proportional to the number of dogs in any subwatershed, but special attention will be given to riparian areas and high-use public facilities. Proposed siting of pet waste projects within the watershed to be implemented by 2040 includes additional units to convert in order to cover reduction loads from WWTFs, horses, deer, and other sources in the Lower East Fork San Jacinto River attainment area, as noted previously (**Table 38**)[69]. Units to be addressed without accounting for loads from WWTFs, horses, deer, and other sources are represented in parentheses.

Table 38. Proposed siting for pet waste solutions to be implemented by 2040

Attainment Area	Units to Address, Total
Lower East Fork San Jacinto River	2,388 (2,097)
Upper East Fork San Jacinto River	278
East Fork San Jacinto River Tributaries	115

[69] The number of dog waste units designated to be addressed by subwatershed is based on each subwatershed's proportional contribution to the total pet waste load for its segment area. This proportion is applied to the reduction load for the segment area and divided by the load per BMP unit to produce the number of BMP units per subwatershed. As with other sources, the focus of implementation will continue to be on siting BMPs opportunistically to generate the greatest bacteria reduction for each segment area. Therefore, actual implementation in each subwatershed may differ from these targets based on opportunities and changing conditions in the watershed.

Pet Waste 1 – Install Pet Waste Stations

Purpose: To reduce pet waste in runoff by encouraging pet owners to pick up after pets in public areas.

Description: Pet waste stations are a widely used, proven technology for reducing pet waste in public areas where dog owners bring their pets. The stations are cost-effective, with low maintenance aside from refilling bags as needed. This solution would install 40 or more pet waste stations in the watershed, which would be installed and continually maintained by the entity receiving them. The pet waste stations would be targeted for high traffic public areas in the watershed, such as neighborhoods, county parks, other recreational areas, and new development. Temporary stations at large events are another potential supplement to this effort.

Priority Area(s): Parks, neighborhoods and other high traffic areas, Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
Local Governments; HOAs; Apartment Complexes	Ongoing-2040	Bacteria	Expand on existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources required are limited to adequate staffing commitment to install and maintain the sites, functions within the scope of the partners' existing capabilities. Financial resources are needed for the purchase of the stations and initial materials (identified sources include existing funding from local partners, CWA §319(h) grants - wholly or in cost-share with partners, and private sector donations through H-GAC); installation and ongoing maintenance (staff time, provided by the receiving partner); and bag refills (provided by the receiving partner, or as appropriate under future grants). Alternative funding sources for initial materials include partnerships with local industry/commercial entities or park volunteer groups. The Partnership will explore with H-GAC the potential to participate in H-GACBuy[70] cooperative purchasing	Estimated costs for 60 pet stations include installation costs of $200 per station, $50 in bags, $200 in labor and materials (total $27,000). Maintenance is estimated at $300/year per station ($288,000 for 16-year period). The total cost is $315,000. Costs for mobile stations at events are variable. Funding sources include local government tax or utility revenues or grants from CWA §319(h) or other sources.

Bacteria Reduction Capability

The number of dogs impacted by this solution will vary based on the location. An average of 50 dogs a day per station served was chosen based on stakeholder description of high-traffic area parks. Assuming half of the dog's daily waste is served, full implementation of this solution would yield 2,000 dogs, or 1,000 representative units, addressed. This would represent a daily bacteria reduction of 2,500 billion cfu/day in riparian areas (300-foot buffer), and 625 billion cfu/day in areas outside the buffer based on SELECT assumptions.

[70] More detail about H-GAC's cooperative purchasing program can be found online at: https://www.hgacbuy.org/

Pet Waste 2 – Expand Dog Parks

Purpose: To provide additional areas for dog owners to bring dogs, to sequester waste and increase the likelihood of owners picking up waste.

Description: This solution would entail partners developing dog park/areas at their properties or developing new specific dog parks. Heavily used recreation areas and other parks adjacent to waterways are prime locations for dog parks or off-leash areas with waste stations. Newly developing private communities with strong amenity focuses are also potential opportunities for expanded parks. Priority areas are based on highest potential use/traffic and population served.

Priority Area(s): New developments, Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
Local Governments; HOAs; Developers; Apartment Complexes	Middle; goal to establish one new park by 2035	Bacteria	New effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed are sufficient staff capacity for park owners to evaluate potential expansion of dog areas, manage capital projects, and/or seek funding. Financial resource needs reflect the stages for which technical resources are needed. Identified sources of funding include internal revenue of the partners, grants from governmental sources and private endowments, and partnerships with private industry/organizations. Dog park costs are highly variable based on location and composition, and whether new land is acquired, or dog facilities are developed in existing parkland.	Cost estimates for new park acquisition in area plans range from $500,000 to $1,000,000+, whereas development of new facilities in existing parks range from $50,000 to $300,000. Funding sources include municipal revenues, CWA §319(h) grant funding, TPWD park grant funding, or foundation grants.

Bacteria Reduction Capability

This solution indirectly reduces waste, by sequestering it where it can be more easily addressed by owners and park staff. The number of dogs served is based on the number and scale of parks/park areas added. An assumption of 50% reduction of daily load per dog visiting the park is used based on stakeholder input.

Pet Waste 3 – Promote Spay and Neuter Events

Purpose: To reduce feral dog populations through reproductive controls.

Description: Spay and neuter programs are an effective means of curbing feral and unwanted pet populations[71]. The Partnership will work with a spay and neuter provider to hold local spay and neuter events or promote local services to pet owners through local governments, special districts, NGOs and HOAs. Potential models include existing spay and neuter programs in Harris County and NGOs like Friends For Life[72].

Priority Area(s): Urbanized areas, downstream attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
Service provider (such as SPCA[73] or similar); Local Partners	Ongoing, goal to have one event every 5 years	Bacteria	New effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical expertise would be provided by the existing spay/neuter program staff. Similarly, outreach materials already exist for these programs. H-GAC and partners will adapt materials as needed. Various providers have had mobile programs in the area. Financial resources needed include funding for the events from a combination of local government funds, other grant funding, or funding from private endowments, in addition to any contributions received from other interested partners. Funding for the spay/neuter of residential pets would be provided by the residents, or to some degree by the spay/neuter program itself based on its internal funding sources.	Costs estimates for Spay/Neuter education events are $5,000 per event, ($15,000 total) and spay/neuter costs for owners are $40-$150 per animal[74]. Funding sources include pet owners, local partner or non-profit funding, and grants.

Bacteria Reduction Capability

This solution's efficiency will vary based on the number of dogs addressed. A single female dog can have up to three litters a year or an average litter size of seven puppies, yielding up to thousands of dogs in five years or less[75]. Even with a low feral survival rate, this is an appreciable, if not directly quantifiable, reduction. The reduction of each average litter represents a 1.75E+10 daily source load reduction[76].

[71] Harris County has an existing Trap, Neuter, Release program for community (feral) cats. More details are available at: https://www.countypets.com/Pet-Resources/Community-Cat-Program

[72] More information on a model program by this NGO to curb pet populations in underserved communities can be found at: https://friends4life.org/programs-and-events/fix-houston/

[73] Society for the Prevention of Cruelty to Animals (SPCA)

[74] Based on cost estimates provided by the Houston Humane Society, available online at: https://www.houstonhumane.org/clinic/spay-neuter

[75] https://dogpages.net/health/how-many-puppies-do-dogs-have

[76] The reduction represents a total potential source load reduction and does not consider spatial location.

Pet Waste 4 – Consider Increased Enforcement

Purpose: To reduce pet waste through enforcement of existing or new ordinances or other restriction.

Description: Requirements to pick up pet waste vary throughout the watershed in both public and private areas. The focus of this solution is to provide model ordinances and outreach materials, as well as direct engagement, for entities considering increasing their enforcement. Specific attention will be given to apartment complexes and high traffic public areas, especially those adjacent to waterways.

Priority Area(s): Urbanized areas, downstream attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
Local Governments; Special Districts; HOAs; Apartment Complexes	Ongoing-2040	Bacteria	New effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Limited technical resources are required for this solution. Model materials already exist and can be adapted as needed. Financial resources needed for the solution are primarily an issue for increased enforcement costs if active enforcement is conducted. Otherwise, costs are limited to staff time in developing and seeking approval for additional restrictions. A primary focus for this watershed is large apartment complexes. Existing models for multifamily property enforcement exist in the watershed.	Cost estimates for developing new ordinances or outreach materials will vary by scope and type. However, H-GAC maintains model materials on its website[77] as do partners like Harris County. Costs for increased enforcement will vary based on the entity involved and scope of enforcement. Funding sources for developing new enforcement or materials are expected to come primarily from the enforcing entity's existing revenue streams. Model materials already developed do not require additional funding.

Bacteria Reduction Capability

This solution is not a direct intervention, but a reinforcement or expansion of restrictions that serve to prevent wastes.

[77] http://www.h-gac.com/pet-waste-pollutes/default.aspx

Agriculture

Agricultural areas in the watershed maintain populations of livestock in addition to row crops. While modern agricultural practices are often efficient in reducing bacteria and nutrient transmission to waterways, loads from cattle, horses, sheep, and goats are still present in the watershed. Fertilizers are also a potential source of nutrient pollution, and pesticides and herbicides can impact macrobenthic communities and aquatic vegetation. The solutions identified by the Partnership focus on addressing wastes from livestock by expanding and supporting existing, successful programs by TSSWCB, USDA NRCS, and Texas A&M University AgriLife Extension (AgriLife Extension) and Research (AgriLife Research) in coordination with local producers and conservation efforts on agricultural lands by the Bayou Land Conservancy and other NGOs. The intent of these solutions is to provide financial assistance or technical resources for local producers to make voluntary improvements to their property and operations. These improvements are designed to be beneficial to the producer and to water quality. These recommendations recognize the benefits that well-run agricultural lands provide.

The solutions selected by the stakeholders include promoting and implementing voluntary, site-specific management plans for individual farms. The efforts will focus on implementing multiple solutions where appropriate. The East Fork San Jacinto River Tributaries attainment area is the primary focus area for the solutions below.

- Agricultural Operations 1 — Develop land management plans including TSSWCB WQMPs and NRCS Conservation Plans
- Agricultural Operations 2 — Implement other land management techniques through financial assistance and technical programs

Agricultural Operations 1 – WQMPs and Conservation Plans

Purpose: Provide technical and financial assistance to agricultural producers to plan and implement land management practices that benefit water quality.

Description: Both the USDA NRCS and TSSWCB offer agricultural producers technical and financial assistance for "on-the-ground" implementation. To receive financial assistance from TSSWCB, the landowner must develop a WQMP with the local SWCD that is customized to fit the needs of their operation. The USDA NRCS offers options for development and implementation of both individual practices and whole farm conservation plans. Priority for WQMPs and other projects will be given to management practices which most effectively control bacteria contributions to the waterways, with a focus on areas adjacent to riparian corridors. Based on site-specific characteristics, plans will include one or more of the TSSWCB's approved practices[78] including but not limited to filter strips, riparian buffers, prescribed grazing, and providing alternative shade and water. More information on the practices is included in Appendix C. Similarly, the USDA NRCS offers conservation planning services through its Conservation Technical Assistance program[79] and financial assistance through its Environmental Quality Incentive Program (EQIP) and related programs. These services assist landowners to conserve resources and protect water quality by providing NRCS expertise and financial assistance. In addition to WQMPs and Conservation Plans, NRCS offers a broad range of other land and habitat management programs[80].

Priority Area(s): Agricultural areas concentrated in the East Fork San Jacinto River Tributaries attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
TSSWCB; SWCDs; USDA NRCS; Agricultural Producers/Landowners	Ongoing-2040	Bacteria	Ongoing and expanded effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources required by this solution are the expertise of TSSWCB and USDA NRCS staff involved with their respective programs, and the local knowledge of the agricultural producers. Additional WQMP technician(s) may be needed to assist in plan development depending on demand. H-GAC and other partners will assist in promoting WQMPs to landowners. Financial resources required for this solution vary based on the type and scope of plan implemented. Costs for implementing WQMPs are borne in part by the landowner, and in part by TSSWCB, with up to $15,000 in financial assistance available for qualified WQMPs. Sources of funding for these costs include agricultural producer contributions and TSSWCB allocated funds. Resources for NRCS conservation plans and financial assistance programs include NRCS staff time and related costs, funding from EQIP and other programs, and contribution from the landowner. The funding for these costs is expected to come directly from the respective parties. WQMPs or other plans addressing an average of 50 livestock units will need to be implemented (**Table 36**).	Estimated costs for WQMPs include up to $15,000 per WQMP in financial incentives, with the landowner share of costs being variable. NRCS Conservation Plan costs are estimated at $2,000-$3,000 in NRCS staff time, with landowner costs being variable. Funding sources include existing programs (TSSWCB, USDA NRCS) and landowner funding.

Bacteria Reduction Capability

This solution's bacteria reduction capacity assumes a direct reduction of bacteria loading from lands covered by a WQMP/*etc.* The specific mix of efforts under a given project may affect the overall efficiency, in conjunction with the nature and location of the property.

[78] For more information, see: http://www.tsswcb.texas.gov/en/wqmp
[79] For more information, see: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/
[80] For more information, see: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/

Agricultural Operations 2 – Maintain or Restore Riparian Buffers

Purpose: To reduce transmission of pollutants by slowing and filtering runoff from agricultural areas.

Description: Vegetative buffers (including filter strips and riparian forests) in areas adjacent to waterways are an effective means of reducing the transmission in runoff of wastes, organic materials, and nutrients from agricultural operations. This solution would seek to promote and implement voluntary landowner and public entity land management to increase the existing healthy riparian buffers of the watershed.

In addition to WQMPs and conservation plans, potential methods of implementation include the utilization of conservation easements held by land trusts, voluntary individual landowner implementation, or participation in a USDA NRCS Farm Bill program (e.g., EQIP or similar).

Priority Area(s): Riparian areas East Fork San Jacinto River Tributaries attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
Landowners/producers (on a voluntary basis); NGOs; Agricultural Agencies	Ongoing-2040	Bacteria	Expanded existing effort

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resource needs include staff capacity at support agencies to provide technical services and knowledge to landowners. Funding resources for this solution are projected to be a mix of landowner costs (including opportunity costs of acreage removed from production and actual costs of installation and/or maintenance); funding under applicable financial incentive programs (WQMP; USDA NRCS Farm Bill programs); and existing staff capacity among support agencies in staff time and travel costs. If used in conjunction with conservation easements, legal and staff costs include establishing and maintaining the easement, potentially through conservation NGOs.	Cost estimates are variable with type and extent of buffer. Costs may be limited to simply not mowing an area (opportunity cost of productive acreage) to restoration/plantings. Funding sources include established programs and property owner contributions.

Bacteria Reduction Capability

Efficiency will vary based on the extent and size of the barrier and its composition. Reduction estimates for fecal bacteria range from 50%[81] to 95%[82].

[81] Rifai, H. 2006. Study on the Effectiveness of BMPs to Control Bacteria Loads. Prepared by University of Houston for TCEQ as Final Quarterly Report No. 1.

[82] Larsen, R.E., R.J. Miner, J.C. Buckhouse and J.A. Moore. 1994. Water Quality Benefits of Having Cattle Manure Deposited Away from Streams. *Biosource Technology* Vol. 48 pp 113-118.

Feral Hogs, Deer and Other Wildlife

Feral hogs are a potential source of bacteria in watersheds, especially those with large undeveloped areas. Within this general category of wildlife and non-domestic animals, feral hogs are the primary focus of this WPP because of their relatively high bacteria concentration, the other damages they create, and the availability of feasible solutions to address them[83]. Other animals included in this WPP's estimates of loading for deer and other wildlife[84] sources are not intended to be addressed specifically by this WPP, primarily for lack of effective solutions and stakeholder preference in addressing other sources.

There are ongoing discussions at the state and national level about effective methods to address feral hogs. The recommendations of this WPP focus on solutions within the scope of local implementation, and already known to be best practices. The focus of implementation for the feral hog solution will be in agricultural and open space areas in which feral hog damage is a potent incentive for landowner participation. Reduction of feral hogs is expected to derive directly from landowner efforts, as supported by partner agencies through information and technical services, although the Partnership recommends that local and state governments consider active involvement in feral hog reduction efforts.

While the WPP does not specifically seek to address deer and other wildlife, the stakeholders considered the benefit of providing alternative habitat away from riparian areas to reduce population densities and time spent near waterways. The wildlife solution presented here represents that indirect focus.

The focus for these solutions is watershed-wide, with special attention paid to localized hog problems, or conservation opportunities may exist in the watershed. To one degree or another, hog, deer, and other wildlife populations are found throughout the project area. For feral hogs, deer, and other wildlife, stakeholders recommended the following solutions:

- Feral Hogs 1 — Remove feral hogs
- Wildlife 1 — Conserve or restore upland habitat

The Partnership's approach to the feral hog, deer and other wildlife source category includes a strong corresponding focus on education and outreach recommendations, as detailed in Section 6.

[83] Contributions from deer were also modeled, but the Partnership does not recommend direct solutions for deer due to a lack of feasible solutions or means to achieve them.
[84] Included in the safety margin.

Feral Hogs 1 – Remove Feral Hogs

Purpose: To encourage landowners and local governments to directly reduce feral hog populations through trapping and hunting.

Description: This solution seeks to reduce feral hog populations in the watershed through active hunting and trapping. The primary focus of this effort is on voluntary efforts from individual landowners, but the Partnership recommends abatement activities on behalf of local governments, as appropriate.

Priority Area(s): Watershed-wide

Responsible Parties	Period	Contaminant(s) Addressed	Status
Landowners; Local Governments; Special Districts; Agricultural Agencies (technical support)	Early; Ongoing-2040	Bacteria	Expansion of existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed for this solution are advice and support for landowners engaged in feral hog abatement, and technical knowledge on behalf of the landowners themselves. The primary agency providing technical support on feral hog issues is AgriLife Extension. Financial resources of this project include the staff time and related costs of the partner agencies, and the cost of implementing solutions borne primarily by the landowners on a voluntary basis. No grant funds have been identified to supplement these contributions. Potential other resources include leasing property to hog hunting at a potential net gain of costs.	To reduce an estimated 2,314 hogs, 463 traps would be needed (assuming each trap serves to reduce five hogs). With an average cost of $1,000 for a medium sized trap, this would represent an annual cost of $463,000[85], not inclusive of staff/landowner time. Funding sources include local government and property owners. No specific grant resources were identified for this solution.

Bacteria Reduction Capability

This solution nominally reduces feral hog waste by a maximum daily *E. coil* load of 4.45 billion cfu/day for each hog reduced, representing a 100% efficiency. However, this may not account for the volatility of hog population dynamics in which lost members may be replaced through reproduction in excess of population maintenance and does not consider SELECT spatial discounting of source load contributions.

[85] The solution covers a range of practices from hunting to trapping. Assumptions of trap usefulness and costs are based on stakeholder feedback on success rates, and review of varying trap options and pricing. Costs vary from single animal small box traps at $400 to automated drop corral traps at $4000-$5000. Costs do not include time, feed, and other elements. The estimate given should be considered conservative due to the capability of feral hog populations to breed rapidly up to (or beyond) the carrying capacity of the areas they inhabit. Rates of removal below 75% are not likely to have a net reduction of feral hog populations.

Wildlife 1 – Conserve or Restore Upland Habitat

Purpose: To encourage landowners, NGOs, and local governments to conserve and restore upland habitat to relieve wildlife pressures on riparian areas.

Description: This solution seeks to encourage voluntary conservation and restoration of upland habitat away from riparian areas to provide suitable habitat for wildlife away from riparian areas. This solution is intended to coordinate directly with the conservation and land management solutions found later in this section, and will be based on the same approaches, partners, and technical/financial needs.

Priority Area(s): Upper East Fork San Jacinto River attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
Landowners; NGOs; Local Governments; Agricultural Agencies (technical support); Developers	Ongoing-2040	Bacteria, Nutrients, Sediment, Flooding	Expansion of existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
The primary technical resources needed for this solution are staff capacity for pursuing and implementing voluntary conservation projects or ecosystem restoration. Potential technical resources include existing NGOs in the watershed (*e.g.*, Bayou Land Conservancy), agricultural agencies, and local governmental staff. Financial resources needed are dependent on the scale. Costs may be limited to opportunity costs of unrealized development potential (conservation), or costs associated with physical remediation of property (restoration). Existing efforts in the watershed provide a basis for estimating costs of restoration activities specific to the western watershed land cover types. New development is an opportunity to increase set asides.	Cost estimates vary based on scale and type of conservation or restoration and area. Funding sources include agricultural agencies (*e.g.*, USDA NRCS Farm Bill programs), other grants, and local governmental or NGO funding (including private donation and in-kind donation of land value from property owners).

Bacteria Reduction Capability

This solution is not intended to directly impact sources, but is expected to generally reduce feral hog, deer, and other wildlife time in riparian areas by providing alternative range. Due to the wide variety of species this may impact, and the potential variety of lands involved, no specific reduction potential can be generated. However, this solution is modeled after existing agricultural best practices designed to reduce cattle time adjacent to streams by providing alternative water/shade. It will contribute to the general reduction of these sources.

Other Concerns

In addition to the practices recommended for specific sources in the preceding pages, the Partnership recommends several solutions to other local concerns. The recommendations fall into three primary categories:

- Conservation and Land Management
  - Conservation and Land Management 1 — Riparian buffers
  - Conservation and Land Management 2 — Voluntary conservation
- Trash/Illegal Dumping
  - Illegal Dumping 1 — Report Chronic Dump Sites and Consider Increased Enforcement
- Flooding
  - Flooding 1 — Coordinate with Ongoing Flood Mitigation Efforts

Conservation and land management activities relate to conserving or developing natural barriers to pollutants entering the water body. These solutions are approached on a voluntary basis. Prioritization is placed on areas adjacent to riparian corridors in the watershed but may include open space areas in the watershed in general. Areas appropriate for restoration activities in more developed areas may also be targeted for conservation activities (*e.g.*, increasing tree canopy, restoring riparian vegetation). Conservation practices recommended by this WPP are wholly limited to voluntary landowner decisions supported by resources from local government, landowners, and conservation NGOs (*e.g.*, Bayou Land Conservancy), and the Partnership. This WPP makes no recommendations concerning recreational trails or development; its sole focus in this category is improving water quality by maintaining or restoring ecosystem services from conserved land. A variety of successful, model conservation activities exist in the watershed.

Trash and illegal dumping are a visible impact on local waterways and were a secondary focus of the Partnership. The WPP's role in trash reduction is primarily in support of the efforts of other agencies or efforts (*e.g.,* local MS4s as part of Texas Pollutant Discharge Elimination System (TPDES) permit activities). Illegal dumping is the primary focus for the Partnership under this category.

Flooding is another concern for the East Fork San Jacinto River community. The focus of this WPP will be to coordinate with and support the advancement of flood mitigation activities, with an eye toward advocating for inclusion of water quality features.

These recommendations are supplementary to ongoing efforts by the area's local governments, organizations, and MS4s relating to these issues.

Conservation and Land Management 1 – Riparian Buffers

Purpose: To reduce transmission of bacteria, nutrients, trash, and sediment to waterways by maintaining or implementing vegetated buffers in riparian corridors.

Description: This solution is supplementary to Agricultural Operations 2 – Maintain and Restore Riparian Buffers, with a focus on non-agricultural areas.

This solution would engage local landowners and local governments to install and/or maintain vegetative buffers along waterways and drainage channels (as appropriate based on drainage needs). Implementation will differ widely in type and scale. Support for these efforts will be provided for residents by the same agencies and partners indicated in the urban and agricultural versions of this solution.

Priority Area(s): Current and new developments, Subwatershed 1

Responsible Parties	Period	Contaminant(s) Addressed	Status
Landowners; NGOs; Counties; Local Governments; Special Districts; Agricultural Agencies	Ongoing-2004	Bacteria, Flooding	Expansion of existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed for this solution include the existing programmatic resources and staff expertise of the partners identified above, which are considered sufficient to meet this need. Financial resources needed for this solution include the staff resources and landowner contributions previously detailed for the other versions of this solution. Other costs include opportunity costs related to lost property value.	Cost estimates are variable depending on type, size, and location of buffer. Savings in maintenance (mowing, *etc.*) may counter some potential costs. H-GAC offers a riparian buffer planning tool for landowners to estimate potential costs[86]. Funding sources include local government revenues (public buffers), landowner funding, or NGO/local partner funding.

Bacteria Reduction Capability

This solution's efficiency will vary greatly based on the type, and extent of riparian buffer and local area. Nutrient/sediment removal may be a greater benefit than bacteria removal based on existing literature. However, some literature values indicate fecal bacteria removal rates more than 80-90%[87].

[86] Available at: http://www.h-gac.com/riparian-buffer-tool/default.aspx
[87] See references under Agricultural Operations 2

Conservation and Land Management 2 – Voluntary Conservation

Purpose: To reduce transmission of bacteria, nutrients, trash, and sediment to waterways through voluntary land conservation.

Description: This solution is intended to represent the range of efforts and need for increased voluntary conservation projects as a mitigating factor for changing land use. This solution has three primary facets:

- Individual conservation — voluntary efforts by local landowners (including commercial properties) to manage property to maintain natural value, alone or with other entities
- Organizational projects — projects by the local governments, special districts, and NGOs in the watershed to implement voluntary conservation projects
- Developer-driven projects — projects or supplemental elements in new development that maintain or restore natural function or mitigate impacts.

Priority Area(s): Upper East Fork San Jacinto River attainment area

Responsible Parties	Period	Contaminant(s) Addressed	Status
Landowners; NGOs; Counties; Local Governments; Special Districts; Agricultural Agencies	Ongoing-2040	Bacteria, Flooding	Expansion of existing efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed for this solution include the existing programmatic resources and staff expertise of the partners identified above, which are considered sufficient to meet this need. Financial resources needed for this solution include the staff resources or individual landowner resources to develop and maintain conservation easements or conservation lands, including staff time, easement or land acquisition costs, and ongoing maintenance funding.	Cost estimates are variable depending on type, size, and location of properties. Tax savings may offset potential lost land value in easements. Funding sources include new grant sources; developer funding or in-kind value for land set-asides or remediation, and additional investment by public and private partners.

Bacteria Reduction Capability

This solution's efficiency will vary greatly based on the type, and extent of conserved lands. No specific reduction efficiency is assumed. Reduction is based on the difference between transmission rates of developed land uses and natural land uses. The value of the land conserved and the potential alternative use for the land (development, *etc.*) determine the difference in potential transmission.

Developers in the watershed stand to play a large role in the future use of natural systems for water quality and flood mitigation. Specific focuses of these voluntary conservation measures include establishing wetland areas in wet or dry detention facilities or including wetland plantings in floodplain mitigation ponds along the corridor. Wetland areas in detention or mitigation facilities can add water quality improvement using existing infrastructure. These recommendations are also relevant for the Urban Stormwater 3 – Promote Low Impact Development recommendation to the extent existing facilities in developed areas can add natural elements.

Illegal Dumping 1 – Report Chronic Dump Sites and Consider Increased Enforcement

Purpose: To reduce trash in waterways at chronic dump sites by encouraging reporting and increased enforcement.

Description: This solution is intended to augment existing county and local efforts to reduce illegal dumping in the following ways:

- Encouraging reporting (see Section 6 for outreach elements)
- Coordinating between the Partnership and local enforcement to ensure reporting for sites
- Consider using cameras to identify dumpers[88]

The primary focus of this solution is chronic dump sites, with emphasis on those adjacent to or near waterways.

Priority Area(s): Watershed-wide

Responsible Parties	Period	Contaminant(s) Addressed	Status
Counties; Local Governments; H-GAC; Landowners	Early; Ongoing-2040	Trash	New and expanded efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed for this solution are local enforcement capacity, especially through the counties, to respond to reports and enforce violations. Enforcement capacity already exists in the watershed. Technical resources for potential camera-based enforcement would require staff capacity to install, operate and maintain the cameras. The camera systems are relatively simple to install and operate and are assumed to be within existing staffing capacity. Financial resources needed for this solution include staff time for local enforcement (variable) and costs of camera technology, which may be eligible for existing solid waste grant programs through H-GAC and other sources.	Cost estimates include the incremental costs to local enforcement, which will be dependent on extent of use; Prior camera programs have spent approximately $500- $1,000 a unit for high end equipment and maintenance. Funding sources include local government revenues and solid waste grant programs.

Bacteria Reduction Capability
This solution is not expected to directly address bacteria, although it may be an ancillary benefit.

[88] While not currently funded, H-GAC and other local partners have successfully utilized camera systems for illegal dumping curtailment in the past. The relatively low cost of camera systems provides an efficient way to monitor problem areas.

Flooding 1 – Coordinate with Ongoing Flood Mitigation Efforts

Purpose: To promote water quality elements in flood mitigation projects and share resources among adjacent efforts.

Description: Flooding is a common issue in the Houston-Galveston Area region. In addition to area-wide studies by the United States Army Corps of Engineers (USACE) and Harris County Flood Control District[89], there are several flood mitigation projects underway such as the Harris County Flood Control District's 2018 Bond Program projects[90].

This solution focuses on areas where flood planning and projects are active and seeks to coordinate WPP efforts with flood mitigation efforts, including the promotion of water quality elements or considerations in these projects. The Partnership will seek to coordinate with new development on water quality features for drainage and detention, as appropriate.

Priority Area(s): Areas where flood planning and projects are active

Responsible Parties	Period	Contaminant(s) Addressed	Status
Harris County Flood Control District; Special Districts; Local Governments; Counties; NGOs	Ongoing-2040	Bacteria, Flooding	Current and expanded efforts

Technical and Financial Resources Needed	Estimated Costs and Funding
Technical resources needed for this solution are primarily found on the flood mitigation entities' side, with the primary WPP role being to coordinate water quality efforts with their work. Continued facilitation of the Partnership would help provide those technical skills, but local technical partners like the Harris County Flood Control District are already actively engaged in these projects. Other potential points of coordination include the Regional Flood Mitigation Committee[91], and the San Jacinto River Regional Flood Planning Group. Financial resources needed for the Partnership's role are primarily staff time for coordination.	Costs estimates are limited to staff time, scaled as necessary to coordinate effectively with the intended efforts. This is conservatively estimated at approximately 10-20 staff hours per year. Funding sources include new grants for WPP implementation (CWA §319(h), etc.) or local partner contributions.

Bacteria Reduction Capability

This solution is expected to directly and indirectly address fecal waste and other water quality concerns, although it may be a wholly ancillary benefit. Rates of reduction from detention facilities and other flood mitigation projects will vary widely based on the project type. However, several studies[92] have shown appreciable impacts of wet bottom detention and other mitigation practices that incorporate natural infrastructure of natural elements on nutrients and, to a lesser degree, *E. coli*.

[89] Including the San Jacinto Regional Watershed Master Drainage Plan. More information can be found at: https://www.hcfcd.org/Activity/Active-Projects/San-Jacinto-River/C-17-San-Jacinto-River-Watershed-Study

[90] The updated status of projects under the 2018 Bond Program can be found at: https://www.harriscountyfemt.org/cb

[91] http://www.h-gac.com/board-of-directors/advisory-committees/regional-flood-management-committee/default.aspx

[92] Including studies from North Carolina (http://lshs.tamu.edu/docs/lshs/end-notes/indicator%20bacteria%20removal%20in%20stormwater%20bmps%20in%20charlotte,%20nc-3678140698/indicator%20bacteria%20removal%20in%20stormwater%20bmps%20in%20charlotte,%20nc.pdf), and Virginia (Clary, J., R. Pitt, and B. Steets, eds. 2014. *Pathogens in Urban Stormwater Systems*. Reston, VA: ASCE. 289 pp.), among others.

H-GAC and other local partners have an active role in both water quality and flood mitigation programs and will continue to seek opportunities to represent water quality concerns in efforts to curb flooding. The Partnership will specifically seek to identify funding opportunities under several of the large disaster mitigation resources available currently and for the short term, including:

- Community Development Block Grants (mitigation funding opportunities related to 2015, 2016, and Hurricane Harvey competitions),
- Texas Water Development Board Flood Infrastructure Fund, and
- Various Federal Emergency Management Agency (FEMA) disaster mitigation programs.

Solutions Summary

The recommended solutions presented in this section are intended to meet the *E. coli* reduction goals defined in Section 4 and to also reduce nutrient sources, or to address other local water quality concerns not specifically related to the primary pollutants. The solutions represent a variety of options for each primary source, which will be scaled to address the number of representative units identified for each source, in each attainment area.

These recommendations were developed and vetted by a diverse stakeholder group as part of a locally led decision-making process. However, the WPP recognizes that additional efforts are ongoing in the watershed that will be complementary to the recommended solutions. These recommendations are not intended to be exclusive of other potential stakeholder projects and efforts that serve the same goals. They represent areas of overlapping concern and agreement among the various interests of the Partnership. It is expected that the toolbox of solutions will change over time as part of local priorities and the adaptive management process.

Further efforts to engage and educate the public are reflected in Section 6, and specifics about the timelines and logistics of implementation are discussed in Section 7.

Section 6

Education and Outreach

Photo Credit: Kendall Guidroz

Section 6. Education and Outreach

Engaging the general public, key project partners, and specific targeted audiences is a crucial component of ensuring the success of the WPP. This section outlines the various educational programs, outreach efforts, and related strategies the Partnership will use to support the implementation of this WPP. The purpose of these efforts is to ensure ongoing stakeholder involvement in the effort as well as to increase public awareness of the water quality issues faced by their community. The recommended engagement elements are presented by the solution category they support.

Engagement Strategies

In keeping with the water quality goals and guiding principles of this WPP, the strategies for engaging with the public are designed to reflect the specific character and needs of the local communities. These strategies provide general guidance for the implementation of the activities discussed in this section.

- Strategy 1: Facilitation — To ensure the continuity of the effort and a consistent point of coordination, a designated facilitator(s) will oversee the early implementation of the WPP (see General Outreach below).
- Strategy 2: Existing Resources — To maximize the use of resources and effectively reach existing stakeholder bases, the Partnership will endeavor to use existing communication networks and work within existing outreach opportunities and partners as one of the tools to further project goals.
- Strategy 3: Audience-specific Messaging — While some outreach is aimed at a broad base of potential stakeholders, the Partnership will focus on making sure its message for individual groups, communities, etc. is tailored to the specific needs and concerns of that group. The underlying assumption in this strategy is that messages are best received when they have an overlapping nexus of value with the audience. A key focus in the watershed is emphasizing the WPP's respect for private property and voluntary solutions.
- Strategy 4: Adjacent Efforts — The density of other efforts planned or ongoing in the watershed provides a wealth of opportunities to build connections and benefits from shared resources with adjacent efforts from practice areas like forestry, flood mitigation, and conservation. As with the implementation of solutions, public engagement efforts will seek to build on work of adjacent programs wherever appropriate and seek to cross-promote water quality messages with communication networks of other practice areas.

General Outreach

The Partnership is one of many organizations working toward similar goals in the watershed but focused primarily on the specific aims of the WPP. A fundamental aspect of ensuring implementation success and community support is to promote public awareness and interest in the watershed and the WPP. To accomplish this goal, the Partnership must maintain itself as an active organization, continue to build its "brand" among the public, represent the watershed among regional and state organizations, and seek to coordinate with related efforts to the greatest degree possible. The Partnership will not supplant existing efforts but will support them however possible while seeking opportunities to expand or enhance links to water quality and the goals of the WPP.

Maintaining the Partnership

The Partnership will maintain its varied composition and strong local commitments through continued facilitation of an active group by H-GAC and TCEQ. The importance of this effort is to continue the use of the Partnership as a platform for coordination of watershed efforts. Meeting this goal will require:

- Periodic meetings of the Partnership (at least twice a year),
- Dissemination of information regarding WPP activities among stakeholders through e-mail, newsletters, and/or other appropriate channels (e.g., social media), and
- Individual meetings with strategic partners to maintain commitments and coordinate efforts.

Building the Brand

The Partnership must maintain visible representation of its specific goals in the eyes of the public. To accomplish this goal, the Partnership will:

- Maintain a presence at local events and meetings to share information on the Partnership, and the goals of the WPP,
- Expand Texas Stream Team monitoring sites and trainings,
- Continue to maintain the project website and expand social media presence,
- Actively support local partners, and
- Seek to build relationships with adjacent practice areas of forestry, conservation, and flood mitigation.

Coordination

The Partnership is one of many watershed-based groups in the area, state, and nation. Finite resources and overlapping areas of interest make coordination of partner efforts a vital part of the WPP which the Partnership will carry out by:

- Participating in and collaborating with groups like the Texas Watershed Coordinator's Roundtable, Regional Watershed Coordinators Steering Committee, Galveston Bay Estuary Program, Clean Rivers Program, and others,
- Supporting other area efforts like the Cypress Creek WPP, the Spring Creek WPP, the West Fork San Jacinto River and Lake Creek WPP, and the various TMDL projects represented by the Houston Area Bacteria Implementation Group,
- Identifying and/or pursuing funding opportunities that would assist local partners in opportunities of shared interest, and
- Seeking additional data necessary to inform stakeholder decisions or evaluate progress[93].

Existing Outreach in the Watershed

Many local stakeholder organizations and regional, state, and national organizations have ongoing education efforts in the watershed. The Partnership recognizes the value of these ongoing programs to positively impact water quality and public awareness in the WPP area. Specific programs of note are described in the discussion of source-based elements. The Partnership will seek to coordinate and support efforts with partners that include the entities listed in **Table 39**[94].

Source-based Outreach and Education Elements

In keeping with the guiding principle of engaging stakeholders with targeted messages, the Partnership will engage, enhance, or support a series of outreach and education efforts aimed at specific pollutant or solution categories. Unless otherwise specified, costs for coordination and outreach tasks by the Partnership are assumed to be part of the cost of maintaining a facilitator for the watershed. Specific costs are called out where applicable.

[93] Specific examples identified in the project include wildlife loading estimates, and spatial data for features like pipelines and new development.

[94] This list is not intended to be exhaustive, but a representative sample of area efforts currently in progress that overlap with WPP goals. The Partnership will actively seek to engage with partners through existing outreach efforts wherever appropriate, including those not specifically listed here. This is undertaken with the caveat that the Partnership will seek to supplement, enhance, or offer general support to activities completed by partners as part of permit or other regulatory requirements, but will not fund or supplant efforts by those partners.

Table 39. Outreach partners

Outreach Partner	Focus Areas
AgriLife Extension/AgriLife Research/Texas Water Resources Institute	Agriculture, OSSFs, water quality, land management, feral hogs, riparian buffers
Bayou Land Conservancy	Conservation, outreach
Bayou Preservation Association	Conservation, water quality, outreach, citizen science, recreation, invasive species management, flood mitigation, trash reduction
City of Houston	Source water protection
Galveston Bay Estuary Program	Galveston Bay, source water protection
Harris County, Harris County Flood Control District	Riparian corridors, stormwater, outreach, recreation, OSSFs, illegal dumping, animal control, environmental enforcement, flood mitigation
Houston Advanced Research Center	Research, urban forestry, water quality
Houston Audubon	Conservation, wildlife, recreation
Houston Canoe Club	Recreation, conservation, outreach
Houston Wilderness	Gulf-Houston Regional Conservation Plan, outreach
Houston-Galveston Area Council	Watershed management, water quality, forestry, public outreach, OSSFs, trash reduction
Houston Sierra Club	Conservation, water quality, forestry, outreach, recreation
Liberty County	Riparian corridors, stormwater, outreach, recreation, OSSFs, illegal dumping, animal control, environmental enforcement
Local HOAs (multiple)	Resident outreach, pet waste, inlet marking
Local MUDs/Special Districts (multiple)	Utilities, stormwater, outreach
Local Soil and Water Conservation Districts	Agriculture, land management programs
Other Cities and Communities	Utilities, stormwater, outreach, resident outreach
Montgomery County	Riparian corridors, stormwater, outreach, recreation, OSSFs, illegal dumping, animal control, environmental enforcement
San Jacinto County	Riparian corridors, stormwater, outreach, recreation, OSSFs, illegal dumping, animal control, environmental enforcement
Texas A&M Forest Service	Forestry
Texas Commission on Environmental Quality	Water quality, wastewater, nonpoint source pollution
Texas Master Naturalists	Environmental education and outreach, habitat
Texas Parks and Wildlife Department	Wildlife, habitat, water quality
Texas State Soil and Water Conservation Board	Agriculture/silviculture, nonpoint source pollution, water quality, conservation
Texas Stream Team	Water quality, volunteering
The Nature Conservancy	Urban forestry, conservation, habitat, water resources
State and Federal Elected Officials	Constituent outreach, environmental events
United States Army Corps of Engineers, Galveston	Flood mitigation, water quality modeling
USDA, Natural Resources Conservation Service	Agriculture, land management, habitat, conservation
USDA, United States Forest Service	Forestry
Walker County	Riparian corridors, stormwater, outreach, recreation, OSSFs, illegal dumping, animal control, environmental enforcement

Wastewater and Sanitary Sewer Overflows

The focus of outreach and education for permitted wastewater and SSOs is on the local governments and utilities of the watershed. However, the Partnership can help promote messages to their communities to serve water quality goals. The Partnership recommends the following activities as specific, supplementary actions under this WPP.

WWTF E1 – Promote Fats, Oils, and Grease (FOG) Awareness

FOG issues are a source of SSOs and operational challenges for local wastewater utilities. Programs like the San Jacinto River Authority's No Wipes in the Pipes (Patty Potty)[95] and the regional Galveston Bay Cease the Grease[96] campaign already exists. The Partnership seeks to promote these programs and maintain model materials[97] on its website, social media, and at outreach events in appropriate translations. Local partners will seek to promote the message through their online presence, utility bills, or through established programs[98]. The promotion will take place throughout the implementation period.

SSO E1 – Increase Public SSO Reporting

The Partnership will increase community knowledge by providing educational resources on how to report SSO events by working with local utilities to develop and disseminate materials in appropriate translations to constituents. This action will take place throughout the implementation period.

On-site Sewage Facilities

There are several existing programs targeting homeowner and practitioner knowledge for OSSFs. The Partnership recommends the following as specific actions under the WPP.

OSSF E1 – Hold Residential OSSF Workshops

Both H-GAC and AgriLife Extension have existing OSSF programs aimed at educating the general public and specific audiences on general maintenance and visual inspection of OSSFs. The recommended frequency is at least one workshop every other year throughout the project period. Costs for these efforts range from $450+ per workshop and are paid for by a mix of existing projects (CWA §319(h) grants for both agencies, H-GAC CWA §604(b), and internal organization funding).

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[95] For more information, see: http://www.pattypotty.com/
[96] For more information, see: http://ceasethegrease.net/
[97] For this and subsequent source category recommendations, materials may include, but not be limited to model flyers, fact sheets, educational program guides, pamphlets, ordinances, technical resources, *etc.*
[98] These efforts are in addition to existing management of utility functions.

OSSF E2 – Participate in County-wide OSSF Workshops for Practitioners
Montgomery and Harris Counties hold annual OSSF workshops for local OSSF practitioners. The Partnership will support the county with publicity and participation as appropriate and seek to support efforts in other project counties as well. This activity will happen throughout the implementation period.

OSSF E3 – Provide Model Educational Materials Online
In addition to existing educational materials from the county, AgriLife, and local governments, the Partnership will host or promote materials on its website in appropriate translations. Materials will be developed in the first two years of implementation and maintained/updated indefinitely.

OSSF E4 – Texas Well Owner Network (TWON)
The Partnership will work with TWON to hold informational meetings or testing events in the watershed and seek to include an OSSF message related to water well siting. The expected frequency is every seven years.

OSSF E5 – Signage at Remediation Sites
H-GAC works with the Harris County District Attorney's Office and TCEQ to provide funding to remediate failing OSSFs as part of a Supplemental Environmental Project to benefit economically disadvantaged households. H-GAC will post signage at completed project sites as an outreach tool for generating additional interest. This practice has been successful in other areas.

Urban Stormwater

Education and outreach elements[99] for urban stormwater will include efforts aimed both at MS4s and at diffuse flow off the land directly into waterways in urban areas. Much of the education and outreach for the former is conducted by the MS4s under the TPDES stormwater permits. For these areas, the Partnership will seek to coordinate and support, but will not add additional elements[100]. The need for maintaining stormwater infrastructure and LID features requires well informed community members. The Partnership recommends the following activities as specific actions under this WPP.

[99] While inlet stream marking is included in the structural solutions noted in Section 5, this program has a significant education and outreach component and has been successfully used by Harris County and other partners in the watershed to engage organizations and neighborhoods. Implementation of that solution should emphasize its outreach aspects.
[100] Except for promoting LID, as indicated in Section 5.

Urban Stormwater E1 – Expand Texas Stream Team Participation

TST[101] volunteers provide valuable information on local conditions in areas where there is not existing CRP monitoring. The role volunteers play as ambassadors to their community about local water quality is an equally important aspect of TST volunteering. H-GAC and local partners foster local volunteers in these efforts. The goal of this element is to increase TST monitoring efforts by five volunteers by 2040.

Pet Waste

Pet waste is an area in which direct engagement with the public is a necessary component of an effective outreach strategy. Unlike centralized sources like WWTFs, pet waste reduction relies on the individual efforts of thousands of residents. The Partnership recommends the following activities as specific actions under this WPP.

Pet Waste E1 – Pet Waste Bag Dispensers at Local Events

H-GAC currently focuses on pet waste reduction as specific action individual residents can take. To support the message, H-GAC uses refillable dog waste bag dispensers with branding or messaging on the dispenser. These units are a low-cost way to engage community members and facilitate reductions. The dispensers take the place of event giveaways to raise awareness and cost approximately $1.50 each. A standard giveaway would be 50 dispensers per outreach event, on average.

Pet Waste E2 – Elementary School Visits

Elementary-age children are a good candidate for educational programs and can influence activities of their parents. H-GAC or other local partners will visit local schools (at least one a year) to put on educational programming appropriate for the age range and subject topic of the classes involved. Past education efforts have included general water quality education with a pet waste message included. Costs for this activity are limited to staff time.

Pet Waste E3 – Provide Model Educational Materials Online

In addition to existing educational materials from local partners, the Partnership will host or promote materials on its website. Materials will be developed in appropriate translations and maintained/updated indefinitely.

Agriculture

A wealth of information and programs exists to promote water-friendly practices for agricultural operations. The focus of the Partnership for this category is largely to support the existing efforts of the Soil and Water Conservation Districts, TSSWCB, Texas A&M

[101] For more information, see: https://h-gac.com/texas-stream-team/

AgriLife, USDA NRCS, and other agricultural partners in promoting their programs in the watershed. The Partnership recommends the following actions.

Agricultural Operations E1 – Develop and Implement Education Measures and Materials for Livestock Operations (Non-CAFO)

There are several livestock operations present in the watershed. The stakeholders identified the need for best practices and educational materials for these facilities. The Partnership will work with the agricultural agencies to identify existing source material and develop educational materials specific to the stabling operations, *etc.* in the watershed within the first two years of implementation.

Agricultural Operations E2 – Hold Agricultural Resources Workshops

The Partnership will hold workshops for local landowners and producers at least once every three years. The workshops will have representation from agricultural and other land management agencies (TSSWCB, AgriLife, USDA NRCS, and others) as a "one-stop shop" for residents to hear about available programs and meet one on one with several agencies.

Agricultural Operations E3 – Support Local Agricultural Conservation

The Partnership will support efforts to develop partnerships or funding sources to implement local conservation initiatives, and future elements of regional conservation plans in agricultural areas, including the H-GAC Regional Conservation Framework[102] program.

Feral Hogs

Feral Hog abatement is a strong concern for properties throughout the watershed, but especially along riparian corridors. Existing outreach programs through AgriLife Extension and other sources are well developed. The Partnership seeks to promote these elements through the website, social media, partner networks, and with event publicity as appropriate. The following programs are of specific interest for the watershed.

Feral Hogs E1 – Lone Star Healthy Streams – Workshops and Feral Hog Resource Manual

The Partnership will promote the AgriLife Lone Star Healthy Streams[103] program by promoting the Feral Hog Resource manual and hosting a workshop in the watershed at least twice during implementation, subject to AgriLife availability.

[102] For more information, see: https://www.h-gac.com/regional-conservation
[103] For more information, see: http://lshs.tamu.edu/workshops/

Feral Hogs E2 – Feral Hog Management Workshop

The Partnership will work with AgriLife Extension in the watershed counties to host a local feral hog management workshop. The expected frequency for this element is at least once every five years, based on AgriLife availability.

Deer and Other Wildlife

Although the Partnership elected not to recommend any direct solutions for reducing deer populations or addressing other wildlife, stakeholders expressed interest in having better data regarding wildlife contributions (see recommendations regarding additional research in Section 7). The Partnership will, however, seek to use existing wildlife events as potential platforms for general outreach. Specifically, the Partnership recommends:

Wildlife E1 – Homeowner Education Materials and Mailing

The Partnership will work with AgriLife Extension to promote distribution of materials for homeowners instructing them on how to use exclusionary devices to deter invasive species such as feral hogs from using deer feeders. The materials will be hosted online and made available at outreach events in the priority areas of the watershed. The Partnership will work with local HOAs and other community groups to include the message in existing communication networks (HOA newsletters, *etc.*).

Land Management

Beyond programs focused on agricultural/silvicultural properties, there are many programs and opportunities to promote or support land management practices that are beneficial to water quality, including Farm Bill programs through USDA NRCS, conservation easements and similar conservation mechanisms. The Partnership recognizes the ample effort already put forth by local partners in developing land management projects for habitat (*e.g.*, Bayou Land Conservancy preserves), recreation and flood retention. The key focus for water quality is lands adjacent to the waterways. The Partnership will generally support and promote voluntary projects and programs however appropriate and recommends the following outreach activities as a specific action under this WPP.

Land Management E1 – Promote Riparian Buffers

In addition to the specific action of developing conservation areas, easements, *etc.* in riparian corridors, the Partnership will maintain resources on its website relating to riparian buffers, including a link to the H-GAC riparian buffer planning tool[104] for landowners. Resources will be developed/obtained and hosted during the first year of implementation. The Partnership will seek to promote the Texas Water Resources Institute (TWRI) Texas Riparian and Stream Ecosystem Education Program

[104] For more information, see: https://www.h-gac.com/riparian-buffer-tool

and Urban Riparian and Stream Restoration Program[105] and similar workshops from Texas A&M AgriLife. Expected frequency is once every five years for these programs. Funding is currently provided by CWA §319(h) grants, and attendee fees. This will focus on fecal waste remediation in this watershed.

Land Management E2 – Texas Watershed Stewards

AgriLife Extension's Texas Watershed Stewards program is an effective way of developing knowledge among the local communities of watershed issues and actions they can take. The Partnership will work with AgriLife to bring the program to the watershed on an expected frequency of every five years.

Land Management E3 – Conservation Coordination

In addition to long-standing efforts by NGOs and local governments in the watershed, several regional conservation and open space planning projects are currently active in the watershed. The Partnership has, and will continue to, participate meaningfully in the Gulf-Houston Regional Conservation Plan, the H-GAC Regional Conservation Initiative, and other local efforts that may have implications or opportunities for riparian-oriented conservation in the watershed.

Trash and Illegal Dumping

In addition to enhanced enforcement, the stakeholders recommended that trash reduction is a local priority and serves as a visible form of outreach. Counties and other local jurisdictions will continue to enforce dumping issues. In addition, the Partnership recommends the following actions.

Trash and Illegal Dumping E1 – Trash Bash Site

The Texas Rivers, Lakes, Bays N' Bayous Trash Bash[106] is an annual trash reduction and community outreach event that takes place throughout the region. Upwards of hundreds of volunteers attend each site, where outreach materials and education about water quality accompany the trash reduction elements. The cleanups focus on areas adjacent to local waterways. The Partnership will participate in this annual effort as a direct way of engaging the public on visible examples of water pollution, and in providing an accompanying water quality message.

[105] For more information, see: http://texasriparian.org/riparian-education-program/
[106] For more information, see: http://www.trashbash.org/

Section 7

Implementation

Photo Credit: Kendall Guidroz

Section 7. Implementation

Implementation is the process of transforming the concerns, ideas, and commitment that went into developing this WPP into tangible action and results. This section details the principles that will guide implementing the solutions identified in Sections 5 and 6, the estimated schedule of implementation, and interim milestones along the way that can be used to gauge progress.

Implementation Strategy

The Partnership balanced the development of potential solutions with the considerations of the logistics of implementation. Some solutions were discarded because they were infeasible to implement, some were focused to specific areas of the watershed, *etc*. The starting point for developing the WPP's implementation strategy is the water quality goals and guiding principles (described in Section 1). From there, the local stakeholders of the Partnership discussed the best ways to translate project ideas into achievable timelines of activity that would be acceptable to the community. The implementation of this WPP will be based on:

- Coordination provided by a watershed coordinator serving as a focal point for WPP efforts;
- Decisions made locally, implemented on a voluntary basis;
- Siting of solutions that considers local needs and conditions, but overall favors areas closest to waterways;
- An opportunistic approach that is flexible enough to maximize resources and opportunities;
- Timelines that consider the changing mix of sources through the implementation period;
- An integrated approach that uses education and outreach to support related solutions;
- A recognition that human waste sources represent a relatively greater pathogenic risk to human health;
- An ongoing focus on adapting plans to meet changing conditions; and
- A special focus on coordinating implementation activities with flood mitigation, source water protection, conservation, and forestry projects in the watershed and region.

Locally Based Watershed Coordinator

Implementing, maintaining, evaluating, and adapting the ongoing and proposed solutions is essential to the success of this project and the future of water quality in the East Fork San Jacinto River watershed. A local watershed coordinator will be necessary to guide

implementation, education, and outreach solutions as the focal point for coordinating these efforts for the WPP. The coordinator will work with local partners to seek opportunities to implement solutions and to find common priorities. The coordinator will maintain a high awareness of and involvement in water quality issues in the area through engagement with related efforts, educational programs, outreach through social media, and communication with the local media. The position will routinely interact with local city councils, county commissioner courts, SWCDs, and other stakeholder groups to keep them informed and involved in implementation activities being carried out in the watershed. Coordinating efforts among key partners is crucial for success and should be one of the primary roles of the position. The watershed coordinator will also work to secure external funding to facilitate implementation activities and coordinate with partner efforts following the initial implementation phase facilitation provided by H-GAC. An estimated $70,000 per year including travel expenses will be necessary for this position, which assumes only a portion of the time of a full-time senior level position, or a greater portion of an entry level position. Initial funding for the watershed coordinator will be incorporated into a CWA §319(h) grant proposal. The Partnership will consider after that point how best to house ongoing facilitation of the Partnership through a watershed coordinator, including consideration of integrating coordination of other local watershed efforts and other local partners.

Coordination with Adjacent Efforts

Coordination with the adjacent practice areas of flood mitigation, conservation, and forestry will be key to successful implementation of this WPP.

Flood Mitigation

While this effort is focused mainly on issues related to water quality, many of the primary grant funding sources (as referenced in **Appendix D**) currently available to local partners focus on resiliency and flood mitigation, a water quantity issue. To maintain visibility as an effort and have the opportunity to tie water quality messages and considerations to flood mitigation efforts, the Partnership will maintain a strong focus on coordinating with local partners (Harris County Flood Control District, and others) and actively participating, as appropriate, in public processes linked to the flood mitigation efforts.

Conservation

The strong tradition of conservation in the watershed and existing organizational capacity among local governments and NGOs provides an opportunity to enhance water quality through the ecosystem services. The Partnership will seek to actively engage with and support conservation initiatives in the watershed and help represent the unique character and needs of the watershed in regional initiatives.

Current efforts include the Gulf-Houston Regional Conservation Plan (Houston Wilderness), the H-GAC Regional Conservation Initiative, and others.

Forestry

Supporting forestry practices is critical in this watershed. Regional efforts include:

- Large scale planting programs by the Harris County Flood Control District, CenterPoint Energy, Texas Department of Transportation, and others;
- Significant research and restoration work by Texas A&M Forest Service and conservation NGOs;
- Broad regional partnerships (e.g., Texas Forests and Drinking Water Partnership[107]).

Project staff have been engaged with local partners in all these pursuits, and the Partnership will continue to participate and actively promote water quality considerations and appropriate areas of the watershed within these efforts.

Timelines for Implementation

Implementation of this WPP is intended to take place over a 16-year initial implementation timeframe (2024-2040). Some of the recommended solutions and outreach elements are intended for the whole implementation period, while some are intended for specific timeframes within that period. Some activities recommended by the Partnership are already underway or are likely to initiate prior to the approval of the WPP. The schedules were developed with the stakeholders to ensure that implementation took place at a feasible rate and meshed with other planned activities and priorities.

Interim Milestones for Measuring Progress

The timelines are intended to reflect the period in which each solution will be implemented, along with the responsible entities and costs they will incur. Additional information about each solution, its intended implementation, and estimated costs can be found in Sections 5 and 6[108]. Interim milestones are identified as goalposts to measure the progress of implementation. Whereas water quality and other criteria will be used to measure the effectiveness of implementation (Section 8), interim milestones measure whether implementation is occurring on schedule (**Table 40**). This table will be updated as part of future WPP updates, after each implementation phase, or as needs warrant.

[107] For more information, see: https://tfsweb.tamu.edu/partnership/#:~:text=The%20Texas%20Forests%20and%20Drinking,important%20and%20interdependent%20natural%20resource

[108] While not specifically noted in Sections 5 and 6, the Supporting Research tasks identified in Section 8, following, are also included in the planning for implementation.

Table 40. Interim milestones for solutions and outreach activities

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
General (N/A)	General – Watershed Coordinator	Retain a Watershed Coordinator to manage day-to-day coordination, pursue resources, and guide implementation	Partnership[112]	Funding application is made for a 2026 start date	Partnership reassess facilitation need	Partnership reassess facilitation need	Partnership reassess facilitation need
Wastewater Treatment Facilities (N/A)	WWTF 1 – Address Aging Facilities and Consider Regionalization	Improve treatment of sewage	Utilities; Cities; Special Districts		At least 1 WWTF makes operational/ structural changes resulting in effluent improvement	At least 1 additional WWTF makes operational/ structural changes resulting in effluent improvement	At least 1 additional WWTF makes operational/ structural changes resulting in effluent improvement

[109] Numbers in parentheses indicate the estimated relative units that will be addressed by the solutions for each target as calculated in **Table 33**, **Table 34**, and **Table 35**.

[110] Availability and timing of all solutions, especially those not directly facilitated by the Partnership, are subject to changes in partner schedules in the future. Timing of some events (workshops, *etc.*) may be adjusted based on partner availability as needed.

[111] Target goals are based on **Table 33**, **Table 34**, and **Table 35**, and may vary based on opportunity, resources, and regulatory changes in the future. All numeric targets (*i.e.*, number of dogs) refer to representative units. Actual units addressed may change based on pollutant removal efficiency, location, *etc.* Outreach and education elements are designated with italics.

[112] Where Partnership appears on this table, it indicates H-GAC, a successor agency, or a watershed coordinator for the WPP acting on behalf of the stakeholders and WPP. While H-GAC is currently acting as the watershed coordinator for the Partnership, this table refers to elements conducted by H-GAC under other projects (CRP, *etc.*) as "H-GAC."

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Wastewater Treatment Facilities (N/A)	WWTF 2 – Recommend Increased Testing	Enhance monitoring to better characterize effluent	Utilities; Partnership		Partnership worked with at least 1 plant to identify capacity for increased testing	Partnership worked with at least 1 additional plant to identify capacity for increased testing	Partnership worked with at least 1 additional plant to identify capacity for increased testing
	WWTF E1 – Promote FOG Awareness	*Reduce SSOs by affecting utility customer behavior regarding FOG*	*Partnership; Utilities*	*Model materials identified and added to website in appropriate translations; distribute printed materials at local events*	*Consistent promotion with partners throughout implementation period*	*Consistent promotion with partners throughout implementation period*	*Consistent promotion with partners throughout implementation period*
Sanitary Sewer Overflows (N/A)	SSO 1 – Remediate Infrastructure	Reduce contamination from human fecal waste by reducing overflows from WWTF collection systems	Utilities		1 fewer SSO occurred than average since 2025 over implementation period	1 fewer SSO occurred than average since 2030 over implementation period	1 fewer SSO occurred than average since 2035 over implementation period
	SSO E1– Increase Public SSO Reporting	*Enhance reporting by increasing public visibility and community knowledge*	*H-GAC; Partnership; Utilities*	*Model materials identified and added to website in appropriate translations; distribute printed materials at local events*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
On-site Sewage Facilities (410)	OSSF 1 – Remediate Failing OSSFs	In conjunction with OSSF 2, address failing OSSFs	H-GAC; Homeowners; Counties (enforcement); Utilities (for conversion projects)		First third of OSSFs addressed, or failures prevented	Second third of OSSFs addressed, or failures prevented	Final third of OSSFs addressed, or failures prevented
	OSSF 2 – Convert to Sanitary Sewer	In conjunction with OSSF 1, address failing OSSFs	H-GAC; Counties; Special Districts; Utilities; Homeowners		First third of OSSFs addressed, or failures prevented	Second third of OSSFs addressed, or failures prevented	Final third of OSSFs addressed, or failures prevented
	OSSF 3 – Improve Spatial Data	Improve OSSF location spatial data to guide remediation efforts	H-GAC; Counties; Authorized Agents	Partners have reviewed and commented on existing spatial data, which is revised accordingly	Authorized Agents continue to provide new data regularly	Authorized Agents continue to provide new data regularly	Authorized Agents continue to provide new data regularly
	OSSF E1 – Hold Residential OSSF Workshop	*Empower homeowners and real estate inspectors to identify the signs of failing/failed OSSFs and promote proper OSSF management to avoid failures*	*H-GAC; Partnership; AgriLife Extension*		*5 workshops held*	*5 additional workshops held*	*5 additional workshops held*
	OSSF E2 – Participate in County-wide OSSF Workshop for Practitioners	*Harris and Montgomery County's annual OSSF workshop provides a point of coordination with practitioners*	*Partnership; Harris County; Montgomery County*		*Partnership participates in annual meetings*[113]	*Partnership participates in annual meetings*	*Partnership participates in annual meetings*

[113] This education and outreach measure is an activity of Montgomery and Harris counties. The counties may change the nature or frequency of these meetings in the future.

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
On-site Sewage Facilities (410)	*OSSF E3 – Promote Model Educational Materials*	*Provide model educational materials online to facilitate education by other organizations*	*H-GAC; Partnership; Utilities*	*Model materials identified and added to website in appropriate translations; distribute printed materials at local events*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*	*Partnership works consistently with local utilities to develop and disseminate materials to customers/ community members*
	OSSF E4 – Texas Well Owner Network Events	*Educate well owners about potential risks from OSSFs and potential contamination of drinking water wells*	*Partnership; TWRI; AgriLife Extension; TSSWCB*	*First TWON event held*[114]		*Second TWON event held*	*If available, third TWON event held*
	OSSF E5 – Signage at Remediation Sites	*Use OSSF remediation sites as outreach to neighbors via signage*	*H-GAC; Harris County; TCEQ*		*Signage placed at OSSF remediation locations*	*Signage placed at OSSF remediation locations*	*Signage placed at OSSF remediation locations*
Urban Stormwater (N/A)	Urban Stormwater 1 – Install Stormwater Inlet Markers	Raise awareness and shift behavior of residents served by stormwater systems to reduce pollutants entering drains/waterways	Local Governments; Special Districts; HOAs; Local Volunteers		At least 1 neighborhood has markers added	At least 1 additional neighborhood has markers added	At least 1 additional neighborhood has markers added

[114] These workshops are expected to occur in 7-year intervals which do not align with usual milestone intervals.

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Urban Stormwater (N/A)	Urban Stormwater 2 – Investigate Drainage Channels	Locate potential sources of pollutants in urban channels[115]	H-GAC; Non-Profit Organizations; Local Governments		Priority areas and grant resources identified ; at least 1 field reconnaissance project completed	At least 1 additional field reconnaissance project completed	At least 1 additional field reconnaissance project completed
	Urban Stormwater 3 – Low Impact Development	To reduce pollutants in stormwater flows through promoting and implementing infrastructure that mimics or improves on natural hydrology	H-GAC; Developers; Local Governments; Special Districts	LID materials developed and hosted on website in appropriate translations		At least 1 LID demonstration project installed	
	Urban Stormwater E1 – Expand Texas Stream Team Participation	*Supplement existing monitoring data with volunteer sites and empower volunteers to acts as water quality ambassadors*	*H-GAC; Partnership; TST Partners*		*1 volunteer added*	*2 additional volunteers added*	*2 additional volunteers added*
Pet Waste (2,781)	Pet Waste 1 – Install Pet Waste Stations	Reduce wastes by facilitating use of bags in public areas	Local Governments; HOAs; Apartment Complexes		At least 20 pet waste stations installed	At least 20 additional stations installed; all stations maintained throughout the implementation period	At least 20 additional stations installed; all stations maintained throughout the implementation period

[115] This solution is intended as a supplement to MS4 activities to detect illicit discharges, *etc.* It is expected additional investigations will take place as part of TPDES MS4 permits. This activity will not replace requirements under permits.

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Pet Waste (2,781)	Pet Waste 2 – Expand Dog Parks	Increase availability of controlled dog recreation areas to sequester wastes in public areas	Apartment Complexes; Local Governments; HOAs; Developers			1 new dog park area developed	
	Pet Waste 3 – Promote Spay and Neuter Events	Reduce pollutants from feral populations through voluntary population control	Service provider (such as SPCA or similar); Local Partners		1 spay/neuter event held	1 spay/neuter event held	1 spay/neuter event held
	Pet Waste 4 – Consider Additional Enforcement	Reduce dog waste by promoting enforcement	Local Governments; Special Districts; HOAs; Apartment Complexes		The Partnership will have worked with at least 1 local partner to promote enforcement	The Partnership will have worked with at least 1 additional local partner to promote enforcement	The Partnership will have worked with at least 1 additional local partner to promote enforcement
	Pet Waste E1 – Handheld Pet Waste Bag Dispensers at Local Events	*Educate residents about impacts of dog waste and reduce waste in stormwater*	*Partnership; H-GAC*		*Distribution of 500 dispensers at 10 local events*	*Distribution of 500 dispensers at 10 local events*	*Distribution of 500 dispensers at 10 local events*
	Pet Waste E2 – Elementary School Visits	*Educate children on pet waste and other water quality issues*	*H-GAC*		*5 visits held*	*5 additional visits held*	*5 additional visits held*

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Pet Waste (2,781)	*Pet Waste E3 – Promote Model Educational Materials*	*Provide model materials to facilitate other organizations' education efforts*	*H-GAC; Partnership; Local Partners*	*Model materials identified and added to website in appropriate translations; distribute printed materials at local events*	*Partnership works consistently with local partners to develop and disseminate materials to community members*	*Partnership works consistently with local partners to develop and disseminate materials to community members*	*Partnership works consistently with local partners to develop and disseminate materials to community members*
Agricultural Operations (2,896)	Agricultural Operations 1 – WQMPs and Conservation Plans	Address waste from 2,896 livestock units through 58 WQMPs, Conservation Plans or other agricultural plans	TSSWCB; SWCDs; USDA NRCS; Agricultural Producers/Land owners		First third of plans (or plans representing one third of the reduction load) addressed by the solution	Second third of plans (or plans representing one third of the reduction load) addressed by the solution	Last third of plans (or plans representing one third of the reduction load) addressed by the solution
	Agricultural Operations 2 – Maintain or Restore Riparian Buffers	In conjunction with, or in supplement to, Agricultural Operations 1, install or maintain riparian buffers in agricultural areas to reduce transmission of pollutants; this strategy coincides with Conservation and Land Management 1	Landowners/ producers (on a voluntary basis); NGOs; Agricultural Agencies		At least 1 rural property has a riparian project	At least 1 additional rural property has a riparian project	At least 1 additional rural property has a riparian project

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Agricultural Operations (2,896)	*Agricultural Operations E1 – Develop and Implement Education Measures and Materials for Livestock Operations (non-CAFO)*	*Develop specific recommendations for stabling and other livestock operations to reduce contributions from these sources*	*Partnership; TSSWCB; AgriLife Extension*	*Identify needs and potential local partners*	*Materials developed in appropriate translations and reviewed locally; hosted and disseminated*	*Materials hosted and disseminated*	*Materials hosted and disseminated*
	Agricultural Operations E2 – Hold Agricultural Resources Workshops	*Promote agricultural programs by facilitating one on one meetings with landowners*	*Partnership; TSSWCB; AgriLife Extension; USDA NRCS*		*First workshop held*[116]	*Second workshop held*	*Third workshop held*
	Agricultural Operations E3 – Support Local Agricultural Conservation	*Increase conservation efforts by lending support and coordination to local partners pursuing opportunities*	*Landowners; Partnership; USDA NRCS; Other local conservation partners*		*Collaborate with at least 1 local partner on a project proposal*	*Collaborate with at least 1 additional partner on a project proposal*	*Collaborate with at least 1 additional partner on a project proposal*
Feral Hogs (2,314)	Feral Hogs 1 – Remove Feral Hogs	Implement trapping/other removal programs to remove feral hogs from the watershed, reduce pollutants/ancillary damages	Landowners; Local Governments; NGOs; Forest Service	Develop or augment trapping program with local partners	Expand program to additional properties	Expand program to additional properties	Expand program to additional properties

[116] These workshops are expected to occur in 3-year intervals which do not align with usual milestone intervals.

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Feral Hogs (2,314)	*Feral Hogs E1 – Lone Star Healthy Streams – Workshops and Feral Hog Resource Manual*	*Educate local stakeholders to promote feral hog reduction*	*AgriLife Extension; TSSWCB; Partnership*		*First workshop has been held*	*Second workshop has been held*	*Third workshop has been held*
Wildlife (N/A)	Wildlife 1 – Restore Upland Habitat	Restore upland habitat to provide wildlife alternative areas and reduce concentration in riparian zones	Landowners; NGOs; Local Governments; Agricultural Agencies (technical support)			Develop at least 1 acre or greater restoration project	
	Wildlife E1 – Homeowner Education Materials and Mailing	*Work with AgriLife Extension, HOAs and Local Partners to distribute exclusionary device materials for homeowners*	*H-GAC; Partnership; AgriLife Extension; HOAs; Local Partners*	*Model materials identified and added to website in appropriate translations; distribute printed materials at local events*	*Partnership works consistently with local partners to develop and disseminate materials to community members*	*Partnership works consistently with local partners to develop and disseminate materials to community members*	*Partnership works consistently with local partners to develop and disseminate materials to community members*
Conservation and Land Management (N/A)	Conservation and Land Management 1 – Riparian Buffers	Promote riparian buffers in all land uses to reduce transmission of pollutants (in conjunction with Land Management 2 – Voluntary Conservation); this strategy coincides with Agricultural Operations 2	Landowners; NGOs		At least 1 property has a riparian project	At least 1 additional property has a riparian project	At least 1 additional property has a riparian project

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Conservation and Land Management (N/A)	Conservation and Land Management 2 – – Voluntary Conservation	Promote voluntary conservation to reduce pollutants from developed areas	Landowners; NGOs		At least one 1+ acre property has a conservation project	At least 1 additional property has conservation projects	At least 1 additional property has conservation projects
	Conservation and Land Management E1 – Promote Riparian Buffers (Tools and Workshops)	*Reduce pollutant loads by promoting riparian buffer areas*	*Landowners; Partnership; TWRI; TSSWCB/TCEQ (granting)*		*First workshop has been held*	*Second workshop has been held*	*Third workshop has been held*
	Conservation and Land Management E2 – Texas Watershed Stewards	*Educate stakeholders on water quality/watershed issues*	*AgriLife Extension*		*First workshop has been held*	*Second workshop has been held*	*Third workshop has been held*
	Conservation and Land Management E3 – Conservation Coordination	*Promote and help coordinate conservation efforts in the watershed*	*Partnership; NGOs; USDA NRCS; Other local conservation partners*		*Partnership has been active in all appropriate conservation initiatives in the watershed*	*Partnership has been active in all appropriate conservation initiatives in the watershed*	*Partnership has been active in all appropriate conservation initiatives in the watershed*
Trash and Illegal Dumping (N/A)	Trash and Illegal Dumping 1 – Report Chronic Dump Sites and Consider Increased Efficiency	Promote enforcement efforts to reduce chronic dumping sites	Local Governments; Residents; Landowners		Identify dumping sites and enforcement priorities with local partners	Address at least 1 chronic site	Address at least 1 additional chronic site

Target[109]	Solutions[110]	Overall Implementation Goal[111]	Responsible Parties	Initial Implementation Phase Milestone	2030 Milestone	2035 Milestone	2040 Milestone
Trash and Illegal Dumping (N/A)	*Trash and Illegal Dumping E1 – Trash Bash Site*	*Reduce trash and educate participants on water quality issues*	*H-GAC; Partnership;*		*Ongoing (annual event)*	*Ongoing (annual event)*	*Ongoing (annual event)*
Flooding (N/A)	Flooding 1 – Coordinate with Ongoing Flood Mitigation Efforts	Promote water quality features as supplementary elements in flood mitigation studies and projects	Partnership	Identify flood mitigation priority projects for water quality enhancements	Partnership or successor maintains presence in flood mitigation projects through public processes, comments, *etc.*	Partnership or successor maintains presence in flood mitigation projects through public processes, comments, *etc*	Partnership or successor maintains presence in flood mitigation projects through public processes, comments, *etc*

It should be noted that developing and ensuring funding to cover the cost of implementation activities without current funding sources is a primary challenge and focus for the successful implementation of a WPP. While the WPP recognizes the need for support from a local coordinator and local partners to identify funding resources, and emphasizes an opportunistic approach to utilizing funding sources, funding will be a primary determining factor in the pace and extent of implementation.

Section 8

Evaluating Success

Photo Credit: Kendall Guidroz

Section 8. Evaluating Success

The WPP is designed as a roadmap for implementation, charting the course to the Partnership's water quality goals. Progress toward those end goals is measured by observable changes in water quality in the watershed and by achieving programmatic milestones (Section 7). Water quality monitoring data and other monitoring or reported data related to TPDES permits will be the primary means for measuring observable change. Records of programmatic achievements compared to established milestones will serve as a measure of the level of effort by the Partnership. These sources of data are compared to established criteria to gauge success. A key to successful implementation of this WPP is continual focus on adaptive management, in which evaluations of success are used to revise decisions for better effectiveness.

Monitoring Program

CRP partners and others will conduct long-term ambient surface water quality monitoring in East Fork San Jacinto River. TST volunteers are an additional source of supplemental data[117]. The Partnership will also evaluate compliance by permitted wastewater dischargers using DMR and SSO data reported to TCEQ. Special studies, including microbial source tracking or other DNA-based categorization of *E. coli* or host species, may be used to supplement these ongoing data collection efforts if the Partnership deems them necessary in the future. The combination of ambient surface water quality data permitted discharge data, and other sources (as appropriate) will be used by the Partnership to understand the end result of WPP actions on the project waterways. Assessments will be conducted in conjunction with CRP annual reporting (Basin Highlights Report/Basin Summary Report) efforts. Formal full water quality evaluations including ambient, DMR and SSO data analyses as shown in the *Acquired Data Analysis Report*[118] will be conducted by the Partnership at the end of every phase of implementation or as necessary in interim periods.

Clean Rivers Program Data

Ongoing monitoring in East Fork San Jacinto River and its tributaries includes 14 long-term sites (seven on East Fork San Jacinto River, and seven on tributaries). All sites are monitored at least quarterly. The current sites are listed in **Table 6** and shown in **Figure 10**, both in Section 3 of this document.

The quality-assured data from these sampling efforts are the primary means for evaluating compliance with water quality standards and will serve as the primary indicator of success

[117] Stream team data will be used for qualitative assessment, and not as part of formal quantitative assessments of water quality.
[118] Available on the project website at: https://eastforkpartnership.weebly.com/uploads/1/3/0/7/130710643/30143_3.2_acquired_data_analysis_report_final.pdf

under this WPP. The ambient parameters sampled are the same as to those sampled during the WPP development project.

While data from all the stations will be reviewed, the most downstream stations of each of the attainment areas (shown in **Figure 34**, Section 4) for this WPP are the ultimate focus of evaluation. However, special attention will also be given to tributary stations to evaluate whether additional attention or modeling is needed to isolate the tributaries. Monitoring will be conducted under an approved quality assurance project plan (QAPP).

Additional Data

In addition to CRP/TCEQ monitoring, other state, regional, and local sources will be used to evaluate specific aspects of water quality in the waterways. These sources include:

- DMR (TCEQ) – The Partnership will review outfall discharge monitoring data from WWTFs in the watershed.
- SSOs (TCEQ) – SSOs reported to TCEQ will be assessed periodically to evaluate progress in reducing this source.
- TST volunteers – TST volunteer data will be used to supplement CRP data as an indicator of change over time and site-specific areas of concern. Observations made by volunteers can provide important information on localized conditions.

The combination of these data will provide the Partnership with a robust picture of the changing health of the waterways. The ambient stations at the end of each attainment area and the WWTF permit data will be the primary point of comparison to indicators of success for the WPP.

Supporting Research

In addition to the solutions identified in Sections 5 and 6, and the implementation strategies outlined in Section 7, the Partnership identified several areas of data in which additional research was warranted to ensure informed future decisions by the Partnership. These proposed research activities may or may not be pursued by the Partnership but are identified areas of inquiry, under a future QAPP, that would benefit future WPP updates.

Wildlife Source Estimation

The current *E. coli* load totals assume a conservative additional load for warm-blooded animals (not including deer) for which there was insufficient data as part of the other sources category. This source has been an appreciable contributor to instream loads in some other watersheds (especially in more rural areas), exceeding 40-50% in some

microbial source tracking studies[119]. Absent any microbial source tracking data for the East Fork San Jacinto River watershed, and in consideration of its more developed character, a conservative estimate of 10% of total source load in current conditions was assigned to the other sources which includes undocumented wildlife. However, additional data, in either the form of microbial source tracking information or wildlife population data estimates or established statewide wildlife loading assumptions based on land cover, could refine those estimates. This need is especially relevant given the propensity for wildlife to use stream corridors to traverse developing areas like this watershed. The Partnership will work with Texas A&M University, other academic institutions and TPWD to determine the feasibility of establishing general or species-based estimates for wildlife populations not usually addressed in WPPs. The intent is to establish loading estimates for the background concentrations of fecal bacteria to ensure WPP projections are as accurate to watershed conditions as possible.

Microbial Source Tracking

Microbial source tracking (MST) (also referred to as bacterial source tracking or fecal typing in this context) is a general name for a range of methods[120] that use genetic information to identify the origins of biological pollutants present in a water body. Identification of *E. coli* is based on the genetic detection of bacteria strains specific to different animal types in surface water samples. MST can help characterize uncertainties in modeling efforts (*e.g.*, undocumented wildlife) and provide more information on what sources are represented instream, as opposed to source loads. However, MST or similar methods can have an appreciable amount of uncertainty and reflects the period of time in which samples were collected, so it should be considered in addition to other data sources.

More narrowly focused approaches of testing for host-specific DNA (instead of host-specific bacterial DNA) are also used and may help overcome some uncertainties related to representativeness of *E. coli* strains across the watershed area or across time. The stakeholders recommended that source tracking or analysis of the most applicable type be employed as needed in the East Fork San Jacinto River Watershed, with an intended focus on specified areas during narrow time frames for purposes such as illicit discharge detection, understanding localized spikes, *etc.* The Partnership recognizes the potential value of these tools for guiding decisions when opportunity and resources allow.

[119] For example, the Watershed Protection Plan for the Leon River Below Proctor Lake and Above Belton Lake indicated that its bacterial source tracking conducted at three stations showed "…between 41 and 55 percent of bacteria sources originate from wildlife or invasive species (e.g., avian species, wild animals, and feral hogs) …". Accessed 11/3/2023 at: http://leonriver.tamu.edu/media/1110/final-leon-wpp.pdf

[120] For the purpose of this discussion, the term is being used to include a broad range of other assays and identification methods using genetic or species-specific markers.

Hydrologic Impacts on Water Quality

Several large studies and efforts are currently evaluating various aspects of the hydrology/hydraulics within the East Fork San Jacinto River system and in adjacent watersheds. Additionally, there is significant investment planned for flood mitigation activities that may change flow patterns in the waterway. The potential for these factors to influence water quality conditions is unknown. While flood mitigation measures are expected to have a relatively positive impact (e.g., settling of pollutants in wet bottom detention basins), water quality impacts have not been a primary focus of the ongoing efforts. The Partnership does not have a specific recommendation, other than ongoing coordination with these efforts, but expressed an interest in subsequent research that might help predict water quality impacts. H-GAC, EPA and USACE are currently involved in a Watershed Management Optimization Support Tool modeling effort that may provide additional detail prior to, or immediately subsequent to, the approval process for this WPP. This information will help guide future decisions and WPP updates, but additional research will likely be needed given the scale of potential flood mitigation efforts in and around the watershed.

Indicators of Success

The Partnership identified key criteria for success for use in evaluating the progress of the WPP. The success indicators are used to measure the effectiveness of the implementation effort and the pace of progress (**Table 41**). Ultimate success in the waterways of the East Fork San Jacinto River watershed is found in achieving the water quality goals of the stakeholders. However, the changing nature of the watershed may mask some achievements in early years, as pollutant sources continue to increase rapidly even as implementation begins. However, the future focus of the WPP takes these considerations into account. To ensure that progress can be evaluated against this background, programmatic metrics will also be used as indicators of successful progress.

Compliance with Water Quality Standards

The primary, quantitative goal of the WPP is to achieve and maintain compliance with SWQSs at the representative stations for each of the attainment areas. A secondary goal is to ensure source reduction by meeting TPDES permit limits. Therefore, the primary indicators of success are listed below.

- The status of the waterways on the most current Texas Integrated Report, with specific focus on the SWQSs for contact recreation standard (bacteria criteria for primary contact recreation 1), is the main benchmark of success. Success is measured by fully supporting all uses, and progress in abating concerns.
- A positive or stable trend in WWTF compliance, as indicated in the DMRs/SSOs will also indicate successful implementation.

While the goal of the WPP is to move water quality toward compliance, the changing nature of the watershed may mean that in interim years, a reduction of projected degradation will also be considered as interim progress. Based on known development and current trends, westward growth spanning toward the headwaters area is likely to continue to be strong but not necessarily linear. Large blocks of developed area can come online in shorter time frames, meaning sudden influxes of sources rather than steady growth or decline. While the end goal for 2040 remains the focus of the WPP, some interim periods will be better measured by programmatic milestones or water quality change in localized areas related to implementation efforts rather than a broad survey instream quality.

Programmatic Achievement

The ability to maintain the Partnership, fund implementation, and put solutions in place are qualitative indicators of the success of the implementation efforts. Additional program elements include the progress partners make toward related requirements (MS4 permits, *etc.*). These programmatic indicators are:

- implementing solutions at a pace that is sufficient to meet interim milestones,
- a Partnership group that continues to be active and engaged in implementation, and
- acquisition of funding levels and technical resources sufficient to realize implementation goals.

Table 41. Indicators of success

Goal	Indicator of Success	Source of Identification
Quantitative, Compliance with SWQSs	Fully support all designated uses	CRP data; Texas Integrated Report status
	Comply with TPDES permit limits	WWTF DMR/SSO
Qualitative, Implementation of WPP	Solutions implemented (based on implementation milestones)	Partnership records; MS4 Annual Reports; partner information
	Implementation funded sufficiently	Funding sources identified and acquired
	Maintain Partnership	At least annual meetings held

Adaptive Management

As conditions change within the watershed, the practices and approach we use to address water quality issues must adapt. This WPP is a living document used to guide implementation of the solutions developed by local stakeholders. It is designed to be flexible to changing conditions. The WPP will engage in a process of continual review and revision called **adaptive management** to ensure it remains relevant to its purpose and the stakeholders' decisions. Adaptive management is a structured process by which changes in conditions and evaluation of progress and programmatic achievements are used to

identify potential revisions to the WPP. Feedback on progress shapes future planning. The Partnership understands that a continual process of review and revision will be needed in the future to ensure the WPP's success. The content and efforts of this WPP will be reviewed at several points during implementation, with the fundamental questions being as to whether the solutions are having their desired effects, and whether progress is being made on water quality standards compliance (**Table 42**).

Table 42. Adaptive management process

Component	Description
Ad hoc review	Each partner responsible for implementing any activity will do due diligence in evaluating the continuing effectiveness of the activity. This review happens on an informal or project-specific basis. Partners are encouraged to share any insights on what is working well or what is working poorly with the Partnership at large. Facilitation staff will talk regularly with partners to assess progress.
Annual Review	Every year the Partnership will review progress made during that year during a public meeting. The results of the annual reviews will be summarized for dissemination to the stakeholders and the WPP may be amended as needed.
Formal WPP Reviews	The Partnership will conduct a formal review and revision of the WPP as appropriate. This process will include at least a 30-day review period and open public meeting. The result of the review will be an amended WPP. Criteria for review will include but not be limited to: • Stakeholder feedback on implemented solutions and resources (stakeholders) • Water quality data summary of segment conditions (H-GAC or successor watershed coordinator) • Review of progress in meeting programmatic milestones • Progress in complementary efforts (MS4 permits, *etc.*)
Continuity Review	Two years prior to 2040, the Partnership will discuss during its Annual Review, how it will plan for the next period of implementation (if needed). At this time, the Partnership will identify any modeling, data analysis and collection, or other information needed to make further projections for future implementation periods.

Appendices

Photo Credit: Kendall Guidroz

Appendix A. WPP Information Checklist

Elements in the table below correspond to the 9 minimum elements required by EPA for developing watershed-based plans using Clean Water Act 319(h) grant resources. For more information on these guidelines, please refer to EPA's Handbook for Developing Watershed Plans to Restore and Protect Our Waters[121].

Table A. 1 Guide to watershed protection plan information

Segment Information	
Name of Water Body	East Fork San Jacinto River (Segment 1003)
Assessment Units	1003_01, 1003_02, 1003_03, 1003A_01, 1003B_01, 1003C_01
Impairments Addressed	Contact recreation/*E. coli*
Concerns Addressed	*E. coli*
Element	**Report Section(s) and Page Number(s)**
Element A: Identification of Causes and Sources	
1. Sources identified, described, and mapped	Section 3 • pp. 38-57; water quality analysis and point source contribution descriptions • pp. 57-93; formal source descriptions, modeled loadings, and maps of spatial distribution
2. Subwatershed sources	Section 3 • pp. 57-93; sources are described in terms of their general spatial distribution and loads by subwatersheds • **Table 24** summarizes all loadings by subwatershed
3. Data sources are accurate and verifiable	Section 2 • In general, data used for characterization and mapping is discussed throughout with footnote links to specific sources • pp. 34; description of water quality data and links to the project water quality report Section 3 • pp. 38-57; discussion of water quality monitoring analyses, point source data analyses, and data sources • pp. 57-93; description of sources and loadings with references to data used Section 4 • pp. 95-101; description of LDCs and data sources. • pp. 105-110; application of data sources to load reduction goals discussed Section 8 • pp. 185-190; discussion of data sources to be used for evaluating success

[121] For more information, see: https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

Element	Report Section(s) and Page Number(s)
4. Data gaps identified	Section 3 • In general, discussion of uncertainty in various modeling and data approaches (pp. 46-49 for WWTF data; pp. 62-64, 88-93 and footnote 45 for SELECT modeling; pp. 85-86 for SSO data) Section 4 • pp. 102-103; discussion of DO precursors Section 8 • pp. 185-190; specific discussion of additional data sources that may be helpful (other wildlife estimations, BST/MST, etc.)
Element B: Expected Load Reductions	
1. Load reductions achieve environmental goal	Section 4 • pp. 105-110; description of linkage of environmental goal (via LDC reductions) to source loads (via SELECT estimations) • Summarized specifically in **Table 29** through **Table 33**
2. Load reductions linked to sources	Section 4 • pp. 105-110; description of linkage of environmental goal (via LDC reductions) to source loads (via SELECT estimations) • Summarized specifically in **Table 29** through **Table 33**
3. Model complexity is appropriate	Section 3 • pp. 57-64; description of modeling approach (p. 61-63 specific to SELECT); link to project modeling report; pp. 62 contains specific description of rationale for modeling approach • Results of modeling indicated above in B1/B2 Section 4 • pp. 95-101; description of LDC modeling approach • pp. 105-110; description of LDC and SELECT linkage
4. Basis of effectiveness estimates explained	Section 4 • pp. 108-109; description of use of representative units Section 5 • pp. 115-150; solution effectiveness/reduction efficiency discussed in the bottom of each recommended solution page
5. Methods and data cited and verifiable	Section 3 • Throughout (pp. 38-93); data and methods for water quality analyses, point source analyses, and source estimations discussed with references in footnotes as appropriate and links to project modeling and water quality analysis reports Section 4 • Throughout (pp. 105-110); data for load reduction goals discussed, links to project modeling report included
Element C: Management Measures Identified	
1. Specific management measures are identified	Section 5 • pp. 115-150; specific measures described, including technical and financial support needed, roles and responsibilities, *etc.* *Section 6* • pp. 153-164; specific educational measures described, including responsible parties
2. Priority areas	Section 5 • pp. 115-150; discussion of priority areas for each category of specific focus Section 6

Element	Report Section(s) and Page Number(s)
	• pp. 153-164; general description of intended audiences/areas for educational activities
3. Measure selection rationale documented	Section 5 • pp. 112-113; specific description of guiding principles for selection and selection process • pp. 151; summary of selection process and intention Section 6 • pp. 153-155; description of Partnership's goals for selected educational measures
4. Technically sound	Section 5 • pp. 115-150; specific measures described, including technical detail Section 6 • pp. 153-164; specific educational measures described Section 7 • pp. 166-169; specific implementation strategies for measures in general, and pet waste as a focus
Element D: Technical and Financial Assistance	
1. Estimate of technical assistance	Section 5 • pp. 115-150; technical assistance needs detailed for each measure in their one-page summaries
2. Estimate of financial assistance	Section 5 • pp. 115-150; financial assistance needs detailed for each measure in their one-page summaries Appendix D • List of potential funding sources related to measures in this WPP
Element E: Education/Outreach	
1. Public education/information	Section 6 • pp. 153-164; description of public outreach activities
2. All relevant stakeholders are identified in outreach process	Section 1 • pp. 3-7; description of initial outreach, forming the Partnership, links to Public Participation Plan for the project Section 6 • pp. 153-164; description of public outreach activities including existing partners/roles and focus areas
3. Stakeholder outreach	Section 1 • pp. 3-7; description of initial outreach, forming the Partnership, links to Public Participation Plan and Stakeholder Outreach Report for the project
4. Public participation in plan development	Section 1 • pp. 3-7; description of initial outreach, forming the Partnership, links to Public Participation Plan and Stakeholder Outreach Report for the project Section 3 • pp. 57-60; description of Partnership process in identifying sources and assumptions (specific to each source, pp. 65-89) Section 4 • pp. 105-110; description of stakeholder choices in reduction linkage, load allocation, etc. Section 5 • pp. 112-114; description of stakeholder participation in measures selection Section 6

Element	Report Section(s) and Page Number(s)
	• pp. 153-155; description of stakeholder decisions on outreach strategies Section 7 • pp. 166-169; description of stakeholder input on implementation strategies Section 8 • pp. 185-190; description of the Partnership's role in determining how the project evaluates success
5. Emphasis on achieving water quality standards	Section 1 • pp. 6-7; description of specific water quality goals for the project/Partnership All Other Sections • Water quality standards are the focus of water quality analyses (Section 3), the focus of all load reduction calculations (Section 4), the focus of recommended solutions (Section 5 and 6), the focus of implementation strategies (Section 7), and the primary measure of success (Section 8).
6. Operation and maintenance of BMPs	Section 5 • pp. 115-150; discussion of specifics of recommended solutions are included with each solution and/or solution category description
Element F: Implementation Schedule	
1. Includes completion dates	Section 7 • pp. 170-183; implementation schedule
2. Schedule is appropriate	Section 7 • pp. 170-183; implementation schedule
Element G: Milestones	
1. Milestones are measurable and attainable	Section 7 • pp. 170-183; milestones described for all measures
2. Milestones include completion dates	Section 7 • pp. 170-183; milestones described for all measures
3. Progress evaluation and course correction	Section 8 • pp. 185-190; describes all methods uses to evaluate success for the project; pp. 190 specifically describes adaptive management processes
4. Milestones linked to schedule	Section 7 • pp. 170-183; Milestones described for all measures with timeframes indicated
Element H: Load Reduction Criteria	
1. Criteria are measurable and quantifiable	Several sections detail the process of developing load reductions, including (as noted in Element B) Section 3 (source loads), Section 4 (load reductions), and Section 8 (evaluation criteria).
2. Criteria measure progress toward load reduction goal	Section 8 • pp. 185-190; describes evaluation criteria and data sources used to evaluate both water quality and programmatic milestones.
3. Data and models identified	Section 8 • pp. 185-190; describes evaluation criteria and data sources used to evaluate both water quality and programmatic milestones.
4. Target achievement dates for reduction	Throughout the document, the plan states that 2030 is the intended goal year (as noted previously). Section 4 bases load reductions on this timeline. Section 5/6 recommendations are based on time period within this planning horizon. Section 7 schedule and milestones are based on this period. Section 8 evaluation criteria also assumes this date.

Element	Report Section(s) and Page Number(s)
5. Review of progress toward goals	Section 8 • pp. 185-190; details the methods that will be used to evaluate progress regarding water quality • pp. 188-190; details the methods that will be used to evaluate progress regarding programmatic means
6. Criteria for revision	Section 8 • pp. 188-190; describes the indicators of success and adaptive management process
7. Adaptive management	Section 8 • pp. 190; describes the adaptive management process
Element I: Monitoring	
1. Description of how monitoring used to evaluate implementation	Section 8 • pp. 185-189; describes the monitoring plan and other potential data sources
2. Monitoring measures evaluation criteria	Section 8 • pp. 187-189 describes the indicators of success, including water quality/monitoring outcomes
3. Routine reporting of progress and methods	Section 8 • pp. 185-190, describes both the monitoring process and its reporting/evaluation, as well as the project evaluation and formal reviews process with the Partnership (Table 43, *etc.*)
4. Parameters are appropriate	Section 8 • pp. 185-186 describes the monitoring program
5. Number of sites is adequate	Section 8 • pp. 185-186 describes the monitoring program
6. Frequency of sampling is adequate	Section 8 • pp. 185-186 describes the monitoring program
7. Monitoring tied to QAPP	Section 8 • pp. 185-186 describes the monitoring program under CRP QAPP • pp. 186-188 describes the potential use of other data sources
8. Can link implementation to improved water quality	Section 8 • pp. 185-186 discusses the monitoring program • pp. 188-190 discussed water quality indicators of success

Appendix B. Wastewater Treatment Facilities

Table B. 1 East Fork San Jacinto River watershed WWTF permittees at study initiation

Permittee	Permit Number
FOREST GLEN INC	TX0071765
STEELY LUMBER CO INC	TX0123421
UTILITIES INVESTMENT CO INC	TX0133167
UNIVERSAL FOREST PRODUCTS TEXAS LLC	TX0028169
QUADVEST LP	TX0134996
SAM HOUSTON AREA COUNCIL BOY SCOUTS OF AMERICA	TX0136948
QUADVEST LP	TX0136921
PLUM CREEK FWSD NO 1	TX0136867
DALASU 686 LP	TX0141372
CITY OF CLEVELAND	TX0053473

Appendix C. Agricultural Best Management Practices

This appendix details the typical practices implemented in WQMPs and similar agricultural land management projects[122]. Emphasis for this WPP is put on practices that reduce animal wastes or impede transmission of wastes to water.

Table C. 1 Agricultural best management practices

Practice	Description
Residue Management	Management of the residual material left on the soil surface of cropland, to reduce nutrient and sediment loss through wind and water erosion.
Critical Area Planting	Establishes permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices.
Filter Strips	Establishes a strip or area of herbaceous vegetation between agricultural lands and environmentally sensitive areas to reduce pollutant loading in runoff.
Nutrient Management	Manages the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize agricultural nonpoint source pollution of surface and groundwater resources.
Riparian Forest Buffers	Establishes an area dominated by trees and shrubs located adjacent to and up-gradient from watercourses to reduce excess amounts of sediment, organic material, nutrients, and pesticides in surface runoff and excess nutrients and other chemicals in shallow groundwater flow.
Terraces	Used to reduce sheet and rill erosion, prevent gully development, reduce sediment pollution/loss, and retain runoff for moisture conservation.
Grassed Waterways	Natural or constructed channel-shaped or graded and established with suitable vegetation to protect and improve water quality.
Prescribed Grazing	Manages the controlled harvest of vegetation with grazing animals to improve or maintain the desired species composition and vigor of plant communities through adaptive multi-paddock grazing and other techniques.
Riparian Herbaceous Buffers	Establishes an area of grasses, grass-like plants, and forbs along watercourses to improve and protect water quality by reducing sediment and other pollutants in runoff, as well as nutrients and chemicals in shallow groundwater.
Watering Facilities	Places a device (tank, trough, or other water-tight container) that provides animal access to water and protects streams, ponds, and water supplies from contamination through alternative access to water.
Field Borders	Establishes a strip of permanent vegetation at the edge or around the perimeter of a field.
Conservation Cover	Establishes permanent vegetative cover to protect soil and water.
Stream Crossings	Creates a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles, improving water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream.
Alternative Shade	Creation of shade reduces time spent loafing in streams and riparian areas, thus reducing pollutant loading and erosion of riparian areas.

[122] Technicians work with local landowners/producers to design WQMPs on a site-specific basis. More information about WQMPs, standard practices, and related TSSWCB programs can be found at https://www.tsswcb.texas.gov/programs/water-quality-management-plan.

Appendix D. Potential Funding Resources

This appendix contains examples of funding resources, by category, that may be utilized to implement aspects of this WPP's recommendations. These resources represent potential external sources of funding other than existing or local contributions (*ad valorem* tax revenue, landowner contributions, *etc.*). The Partnership will continue to track, evaluate, and match grant sources for potential implementation activities as part of the ongoing facilitation of this WPP.

Table D. 1 Potential funding sources

Grant Program	Grantor	Uses
Clean Water Act 319(h) Nonpoint Source grants	TCEQ, TSSWCB	Multiple implementation and outreach activities
Clean Water Act 604(b) water quality management planning grants	TCEQ	Data development, forestry outreach
Flood Infrastructure Fund / Flood Mitigation Assistance Program	TWDB	Flood mitigation, resilience
Clean Water State Revolving Fund	TWDB	Utility infrastructure, related planning
Community Development Block Grant (MIT/DR)	GLO/HUD	Flood mitigation, resilience
Private Foundation Grants	Private Foundations (e.g., Houston Endowment, Hershey Foundation, Powell Foundation, and others)	Multiple, specific to foundations
Various grant programs	TPWD	Wildlife, parks and recreation, farm and ranchland preservation, trails
Building Resilient Infrastructure and Communities (BRIC)	FEMA/Texas Division of Emergency Management	Disaster resilience
WQMP	TSSWCB	Agricultural best practices
Regional Conservation Partnership Program (RCPP)	USDA NRCS	Conservation
H-GAC OSSF SEP	TCEQ/WWTFs; Harris County	OSSF remediation for low-income households
Restoring America's Wildlife Act	TPWD	Federal support for ecosystem restoration and related projects.
Farm Bill Programs (EQIP, and others)	USDA NRCS, local SWCDs	Landowner support for property improvements with environmental benefits, including conservation easements, forest reserves, watershed protection, wetland mitigation, water quality, etc.
Corporate donations	Corporate partners	Varies by entity
Land and Water Conservation Fund	US Forest Service	Conservation

Grant Program	Grantor	Uses
Various grant programs	US Fish and Wildlife Service	Conservation, habitat restoration, wetlands restoration, endangered species
Various grant programs	National Park Service	Outdoor recreation, conservation
Various other grant programs	EPA	Coastal watersheds/estuaries, brownfields, clean water
Wetland and Stream Mitigation Banks	USACE	Wetland and stream mitigation banking
Deepwater Horizon/RESTORE Act Settlement funds	Gulf Coast Ecosystem Restoration Trust Fund, State of Texas (representative)	Conservation, restoration, resilience
Inflation Reduction Act/Bipartisan Infrastructure Law funded programs	Multiple	Multiple, including forestry, water quality, *etc.*