BASIN CHARACTERIZATION REPORT FOR THE BRAZOS – COLORADO COASTAL BASIN FOR INDICATOR BACTERIA

YEAR TWO

Segments: 1301, 1302, 1304, 1305

September 13, 2017

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Prepared for

Total Maximum Daily Load Program

Texas Commission on Environmental Quality

MC-203

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AU	Assessment Unit
BMP	Best Management Practice
C-CAP	Coastal Change Analysis Program
CMP	Coordinated Monitoring Program
CRP	Clean Rivers Program
E. coli	*Escherichia coli*
FDC	Flow Duration Curve
FIB	Fecal Indicator Bacteria
FOR	Friends of the River San Bernard
FROG	Fats, Roots, Oil and Grease
GIS	Geographic Information System
GIWW	Gulf Intracoastal Water Way
H-GAC	Houston-Galveston Area Council
I/I	Inflow and Infiltration
I-Plan	Implementation Plan
LDC	Load Duration Curve
LOESS	Locally-weighted Least Squares
LOQ	Limit of Quantitation
mi	Mile
mL	Milliliter
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

NRCS	Natural Resources Conservation Service
OSSF	Onsite Sewage Facility
QAPP	Quality Assurance Project Plan
RUAA	Recreation Use Attainability Assessment
SAS	Statistical Analysis System
SSO	Sanitary Sewer Overflow
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
WQMP	Water Quality Management Plan
WPP	Watershed Protection Plan
WWTF	Waste Water Treatment Facilities

1 INTRODUCTION

1.1 BACKGROUND AND OVERVIEW

Clean water is an important element to all living things. The Houston-Galveston Area Council (H-GAC) Clean Rivers Program (CRP) service area (Figure 1.1) contains 16,000 miles of streams and shoreline providing a network of valuable habitat and ecosystem services for the region, connecting freshwater streams to productive coastal estuaries and connecting us to nature and to each other. Clean water is a foundation for our regional economy, contributing $4 billion annually through ecotourism, oyster harvesting, and commercial fishing.

However, more than 80 percent of stream miles within the region fail to meet state water quality standards or screening criteria for one or more parameters. Rapid development and population growth, aging and poorly maintained infrastructure, and certain types of land management techniques strain the health of waterways if proper management practices are not in use or established. H-GAC was tasked by the Texas Commission on Environmental Quality (TCEQ) to apply a targeted basin approach to the Brazos – Colorado Coastal Basin, Basin 13. This approach characterized water quality problems, particularly bacteria; identified opportunities for public and stakeholder involvement; and recommended potential management approaches to begin to address bacteria impairments found in the basin.

1.2 WATER QUALITY STANDARDS AND ASSESSMENT

The TCEQ conforms to the requirements of the federal Clean Water Act Sections 305 (b) and 303 (d) by producing the *Texas Integrated Report of Surface Water Quality (Integrated Report) for Clean Water Act Sections 305 (b) and 303 (d)* every two years. The report assesses the state's waters to determine if they meet state water quality standards. Those water bodies, often referred to as segments, that do not meet water quality standards are included on the 303 (d) list as impaired.

The TCEQ established water quality standards to protect the public's health and use, and support aquatic life, while sustaining economic development. The standards set explicit goals for the quality of streams, lakes, rivers, and bays throughout the region.

Water quality standards identify appropriate uses for the state's surface waters, including aquatic life, recreation, and sources of public drinking water. Criteria are established to evaluate these uses, including: dissolved oxygen, temperature, pH, dissolved minerals, toxic substances, and bacteria.

These state standards are codified as state rules under Title 30, Chapter 307 of the Texas Administrative Code. The standards are written by the TCEQ under the authority of the Clean Water Act and the Texas Water Code. The US Environmental Protection Agency (EPA) approves the Texas Surface Water Quality Standards.

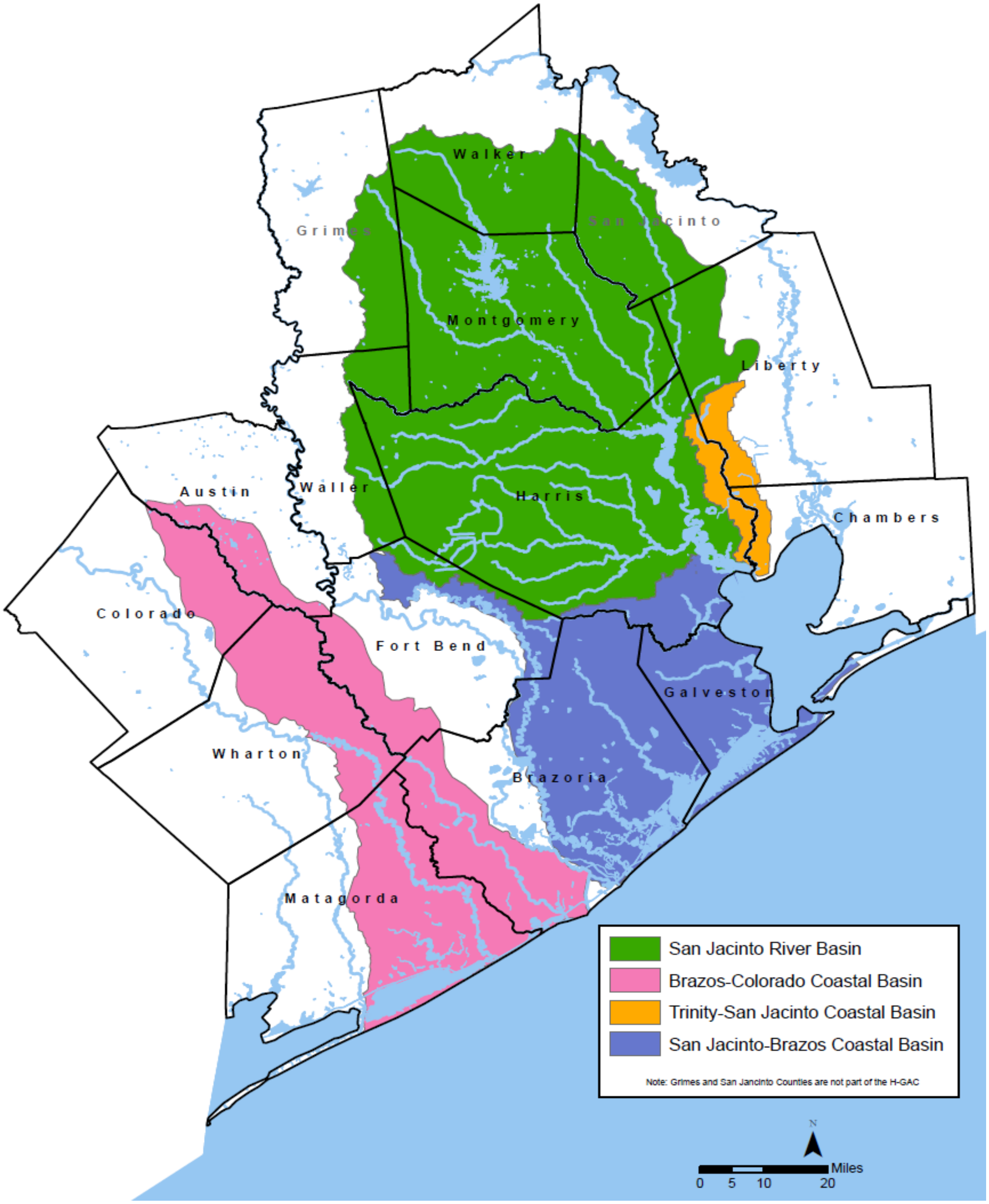


Figure 1.1. Four Texas river basins within the H-GAC Clean Rivers Program service boundary for southeast Texas.

The Texas Surface Water Quality Standards (TCEQ, 2010) are designed to

- Designate the uses, or purposes, for which the state's water bodies should be suitable;
- Establish numerical and narrative goals for water quality throughout the state; and
- Provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality.

The TCEQ encourages public participation in development and revision of the water quality standards through participation on the Surface Water Quality Standards Advisory Work Group.

1.3 CONTACT RECREATION AND BACTERIA

Water quality professionals are challenged to ensure the region's water bodies meet state water quality standards. Elevated bacteria concentrations represent the most common impairment in Texas.

Bacteria concentrations are used as indicators of the potential risk of illness during contact recreation (e.g. swimming and water skiing) from the ingestion of water (Figure 1.2). The state and the EPA use *E. coli* (fresh water) and enterococci (salt water) as fecal indicator bacteria (FIB) as they both are found in human and animal intestines and their feces. FIB is easily assessed and predictive of human health risk (Byappanahalli, 2012). The presence of FIB in waters suggests that human and animal wastes may be reaching the assessed waters because of such sources as inadequately treated waste water, agriculture, and animals.

On February 12, 2014, the TCEQ adopted revisions to the Texas Surface Water Quality Standards (TCEQ, 2010) and on September 23, 2014, the EPA approved the categorical levels of recreational use and their associated criteria. Recreational criteria are based on FIB rather than direct measurements of pathogens. Criteria are expressed as the number of bacteria per 100 milliliters (mL) of water (in terms of colony forming units, most probable number (MPN), or other applicable reporting measure.)

Recreational use consists of five categories for freshwater:

I. Primary Contact Recreation 1 – activities that pose a significant risk of ingestion of water (e.g., swimming, wading by children, water skiing, diving, tubing, surfing, and the following whitewater activities: kayaking, canoeing, and rafting). Classified segments are designated for Primary Contact Recreation 1 unless sufficient site-specific information demonstrates that (1) elevated concentrations of FIB frequently occur due to sources of pollution that cannot be reasonably controlled by existing regulations; (2) wildlife sources of bacteria are unavoidably high and there is limited aquatic recreational potential; or (3) primary or secondary contact recreation is considered unsafe for other reasons, such as ship and barge traffic. The geometric mean for this criterion for *E. coli* of 126 most probable number (MPN) per 100 mL and an additional single sample criterion of 399 MPN per 100 mL in fresh water.

II. Primary Contact Recreation 2 – applies to water bodies where recreation activities that involve a significant risk of ingestion of water occur, but less frequently than for Primary Contact Recreation 1 due to physical characteristics of the water body or limited public access. The geometric mean criterion for *E. coli* is 206 per 100 mL.

III. Secondary Contact Recreation 1 – activities that commonly occur but have limited body contact incidental to shoreline activity (e.g., wading by adults, fishing, canoeing, kayaking, rafting and motor boating). These activities are presumed to pose a less significant risk of water ingestion than Primary Contact Recreation but more than the following category, Secondary Contract Recreation 2. The *E. coli* geometric mean criterion for fresh water is 630 MPN per 100 mL.

IV. Secondary Contact Recreation 2 – activities with limited body contact incidental to shoreline activity (e.g., fishing, canoeing, kayaking, rafting and motor boating) that are presumed to pose a less significant risk of water ingestion than Secondary Contact Recreation 1. These activities occur less frequently than Secondary Contract Recreation 1 due to physical characteristics of the water body or limited public access. The geometric mean criterion for *E. coli* is 1,030 MPN per 100 mL.

V. Noncontact Recreation – activities that do not involve a significant risk of water ingestion, such as those with limited body contact incidental to shoreline activity, including birding, hiking, and biking. Noncontact recreation use may also be assigned where primary and secondary contact recreation activities should not occur because of unsafe conditions, such as ship and barge traffic. This category has a geometric mean criterion for *E. coli* of 2,060 MPN per 100 mL.

Figure 1.2 Creeks, bayous, rivers and bays are popular places for water activities. Water and children often equal contact recreation, Spring Creek, H-GAC CRP region.

Recreational use consists of three categories for saltwater:

I. Primary Contact Recreation 1 – the geometric mean criterion for enterococci is 35 MPN per 100 mL. The single sample criterion is 104 MPN per 100 mL.
II. Secondary Contact Recreation 1– A secondary contact recreation 1 use for tidal streams and rivers can be established on a site-specific basis if justified by a use-attainability analysis and the water body is not a coastal recreation water as defined by the Beaches Environmental Assessment and Coastal Health Act of 2000 (Beach Act). The geometric mean criterion for enterococci is 175 MPN per 100 mL.
III. Noncontact recreation – a noncontact recreation use for tidal streams and rivers can be established on a site-specific basis if justified by the use-attainability analysis and the water body is not a coastal recreation water as defined by the Beach Act. The geometric mean criterion for enterococci is 350 MPN per 100 mL.

1.4 TOTAL MAXIMUM DAILY LOAD PROGRAM

The development of an impaired water bodies list satisfies federal Clean Water Act requirements under Section 303 (d) by identifying waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of a listed water body. The TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

A TMDL is like a budget – it determines the amount of a particular pollutant that a water body can receive and still meet its applicable water quality standards. TMDLs are the best possible estimates of assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time, but may be expressed in other ways. In addition to the TMDL, an implementation plan (I-Plan) is developed. The I-Plan is a description of the regulatory and voluntary management measures necessary to improve water quality and restore full use of the water body.

The TMDL Program is a major component of Texas' overall process for managing the quality of its surface waters. The program addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries in, or bordering on, the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses – such as drinking water supply, recreation, support of aquatic life, or fishing – of impaired or threatened water bodies.

1.5 HOUSTON – GALVESTON AREA COUNCIL

H-GAC, an established Council of Governments and regional planning agency for the Gulf Coast State Planning Region, has more than 35 years of regional environmental planning and public outreach experience. H-GAC continues to develop a comprehensive regional Geographic Information System (GIS) for valuable data analysis and modeling techniques. Many key agencies and individuals normally involved in regional water quality matters already work cooperatively under the umbrella of H-GAC's existing environmental committees and programs.

H-GAC is designated as the lead agency responsible for regional water quality assessment for the San Jacinto River Basin, Trinity-San Jacinto Coastal Basin, San Jacinto-Brazos Coastal Basin, Brazos-Colorado Coastal Basin, and Bays and Estuaries under the Texas Clean Rivers Program (CRP) (Figure 1.1). H-GAC coordinates the CRP in these basins.

The Texas Clean Rivers Act requires river authorities to prepare written water quality assessment reports for their respective basins and present the reports to the Governor, TCEQ, Texas State Soil and Water Conservation Board, and Texas Parks and Wildlife Department. The data and information provided by the state's CRP partners forms the backbone supporting the *Integrated Report*.

The Act also established the Texas Clean Rivers Program, funded by fees paid by wastewater discharge permittees and water rights holders. CRP, under the direction of the TCEQ, requires continuous assessment of ambient water quality to identify key issues and develop management strategies statewide. Results from the CRP process help set the agenda for all other water quality management programs, including monitoring, standards development, permitting, enforcement, public outreach, and field investigation and research.

1.6 REPORT PURPOSE AND ORGANIZATION

The Basin 13 project was initiated through a contract between the TCEQ and H-GAC. This report is the second report in a series of reports that record the actions, tasks, and accomplishments of the TCEQ and H-GAC using the basin approach in Basin 13. This report is an update to The Basin Characterization Report for the Brazos-Colorado Basin for Indicator Bacteria (June 2016). The tasks for the second year of the project were to (1) build on public outreach and engagement; (2) acquire and update existing (historical) data and information necessary to produce this report; (3) perform appropriate analyses to document the current state of water quality in the basin and make water quality management recommendations with the concurrence of the TCEQ; (4) conduct special studies on identified segments and initiate water quality planning activities in accordance with TCEQ; and (4) initiate and coordinate Texas Stream Team activities within the basin. This report contains:

- Information on historical data;
- Basin and watershed properties and characteristics;
- Summary of historical bacteria data that confirm the State of Texas 303 (d) listings of impairment due to the presence of FIB;
- Development of load duration curves;
- Segment special studies; and
- A review of water quality management programs in the Basin.

2 PUBLIC OUTREACH AND STAKEHOLDER INVOLVEMENT

2.1 WATER QUALITY PLANNING PROCESS

Throughout the water quality planning process, the TCEQ encourages the participation and input of residents and interest groups. Whether that contribution is providing comments on standards development, monitoring locations, and periodic assessments, or participating in recreation use attainability analyses (RUAAs), watershed protection plan (WPP) creation, and TMDL implementation plan (I-Plan) development, the public and interest groups are actively sought out and invited to play key roles in water quality planning.

The reasoning – local input is considered necessary for the success of water quality planning (Figure 2.1). Residents, business owners, industry representatives, local government staff, non-profit members, and other interested parties hold critical knowledge and technical expertise concerning watershed conditions and pollutant sources. These groups hold a stake in the quality of their water and, as stakeholders, are important in directing solutions to addressing pollutant concerns, identifying and recommending voluntary pollutant reduction measures, and becoming central to implementing those measures.

Figure 2.1 San Bernard River Watershed Protection Plan stakeholder meeting, November 17, 2009.

2.2 PROJECT OUTREACH

To update the basin characterization report and continue building a foundation for future work in the basin, H-GAC engaged basin stakeholders by:

- maintaining contact with interested stakeholders and basin interest groups to share project information and provide notification of public meetings (Appendix A);
- updating as needed, the one-page information brochure (Appendix B);
- maintaining a Basin 13 website; and
- hosting public and one-on-one stakeholder meetings to share project information and feedback on topics concerning the basin.

In 2016, H-GAC identified a total of 113 potential stakeholders in Basin 13. H-GAC contacted each stakeholder through an email sent to the entire stakeholder group. The email "blast" was then followed up by prioritizing the list for further direct phone and email outreach. Each potential stakeholder was given the one-page project brochure. Stakeholders directly contracted were afforded greater project information, given an opportunity to fill out a project survey, and queried as to their interest in participating in future basin and watershed meetings. From the initial list of 113 potential stakeholders, 18 individuals and organizations voiced interest in participating in Basin 13.

2.2.1 First Public Meeting

The first public meeting was held at the Wharton County Public Library in Wharton, Texas on November 28, 2016. Six stakeholders were present at the meeting. The attendees heard from H-GAC and Texas State Soil and Water Conservation Board (TSSWCB) on water quality in the Basin, tools available to improve water quality and additional steps that will be taken under the basin approach.

2.2.2 One-on-One Meetings

Meeting with individuals and organizations directly are important for fostering interest, building support and trust with stakeholders. H-GAC initiated that process in year two with the City of Sweeny. The one-on-one meeting focused on the characterized water quality information for the basin, discussing watershed interests, providing the project schedule, exchanging contact information and soliciting participation in future meetings. One-on-one meetings will continue in the third year of the basin approach.

2.2.3 Second Public Meeting

The second public meeting was held at the West Columbia Convention Center in West Columbia, Texas on August 1, 2017. The meeting outreach approach changed since the first public meeting. H-GAC contacted directly via phone and personal email with identified stakeholders. Along with the meeting announcement, H-GAC offered to meet one-on one with each organization and asked the organization to assist with announcing the meeting. Outreach efforts resulted in fifteen stakeholders attending the meeting. The attendees were provided a project update that included the latest information on basin water quality, and next steps that will be taken in the basin, including development of a TSD for Caney Creek.

2.3 PLANNING OUTREACH TOOLS

There are four watershed-based tools that were evaluated for use in Basin 13.

- Additional monitoring – segments and AUs in Basin 13 were reviewed for spatial and temporal environmental data gaps.
- Recreational Use Attainability Analysis (RUAA) – segments and AUs were reviewed for the appropriateness to conduct an RUAA.
- Watershed Protection Plan – segments and AUs were reviewed for the appropriateness to develop WPPs.
- TMDL studies – segments and AUs were reviewed for the appropriateness to conduct TMDL studies and develop implementation plans.

Determining when and where to engage the use of these tools will involve the input of local stakeholders and concerned residents. H-GAC, in analyzing available information for this basin, discusses the potential for utilizing one of these approaches as an initial starting point for the watershed planning process discussion. In certain cases, one or more of these tools has already begun or is in process. The segment analyses found in Appendix D notes if any of these tools has been used. Additionally, recommendations made in Section 6, Conclusions and Recommendations, will note if H-GAC suggests TCEQ consider implementing one of these tools in the future.

2.4 CURRENT AND FUTURE BASIN 13 INVOLVEMENT OPPORTUNITIES

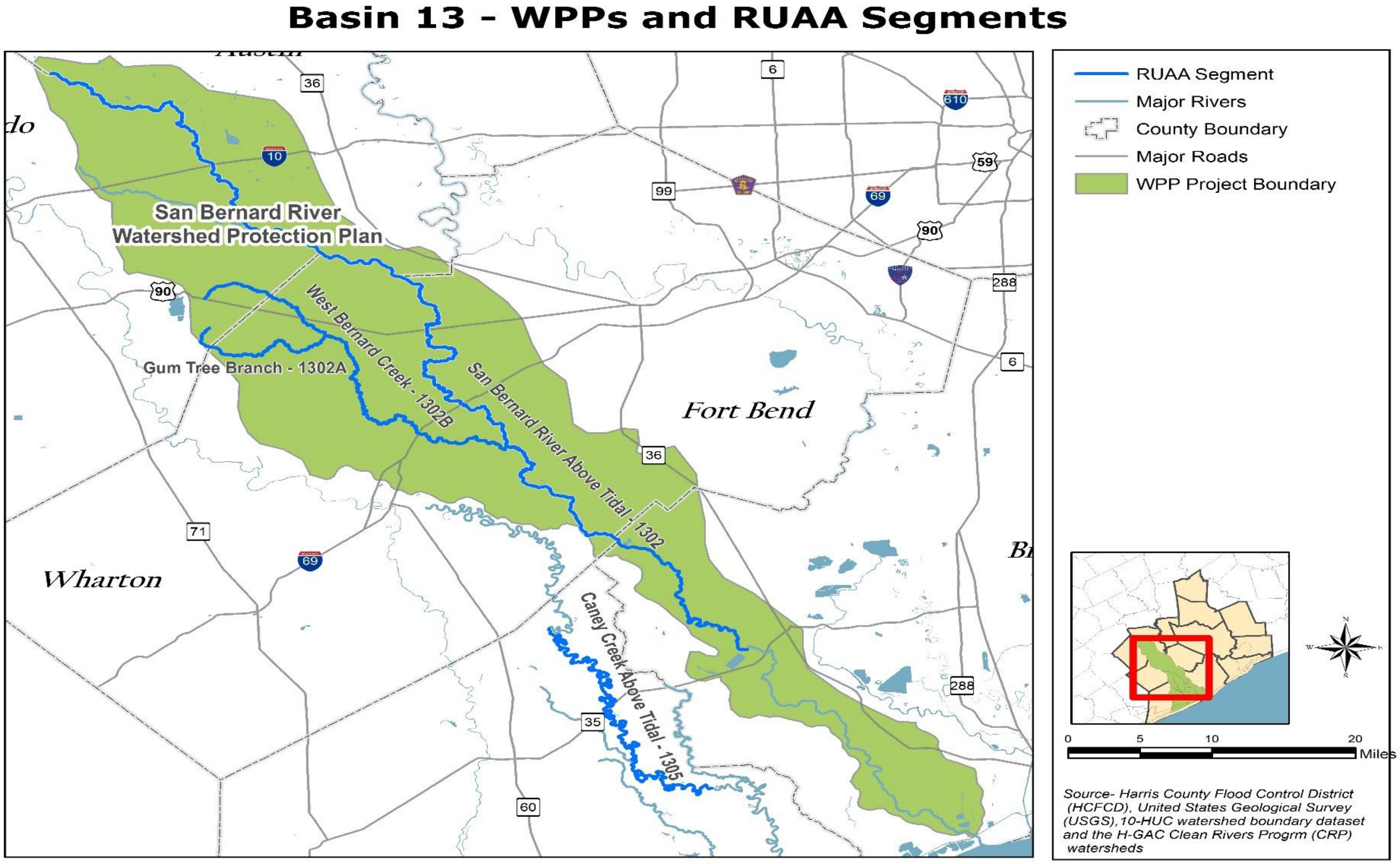
Implementing any of the tools listed in section 2.3 will actively involve residents and organizations. Outreach as the basin approach is implemented will use public notices, outreach materials, public meetings, and individual and organization surveys. Each tool generally hosts its own public engagement process.

2.4.1 Clean Rivers Program

H-GAC, as the CRP lead in the region, encourages concern resident and stakeholder involvement in its annual coordinated monitoring meeting and CRP Steering Committee meeting. H-GAC uses these outreach opportunities to assist the CRP program to address gaps in spatial and temporal monitoring, remove duplicative efforts due to proximity of monitoring stations, and to establish new monitoring stations to reflect a special study, e.g. TMDL, WPP, or special project (H-GAC, 2016).

2.4.2 Recreation Use Attainability Analysis

RUAAs are scientific assessments conducted to evaluate and determine what category of recreational use is appropriate for a water body. These site-specific studies, carried out by the TCEQ, assess reasonable attainable recreational uses that can occur based on the physical and flow characteristics of a stream, e.g. water depth and persistence flow. Supporting information also includes outreach through surveying individuals and organizations with first-hand knowledge of the waterbody, to establish historical and existing patterns of recreational use (TCEQ, 2016). There are two current RUAAs under review by the TCEQ in the basin: San Bernard River Above Tidal – Segments 1302, 1302A, and 1302B and Caney Creek Above Tidal – Segment 1305 (Figure 2.2).



Source- Harris County Flood Control District (HCFCD), United States Geological Survey (USGS),10-HUC watershed boundary dataset and the H-GAC Clean Rivers Progrm (CRP) watersheds

Figure 2.2. Recreation Use Attainability projects and Watershed Protection Planning found in Basin 13.

The public comment period for both studies has expired but the TCEQ has not made any changes to the standards. There will likely be future opportunity for public outreach regarding these two RUAAs.

2.4.3 Watershed Protection Planning

WPPs are watershed-based, stakeholder-led planning processes supported by the TCEQ and the TSSWCB to address non-point sources of pollution. The plans are developed by local stakeholders, usually with funding and technical assistance provided by the TCEQ and/or TSSWCB, along with the EPA (TCEQ, 2016). Public meetings, resident outreach, and public tours of the watershed are popular outreach tools used by WPP participants. There is currently one WPP in Basin 13 (Figure 2.2.). The San Bernard Watershed Protection Plan was completed in December 2012 (San Bernard WPP, 2012) and approved by the EPA in June 2017. The public involvement process included a 28-member stakeholder group.

2.4.4 Total Maximum Daily Loads

TMDLs developed by the TCEQ, bring communities together to develop a plan to reduce pollutant loads to meet state standards. The TMDL is a scientifically derived target that describes the greatest amount of a substance that can be added to a waterway and the waterway remains healthy (TCEQ, 2016). A TMDL implementation plan (I-Plan) is then developed by local stakeholders to reduce the pollutant to meet the target. Public meetings are key to identifying local-specific measures adopted in the I-Plan and to encouraging the eventual use of those measures.

2.5 TEXAS STREAM TEAM AND OTHER OUTREACH OPPORTUNITIES

H-GAC will coordinate outreach, workshops, and volunteer training events in Basin 13. Several existing state and regional water quality programs can be brought to the basin to assist with education and offer early water quality best practices to reduce bacteria and other pollutants. Programs such as Texas Stream Team offer hands-on volunteer opportunities for stakeholders and residents interested in water quality monitoring. Other programs, including those by Texas A&M AgriLife Extension Service, offer technical training to agriculture producers and owners of onsite sewage facilities (OSSFs) to offer implementable solutions to current practices with the goal of preventing or eliminating sources of bacteria.

2.5.1 Texas Stream Team

Texas Stream Team (TST) is a network of volunteer water quality monitors (Figure 2.3) that collect water quality information, expanding the monitoring capabilities of state and local partners, and making that information available to all Texans (H-GAC, 2016). At the state level, TST is administered by Texas State University, TCEQ and EPA. H-GAC is the lead regional TST agency. H-GAC provides certified water monitoring training to volunteer participants, using quality assured methods for gathering water quality information. There are currently 133 TST volunteers for 123 monitoring sites in the H-GAC CRP region, including 14 TST volunteers at 13 sites in Basin 13.

Figure 2.3 Texas Stream Team volunteer monitoring.

2.5.1.1 Support for TST in Basin 13

During the second year of the Basin 13 approach, H-GAC supported TST by hosing a TST training event on September 16, 2016. The event was held at the Friends of the River San Bernard Community Center near Brazoria, Texas. Twelve new and four current volunteers participated. H-GAC purchased supplies to build six TST monitoring kits for use in the basin.

2.5.2 Texas A&M AgriLife Extension Service

AgriLife Extension provides programs that center on water quality, including watershed education, land practices, and OSSFs (Agrilife Extension, 2016).

2.5.2.1 Texas Watershed Steward Program

AgriLife Extension's Texas Watershed Steward Program (TWS) is an educational program offering an online course and one-day workshop seeking to educate and inform local stakeholders about the watersheds where they live, water quality impairments and concerns, and steps that can be taken to help improve and protect their water resources. On July 11, 2017, Texas AgriLife hosted the program at the Brazoria County Fair Grounds in Angleton, Texas. Twenty-seven participants attended the event.

2.5.2.2 Lone Star Healthy Streams

AgriLife Extension's Texas Water Resources Institute (TWRI) manages the Lone Star Healthy Streams (LSHS) program which seeks to educate interested Texas farmers, ranchers, and landowners about proper grazing, feral hog management, and riparian area protection to reduce the levels of pollutant contamination to streams and rivers. TWRI hosts an informative LSHS website and conducts LSHS workshops around the state.

2.5.2.3 Onsite Wastewater Treatment Training Program

AgriLife Extension offers short courses and training centers to educate homeowners and improve the skills of installers, site evaluators and designers of onsite waste water treatment systems. The courses meet OSSF inspection credit hour requirements.

2.5.3 OSSF Real Estate Inspection Training Course and Homeowner Training

H-GAC offers a Texas Real Estate Commission (TREC) approved OSSF real estate training course and general OSSF information for homeowners. The real estate course is designed to help real estate agents and home inspectors identify OSSFs on properties and determine if failing through visual inspection. The course provides six TREC continuing education credit hours. H-GAC also offers training to homeowners interested in learning more about their OSSFs and basic inspection and repairs. On July 21, 2017, H-GAC offered its homeowner training at the Brazoria County Extension Office in Angleton, Texas. Nineteen residents were present at the workshop.

3 BASIN PROPERTIES

3.1 DESCRIPTION OF STUDY AREA

The Brazos – Colorado Coastal Basin (Basin 13) lies in southeast Texas. The basin is southwest of the Houston metropolitan area and a portion of the basin is in the Houston – The Woodlands – Sugar Land Metropolitan Statistical Area (Houston Metro Profile: KET Enterprises Inc., 2014). The study area includes portions of six counties: Austin, Brazoria, Colorado, Fort Bend, Matagorda, and Wharton. All or part of twenty cities, villages and census designated places can be found in the Basin (Figure 3.1). The basin's current population is 88,000, a 3.5% increase over the 2000 US Census (Table 3.1).

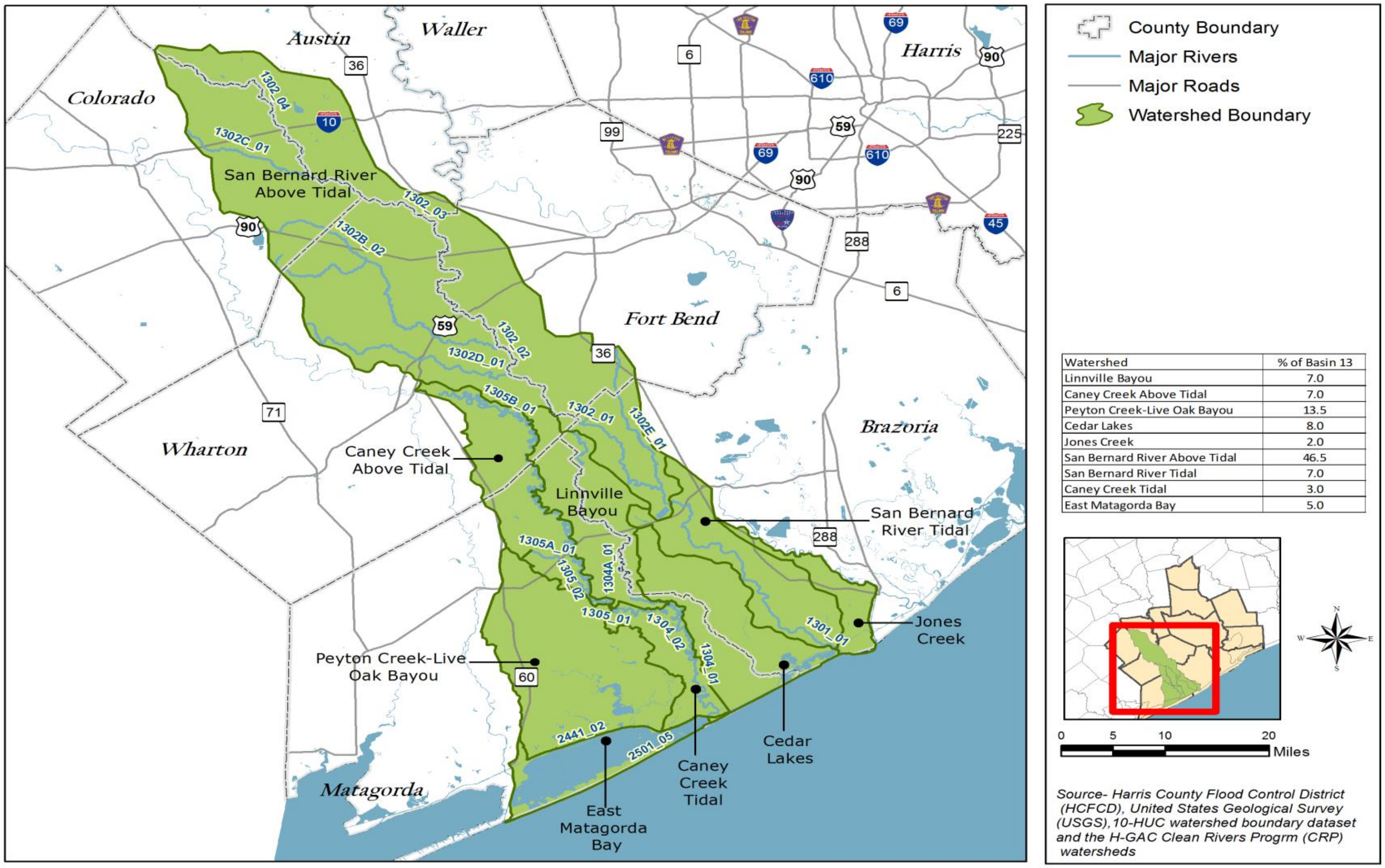
Basin 13: Population	
2000 Population	85,000
Current Population	88,000
Change 2000-Current	3.5%

Table 3.1: Basin 13 population growth since 2000.Source – US Census.

The waterbodies in the basin flow southeast from the headwaters in Austin and Colorado counties, through Fort Bend, Wharton, Brazoria and Matagorda before emptying into Matagorda Bay via the Gulf Intracoastal Water Way (GIWW). The major tributaries are divided into four segments (Figure 3.1). The 2014 *Integrated Report* (2015) provides the following segments found in the Basin for waterbodies considered in this document:

- Segment 1301. The entire tidal segment covering the San Bernard River from a point two miles upstream of State Highway 35 to the Intracoastal Water Way (ICWW) in Brazoria County and the Gulf of Mexico.
- Segment 1302. San Bernard River Above Tidal from the headwaters in Austin and Colorado counties to a point two miles upstream of State Highway 35 in Brazoria County, including Gum Tree Branch, West Bernard Creek, Peach Creek, and Mound Creek tributaries.
- Segment 1304. Caney Creek Tidal from the upstream tidal boundary near the unincorporated city of Cedar Lane in Matagorda County to the confluence with the ICWW near the eastern edge of East Matagorda Bay, including the entire segment of Linnville Bayou.
- Segment 1305. Caney Creek Above Tidal from the headwaters near the city of Wharton in Wharton County to the tidal boundary near the city of Cedar Lane, including Hardeman Slough, Snead Slough, and Waterhole Creek.

These segments are broken down further into assessment units (AUs). For the four segments, there are 19 AUs (Appendix C) studied for this report. One additional AU, 2441A, Live Oak Bayou was added to the review, though there is limited data available to complete an assessment. More detail on each of these segments and related AUs can be found in Appendix D.



Basin 13 - Watershed

Watershed	% of Basin 13
Linnville Bayou	7.0
Caney Creek Above Tidal	7.0
Peyton Creek-Live Oak Bayou	13.5
Cedar Lakes	8.0
Jones Creek	2.0
San Bernard River Above Tidal	46.5
San Bernard River Tidal	7.0
Caney Creek Tidal	3.0
East Matagorda Bay	5.0

Source- Harris County Flood Control District (HCFCD), United States Geological Survey (USGS),10-HUC watershed boundary dataset and the H-GAC Clean Rivers Progrm (CRP) watersheds

Figure 3.1: Watershed Map of Basin 13.

3.2 GEOGRAPHY

Typical soil types in the region include fine, poorly draining alluvial clays, silts, and loams with dispersed areas of sandy substrate resulting from subtropical climate and fluvial geologic characteristics (Figure 3.2). Average precipitation rates range from between 45 and 47 inches per year (Table 3.2) taken from two rain gauges near the basin. Evaporation rates reach up to 60 inches per year during drought conditions (San Bernard River Watershed Protection Plan (WPP), 2012).

STATION	STATION_NAME	LATITUDE	LONGITUDE	Average Annual Rainfall (in)
GHCND:USC00413340	FREEPORT 2 NW TX US	28.9845	-95.3809	46.8
GHCND:USC00419655	WHARTON TX US	29.31778	-96.08472	45.1

Table 3.2. NOAA rain gauges located near Basin 13.

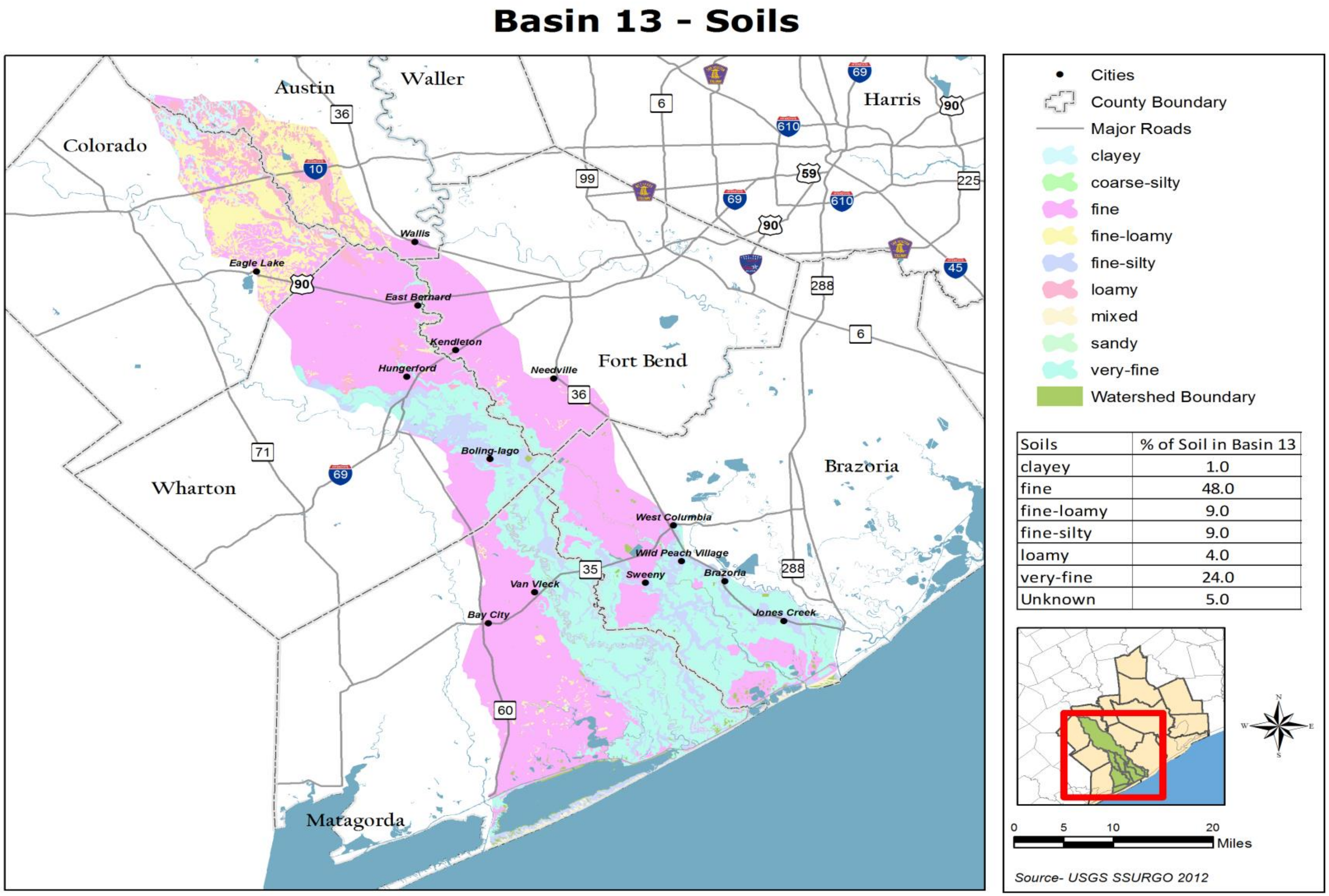
Topography ranges from rolling hills nearing 400 feet near the town of New Ulm in Austin County at the edge of the Post Oak Savannah region to sea-level at the Gulf of Mexico. Most the basin is found in the gently 0.04% sloping Gulf Coast Plain (Snowden, 1989) that is characteristically flat (Figure 3.3). Freshwater inflows from streams and rivers into GIWW and Matagorda Bay are sluggish due to this gently sloping relief.

Riparian vegetation is common along river floodplains. Primary mineral resources within the region include oil and gas fields, salt domes, sulfur, sand and gravel. Magnesium is also extracted from seawater (Handbook of Texas, 2016).

3.3 LAND COVER AND ECOSYSTEMS

All creeks and bayous and the San Bernard River, beginning as far north as Austin and Colorado counties, traverse the basin, southeasterly before draining into the GIWW and Matagorda Bay. The mouth of the San Bernard River which empties into the Gulf of Mexico, periodically closes due to silt from the Brazos River (Figure 3.3). Closure of the mouth has affected water quality, particularly dissolved oxygen and nutrients (San Bernard WPP, 2012), and is a concern for a local non-profit organization, Friends of the River San Bernard (FOR).

The project area is primarily coastal prairies and marshes, broken up by ribbons of riparian hardwoods and pine forests that are continually influenced by the sea, wind, rain, and occasional hurricanes. The flat nature of the coastal plain has seen the Brazos and Colorado rivers meander across the basin. Over time, the elements and impacts from the Gulf of Mexico and the rivers have shaped the area by creating a network of streams, bayous, bays, estuaries, salt marshes, and tidal flats rich in wildlife. Native vegetation consists of tallgrass prairies, live oak woodlands, and a variety of halophilic (salt tolerant) plants with extensive wetland and seagrass habitats providing food and shelter for numerous bird species and aquatic organisms.



Basin 13 - Soils

Soils	% of Soil in Basin 13
clayey	1.0
fine	48.0
fine-loamy	9.0
fine-silty	9.0
loamy	4.0
very-fine	24.0
Unknown	5.0

Source- USGS SSURGO 2012

Figure 3.2. Basin 13 soil types and percentage of soil types within the basin.

Figure 3.3 Relatively flat topography of the Gulf Coast Plain. The mouth of the San Bernard River is closed due to siltation on April 29, 2015. GIWW can be seen intersecting the San Bernard River running parallel to the coast at the top of the photo and the Gulf of Mexico at the bottom.

East Matagorda Bay is a productive bay bounded by marshes and built up reefs, support a thriving recreational and commercial fishing and oyster economy. The open bays see recreational activity and commercial/industrial activity, with ships and barges transporting goods through the bay area and along the GIWW.

The National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program (CCAP) data was used to assess land cover for the basin. Twenty-two land cover types were used to analyze the basin. Some of the land cover types were combined to form 10 land cover types, simplifying analysis (Figure 3.4). The basin covers nearly 1.2 million acres. The most predominant land cover type is Pasture/Hay (27%) (Table 3.3). Cultivated Crops and Natural Land Cover are the next two dominant land cover types at 24% and 22%, respectively. NOAA's CCAP also delineates developed areas, making up only 2% of the basin. The largest developed land cover type is Developed – Low Intensity (0.88%). Other developed categories, in order of size, are: Developed – Open Space (0.74%), Developed – Medium Intensity (0.34%), and Developed – High Intensity (0.11%).

H-GAC does not maintain parcel data for most of the counties in this basin. Therefore, land use could not be derived. However, upon review of the basin's land cover, the basin is found to be homogenous. Inferring from the land cover, the basin's predominant land use is agriculture, as Cultivated Land and Hay/Pasture account for over half of the land cover for the basin. There are no large cities in the basin, and only the edges of a couple of medium-sized cities skirt the basin. There are a few small cities throughout the basin, but their footprint is minimal.

BASIN 13 LAND COVER TYPES		
Types	**Acres**	**% Basin**
Natural Cover	259316.34	21.77
Cultivated Crops	284953.27	23.93
Pasture/Hay	321588.10	27.01
Estuarine Wetland	78931.66	6.63
Palustrine Wetland	167724.32	14.09
Open Water	53546.76	4.5
Development - High Intensity	1292.20	0.11
Development - Medium Intensity	4010.23	0.34
Development - Low Intensity	10498.72	0.88
Developed - Open Space	8867.06	0.74
Basin 13 Total	**1190728.65**	**100**

Table 3.3. Ten Land Cover Types found in Basin 13.

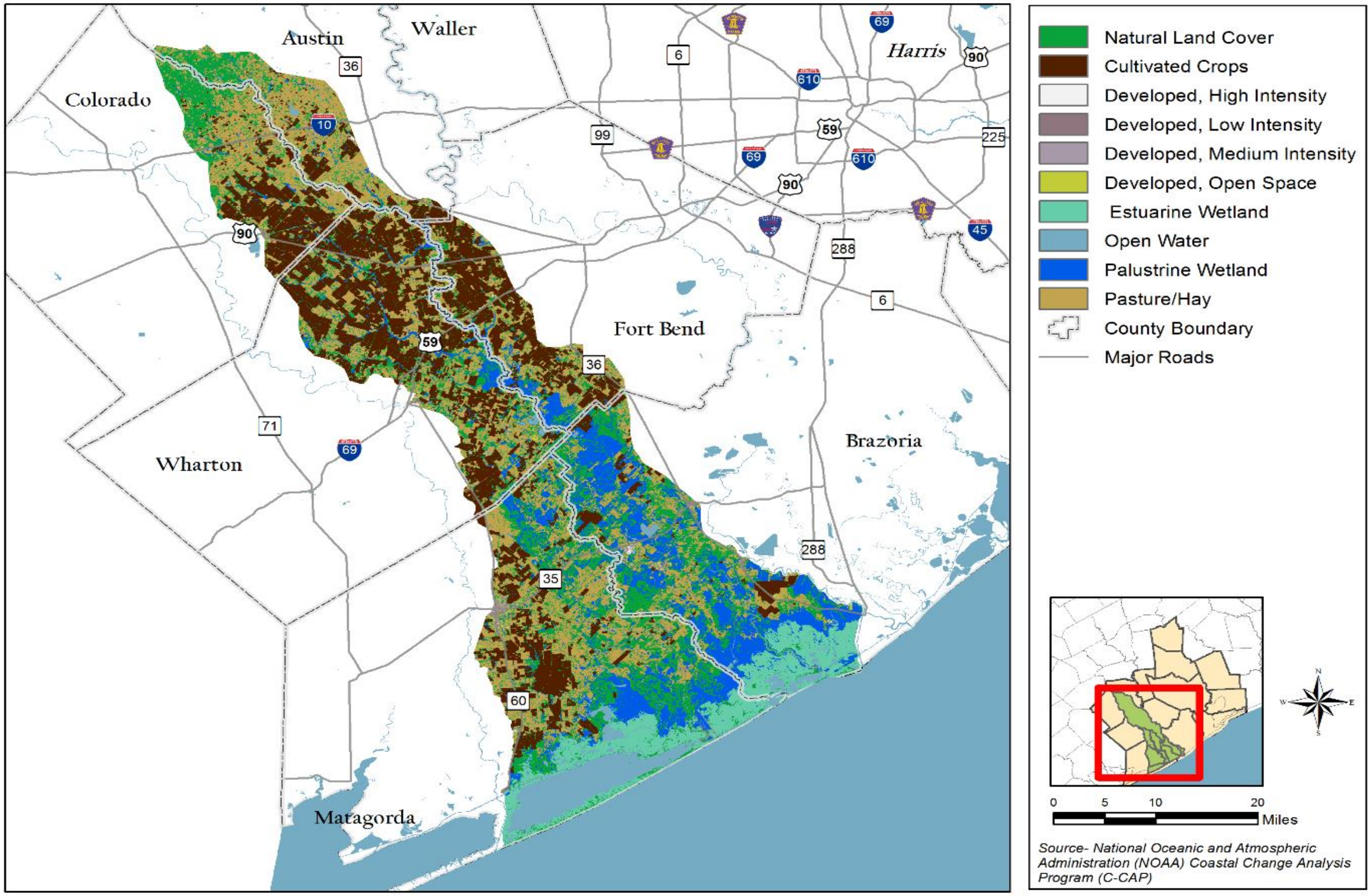
The second largest land use type is Park and Natural Areas. There are three designated wildlife and habitat areas in the San Bernard Watershed (San Bernard Watershed Protection Plan, 2012).

- The San Bernard National Wildlife Refuge is a 27,000-acre sanctuary established in 1968 to protect habitat for wintering waterfowl and estuarine systems for marine spaces. The refuge is located at the San Bernard River terminus, adjacent to the Gulf of Mexico.

- The Justin Hurst Wildlife Management Area can is at the southernmost portion of the San Bernard River. The area contains over 10,000 acres of coastal prairie and marsh.

- The Attwater Prairie Chicken National Wildlife Refuge is located near the town of Eagle Lake in the upper third of the San Bernard River. Over 10,000 acres have been set aside for the recovery of the Attwater’s Prairie Chicken.

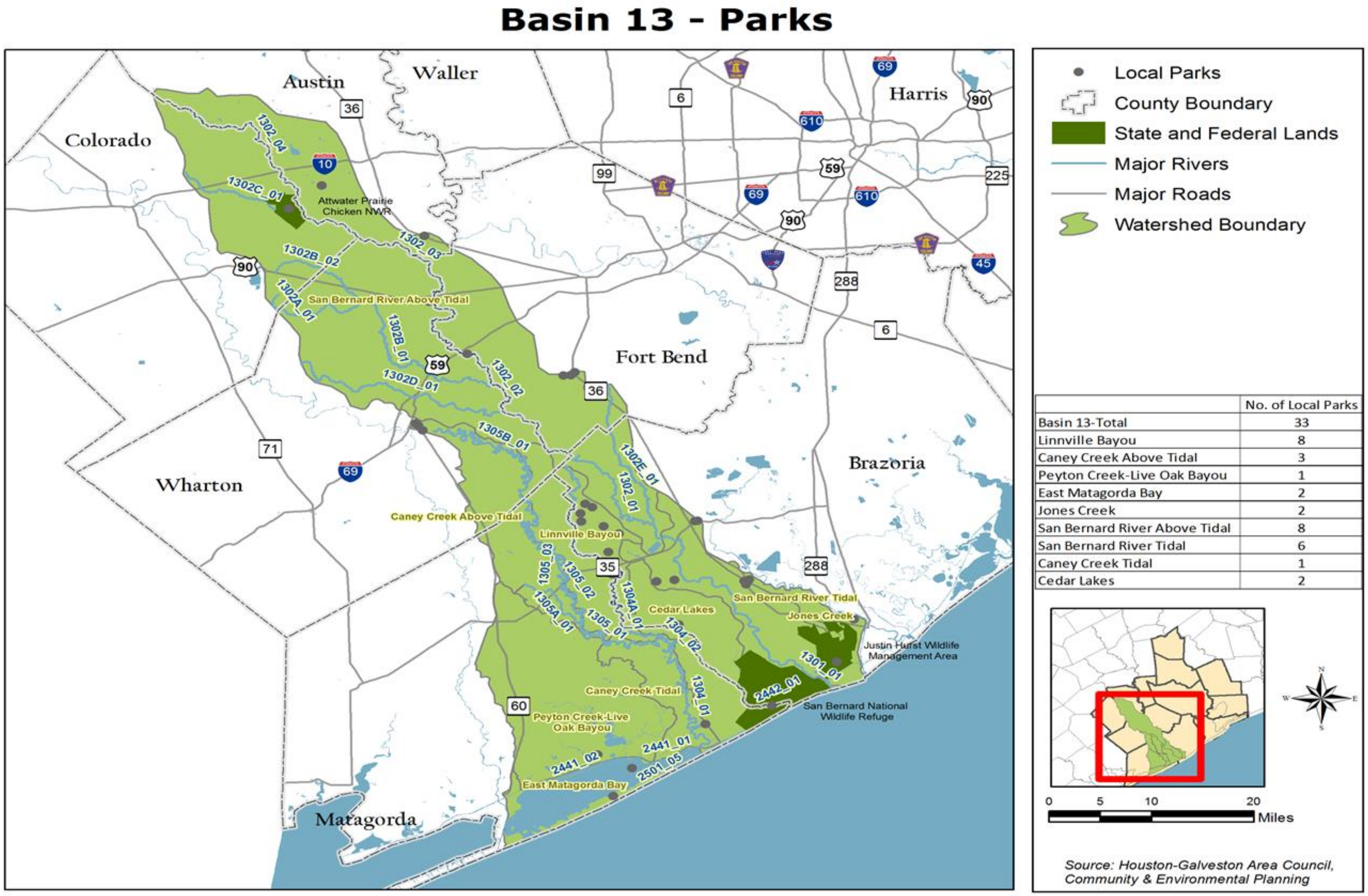
There are also another 33 parks located in the basin that account for another 31 acres (Figure 3.5).



Basin 13 - Land Cover

Source- National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP)

Figure 3.4: Land cover classification map for Basin 13 using 10 land cover classifications.


Basin 13 - Parks

	No. of Local Parks
Basin 13-Total	33
Linnville Bayou	8
Caney Creek Above Tidal	3
Peyton Creek-Live Oak Bayou	1
East Matagorda Bay	2
Jones Creek	2
San Bernard River Above Tidal	8
San Bernard River Tidal	6
Caney Creek Tidal	1
Cedar Lakes	2

Source: Houston-Galveston Area Council, Community & Environmental Planning

Figure 3.5. Thirty-three parks found in Basin 13 broken out for each segment.

3.4 ECONOMIC DEVELOPMENT

3.4.1 Mining

The principal geologic feature for the Texas Coastal Plain is alluvial sedimentation. The layering of sediments over millennia has led to one of the key economic drivers for the region. Mining is the leading industry in the basin with oil, gas, sulfur, lime, salt, sand, and gravel in abundance. Salt domes are a regular subsurface feature in the region, including Boling Dome and Damon Mound where salt, sulfur, oil, and gas are extracted. A large employer for the basin is the Conoco-Phillips refinery near the town of Sweeny (San Bernard Watershed Protection Plan, 2012).

3.4.2 Recreation and Ecotourism

Recreation and ecotourism expanded in the late 1980s and 1990s. The San Bernard National Wildlife Refuge and presence of East Matagorda Bay makes the area an attractive destination spot for wildlife viewers, hunters, and recreational anglers.

3.4.3 Agriculture

With about 51% of land use in the region classified as agricultural – crop production and cattle grazing, the basin is a major international agribusiness center, emphasizing the marketing, processing, packaging, and distribution of agricultural commodities including cotton, rice, sorghum, and other grains. Agricultural production values for the region in 2012 totaled more than $1.1 billion in revenues (Houston Metro Profile: KET Enterprises Inc., 2014). Agricultural activity is a focus throughout the Brazos – Colorado Coastal Basin. Cattle, rice, cotton, milo, corn, sorghum, and soybeans are the top agriculture products generated.

3.5 KEY FACTORS INFLUENCING WATER QUALITY

Some of the sources that potentially influence water quality in the basin include: OSSFs, agricultural activities, feral hogs and natural sources e.g. wildlife. The basin is not expected to grow rapidly over the next 20 years, so urban and suburban development is not seen as a large pollution source currently or in the future. Considering pollutants on a watershed scale allows for simultaneous analysis of potential pollution sources in multiple water bodies. Potential sources of FIB are discussed in Section 4, Historical Data Review.

3.6 SEGMENT AND AU SUMMARIES (APPENDIX D)

Watershed Summaries for Basin 13 include water quality information for each formally defined stream segment where environmental data has been collected and assessed. Water quality impairments and concerns highlighted in the summaries were identified in the 2014 *Integrated Report*. The *Integrated Report* is a comprehensive evaluation of the condition of surface waters in Texas. It is based on historical monitoring data and provides resource managers with a tool for making informed decisions when directing agency programs. It identifies the water bodies that are not meeting contact recreation standards set for their use in the *Texas Surface Water Quality Standards*, published in Title 30, Chapter 307 of the Texas Administrative Code. The federal Clean Water Act requires the TCEQ to submit an updated *Integrated Report* to the EPA every two years.

Each watershed summary includes the following information:

- Segment Number
- Segment Name
- Segment Length
- Watershed Area
- Designated Uses
- Number of Active Monitoring Stations
- Texas Stream Team Monitors
- Permitted Outfalls
- Description
- Degree of Impairment (by percent of stream or water body impaired)
- FY 2014 Active Monitoring Stations
- Standards and Screening Criteria

The summary tables include an overview of bacteria impairments and concerns affecting the watershed, descriptions of the affected areas, possible causes and influences or concerns voiced by stakeholders, and possible solutions or actions to be taken. The summary tables are followed by narrative discussions of watershed characteristics, water quality issues, special studies and projects completed in the watershed, water quality trends, and recommendations.

Several watershed maps and statistical graphs accompany the discussions to illustrate spatial variations and critical bacteria trends. Typically, graphs are a plotted measure of bacteria values over time where the trend has been found to be statistically significant.

4 HISTORICAL DATA REVIEW

4.1 REVIEW OF ROUTINE MONITORING DATA FOR BASIN

4.1.1 Data Acquisition

Ambient *E. coli* and enterococci data were obtained from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS). The data represented the routine ambient bacteria and other water quality data collected for the project area by the TCEQ's CRP for the study area (CRP, 2016). General assessment criteria methodologies established by the TCEQ were used in data evaluations.

4.1.2 Analysis of Bacteria Data

Recent environmental monitoring within watersheds found in Basin 13 has occurred at numerous CRP monitoring stations (Figure 4.2). There are 15 monitoring sites being routinely visited by CRP partners. Those 15 stations are evenly distributed throughout the watershed. Appendix C contains the table of all segments and assessment units (AUs) found in the study area. Appendix D provides greater detail on each AU and monitoring station.

Bacteria data retrieved from these stations through November 30, 2016, were reviewed, and trends were developed. The method for data selection, review, and trend analysis is discussed further in 4.2, Data Review Methodology. The Rolling seven year bacteria geometric mean trend for all data gathered from all stations, 123 data results, found elevated bacteria concentration consistently above the standard between 2010 and 2016 (Figure 4.1).

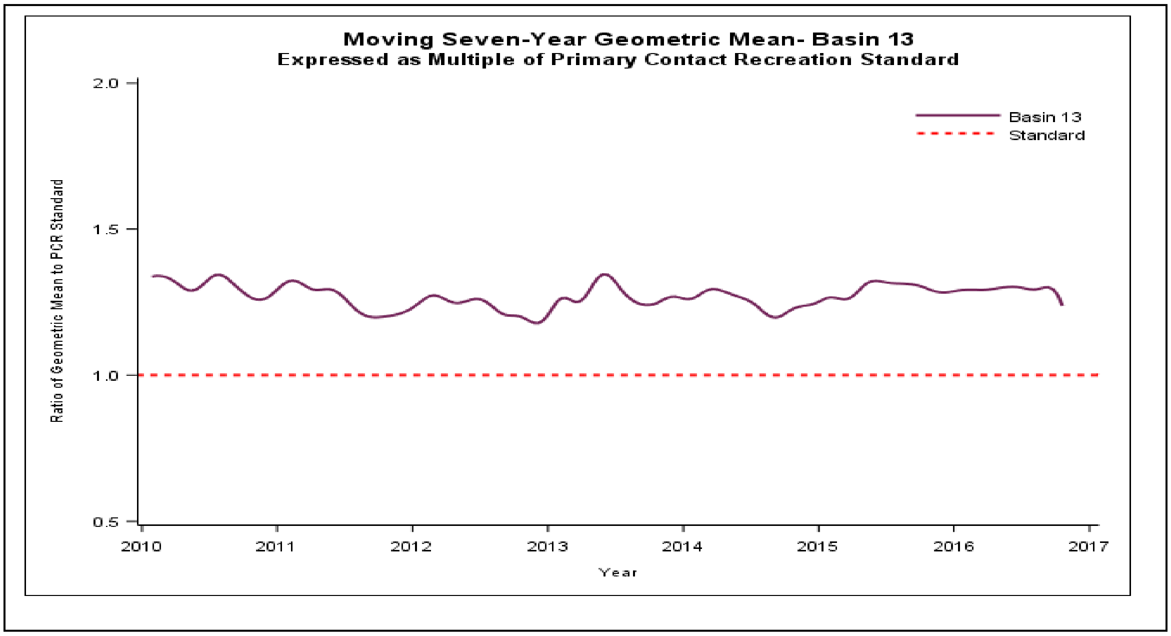
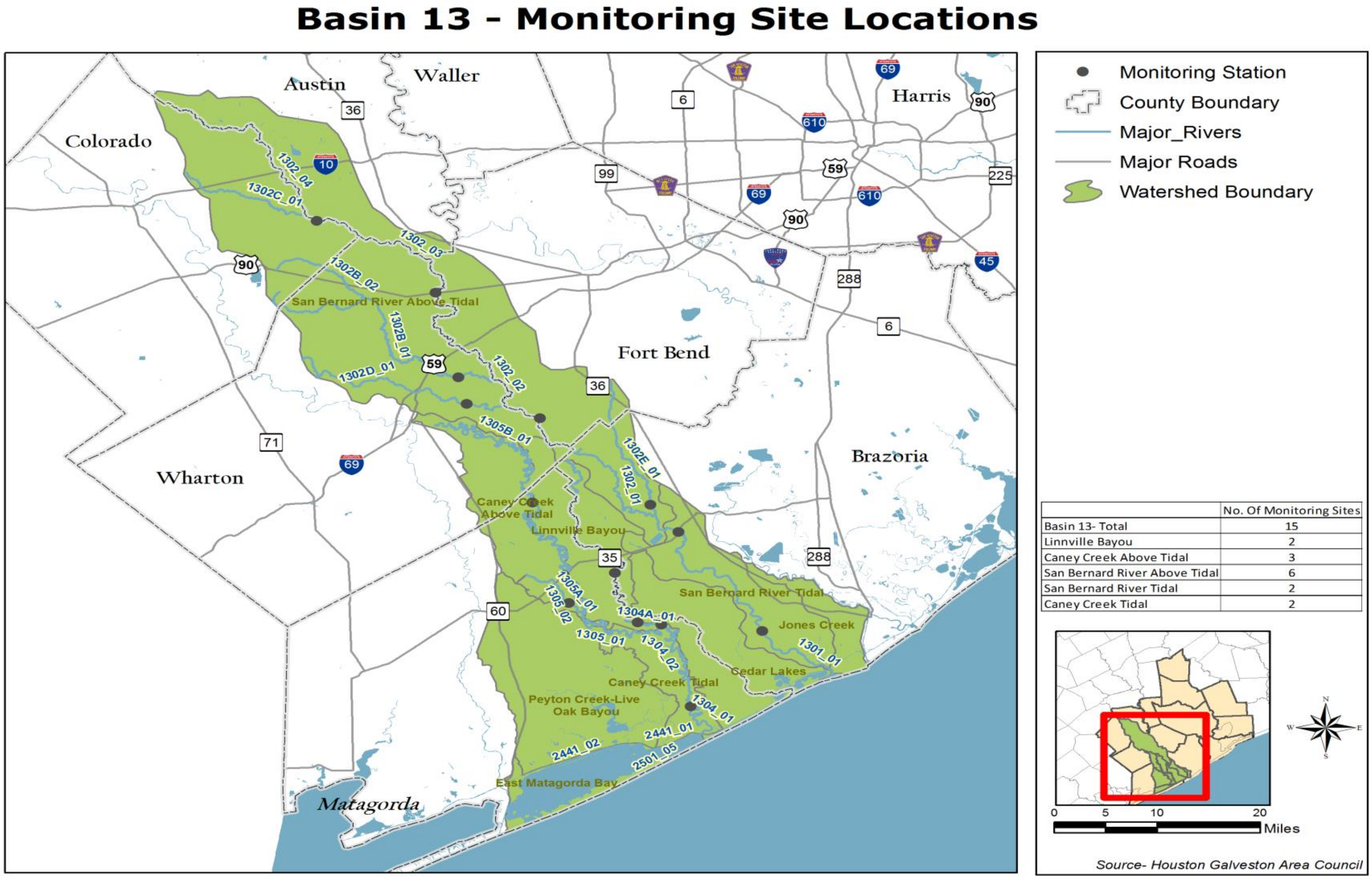


Figure 4.1. Moving relative bacteria geometric mean for all bacteria indicator data collected in Basin 13 for a period on 2010 through 2016.



	No. Of Monitoring Sites
Basin 13- Total	15
Linnville Bayou	2
Caney Creek Above Tidal	3
San Bernard River Above Tidal	6
San Bernard River Tidal	2
Caney Creek Tidal	2

Source- Houston Galveston Area Council

Figure 4.2. Texas Clean Rivers Program monitoring site locations contained in the study area.

Of the 20 AUs reviewed, there are nine AUs currently listed as impaired for bacteria and given a category 5 listing (Table 4.1) in the 303 (d) List of Impaired Waters (2014 *Integrated Report*, 2015). These AUs may be appropriate for development of future TMDLs. The remaining 11 were not placed in a category due to either a limitation with the data or because the AU meets water quality standards. A total of 285 bacteria samples were used in the 2014 *Integrated Report* assessment for all AUs assessed during the seven-year period from 2005 through 2012.

4.2 DATA REVIEW METHODOLOGY

4.2.1 Data Selection

Water quality data used for analyses in this report were extracted from a complete data set downloaded from the Surface Water Quality Monitoring System (SWQMIS) on May 16, 2017. SWQMIS is a database that serves as the repository for TCEQ surface water quality data for the state of Texas. All data used for these analyses were collected under a TCEQ-approved Quality Assurance Project Plan (QAPP). Qualified data (data added to SWQMIS with qualifier codes that identify quality, sampling, or other problems that may render the data unsuitable) were excluded from the download. All data for all stations in Basin 13, collected from January 1, 2002, through November 30, 2016, were combined into a working data set. U.S. Geological Survey (USGS) flow data for gauging stations were downloaded from the USGS website on September 16, 2015.

Variables in each data set were transformed as appropriate, and new variables were created to facilitate analysis and the graphical display of results. Censored data (data reported as "<[parameter limit of quantitation (LOQ)]>" were transformed to a value of one-half the parameter LOQ. In cases where some data reflected use of a lower LOQ than the current H-GAC CRP LOQ, the data were transformed to one-half of the current H-GAC CRP LOQ. In some cases, data from two or more STORET (method) codes were combined because the results obtained from each method can be considered equivalent. Any data that were not collected at a depth greater than 0.4 meters or that were not collected under a routine ambient monitoring program were deleted.

The following parameters were retained for analysis: *E. coli* (31699), Enterococci (31701).

4.2.2 Data Selection for Trend Analysis

A subset of data was compiled for segment-level trend analysis. The temporal range and number of available data, mean, median, and 95th percentile was calculated for each station and parameter and for all data in the segment. Station data were ranked by the number of data points, the length of the time series, and the proximity of data points to each other to develop parameter statistics for the segment. Stations with the longest time series and most data points were preferred in the cases where parameter statistics were similar. The station with the highest rankings on these measures in each segment was selected and mapped. If two stations were closely ranked, a station associated with a USGS gauging station was preferred. In almost all cases, the station selected based on numeric criteria was located near the downstream boundary of the segment. If that station was located far from the boundary, further evaluation was performed and another station was selected.

BASIN 13 IMPAIRED ASSESSMENT UNITS

Assessment Unit	Name	Parameter	Category	Data Date Range	No. of Samples in AU	AU Geometric Mean (MPN/100 mL)
1301_01	San Bernard River Tidal	Enterococcus	5c	2005-2012	50	50.49
1302_01	San Bernard River Above Tidal	*E. coli*	5b	2005-2012	35	192.79
1302_02	San Bernard River Above Tidal	*E. coli*	5b	2005-2012	0	
1302_03	San Bernard River Above Tidal	*E. coli*	5b	2005-2012	48	141.69
1302A_01	Gum Tree Branch	*E. coli*	5b	2005-2012	0	
1302B_02	West Benard Creek	*E. coli*	5b	2005-2012	0	
1304_01	Caney Creek Tidal	Enterococcus	5c	2005-2012	64	49.28
1304A_01	Linnville Bayou	*E. coli*	5b	2005-2012	11	170.23
1305_02	Caney Creek Above Tidal	*E. coli*	5b	2005-2012	27	137.03

Table 4.1. Impaired assessment units listed in the 2014 Texas 303 (d) list of impaired water bodies, Category 5 for Basin 13.

For each segment/parameter combination, one data point per month for each year was retained and data gaps were evaluated. If there were no data for a parameter in a segment during one year in the 16-year time, additional data were added from the geographically closest station in the segment (for that year and parameter only). This process continued until a complete time series was produced. If any segment/parameter had either fewer than 30 data points or a time series range of less than seven years, it was deleted from the trend data subset and not included in the trend analysis. A separate dataset with these deleted data was saved for reference.

For station-level trend analysis, a data set containing all data for all stations in the 2016 CRP's Coordinated Monitoring Schedule (CMS) was compiled. In addition, this station-level data set was transposed for analysis of inter-parameter relationships, correlations with flow, rain event reports, and other analyses, as deemed appropriate.

A table of descriptive statistics for FIB was produced for every monitoring station and segment (see Appendix D). In addition to basic summary statistics, water quality standard statistics were calculated.

All data management and statistical analysis was performed using Statistical Analysis System (SAS) version 9.3. Complete details of data selection, preparation, and analysis can be found in the SAS code used to select, format, and analyze data for this report, and can be made available for review by request.

4.2.3 Trend Analysis Methodology

All data were screened with nonparametric correlation analysis (Kendall's tau-*b*) of the parameter value with the sample collection date to identify correlations that were significant at $p < 0.0545$. These potential trends were then evaluated by simple linear regression of the natural log of the data on the time variable, LOESS (locally-weighted least squares) regression and correlation of flow-adjusted residuals, and seasonal Kendall/Sen Slope estimation/Theil regression. If more than 15 % of the data were censored at the analytical limit of quantitation, survival analysis (Tobit analysis in SAS PROC LIFEREG) was performed. The trends identified by Kendall correlation should be considered the most defensible, since nonparametric methods are insensitive to outliers in the time series. There were some cases where analysis of flow-adjusted concentrations suggested a significant trend that was not revealed by correlation analysis.

Plots of selected statistically significant trends are included as appropriate in the water quality reviews of each watershed found in Appendix D. An inset was added to each plot of statistically significant trends to facilitate comparison by the reader. The trend suggested by each of the five analytical techniques appears in the inset, and are labeled as "Stable," "Increasing," or "Decreasing." If no (or insufficient) flow data were available, the flow-adjusted trend will appear as "Not Calculated" or "Insufficient Data." If the seasonal Kendall trend was not calculated due to gaps (missing seasons) in the time series, the trend will appear as "Not Calculated." If fewer than 15 % of the data were censored, survival analysis was not performed, and the trend will show as "Not Applicable."

In addition, LOESS plots of the parameter value against time were made for every segment/parameter and station/parameter combination, whether a statistically significant trend was present or not. These graphs can be found in the appendix D of this report.

4.3 BACTERIA SOURCE ANALYSIS

A common approach to analyze potential FIB sources is to review regulated and unregulated sources for the basin. Pollution sources that are regulated have permits under the Texas Pollutant Discharge Elimination System (TPDES) and the National Pollutant Discharge Elimination System (NPDES).

Unregulated sources, often considered nonpoint sources, are those where the pollutant originates from diffuse locations and is usually carried to surface waters by rainfall runoff. Nonpoint sources are not regulated by a permit. Examples of unregulated sources include: wildlife, OSSFs, and agriculture production.

4.3.1 Regulated Sources

Waste water treatment facilities (WWTFs) and stormwater discharges from industries, construction, and municipal separate storm sewer systems (MS4s) of cities are regulated sources permitted under the TPDES and NPDES programs.

4.3.1.1 Domestic and Industrial Waste Water Treatment Facilities

There is a total of 38 regulated discharge outfalls permitted to 27 WWTFs located in Basin 13 (Figure 4.3). The San Bernard River has largest number of outfalls in the basin, the petroleum and chemical production from the industrial facility is a large reason for that number. Most these dischargers are industrial and would not be considered sources of bacteria.

Of the 28 WWTFs in the basin there are 23 currently permitted for bacteria in their effluent (Table 4.2). Any future TMDL will require developing a waste load allocation for one or more of these facilities.

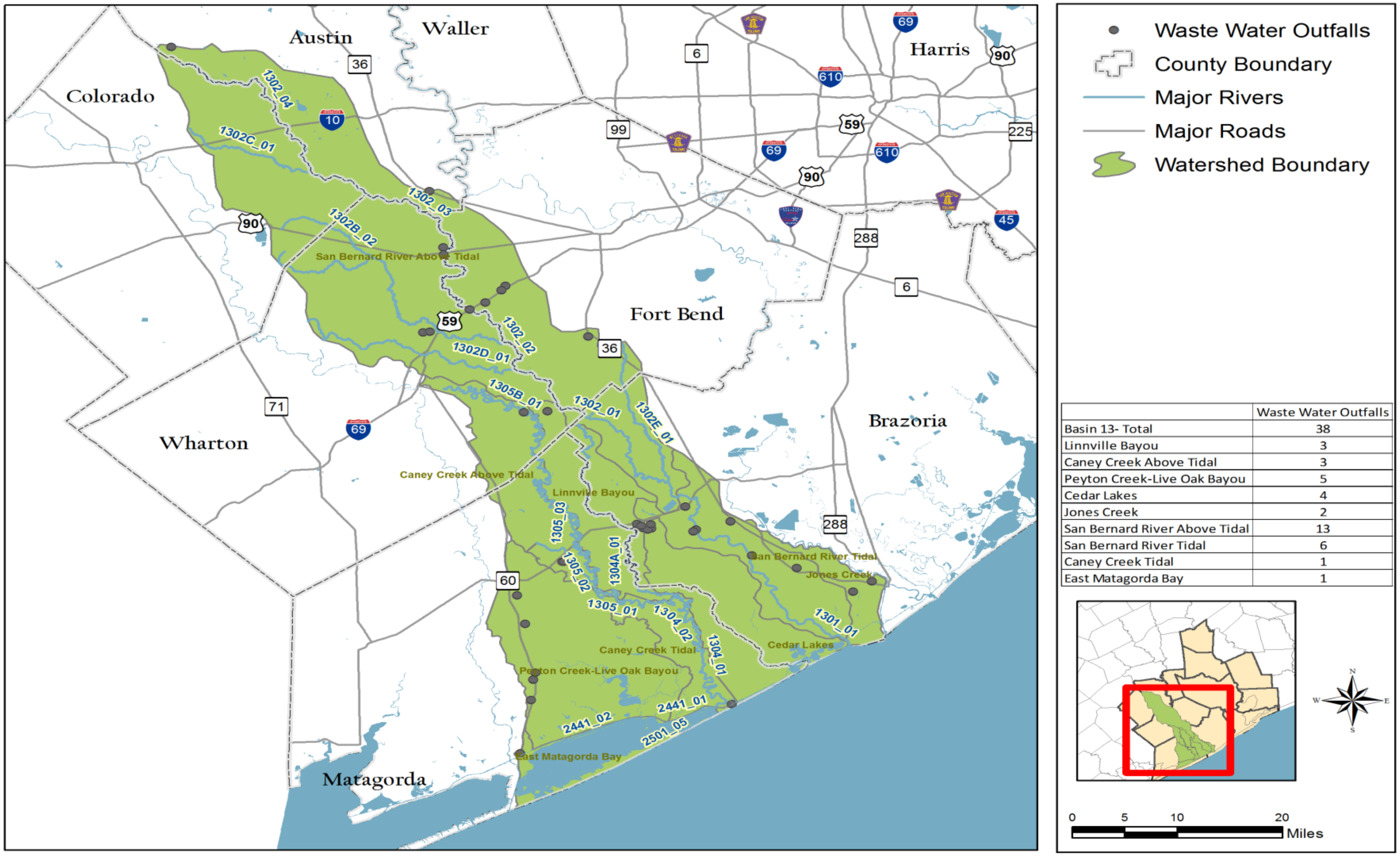
4.3.1.2 Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party, either the TPDES permittee or the owner of the collections system that is connected to the permitted system. SSOs in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease and other debris. Inflow and Infiltration (I/I) are typical causes of SSOs under conditions of high flow in the WWTF system due to excess rain fall entering the system.

SSO data is reported by municipalities to the TCEQ and EPA. Data was retrieved from the EPA's ICIS online database. SSO data reviewed for this basin covers the period of 2011 through 2016. Municipalities report the cause of the spill, an estimate of the size of the spill in gallons, and a general location of the spill.

Figure 4.4 presents Basin 13 SSOs by the recorded number of events and reported cause for the overflow for the calendar years starting 2011 through 2016. Based on the municipality reports, I/I produced the largest number of SSOs in the basin, contributing over 72% of the reported events.

Basin 13 - Waste Water Outfalls



	Waste Water Outfalls
Basin 13- Total	38
Linnville Bayou	3
Caney Creek Above Tidal	3
Peyton Creek-Live Oak Bayou	5
Cedar Lakes	4
Jones Creek	2
San Bernard River Above Tidal	13
San Bernard River Tidal	6
Caney Creek Tidal	1
East Matagorda Bay	1

Figure 4.3 The location of thirty-eight waste water treatment facility outfalls found in Basin 13.

TPDES ID	Permittee	Segment	Latitude	Longitude
WQ0000721000	PHILLIPS 66 COMPANY	1301	29.061172	-95.672235
WQ0000721000	PHILLIPS 66 COMPANY	1304	29.07244	-95.764743
WQ0000721000	PHILLIPS 66 COMPANY	2442	29.071396	-95.742879
WQ0002462000	BAE SYSTEMS TACTICAL VEHICLE SYSTEMS LP	1302	29.759535	-96.217659
WQ0002469000	LAMBERTI USA, INC.	1302	29.437064	-96.017742
WQ0002481000	EQUISTAR CHEMICALS, LP	2441	28.782408	-95.94028815
WQ0003891000	WHARTON COUNTY GENERATION LLC	1302	29.264212	-95.89969008
WQ0003985000	HUDSON PRODUCTS CORPORATION	1302	29.475246	-95.96068685
WQ0004998000	CHEMICALS INCORPORATED	2441	28.909727	-95.94593135
WQ0005147000	CHEVRON PHILLIPS	1304	29.076366	-95.7661099
WQ0010123004	BAYCITY,CITY OF	2441	28.955861	-95.95713951
WQ0010297001	SWEENY, CITY OF	1301	29.057856	-95.676764
WQ0010343001	NEEDVILLE, CITY OF	1302	29.387506	-95.832245
WQ0010663001	MATAGORDA COUNTY WCID NO. 6	1305	29.012261	-95.884076
WQ0010843001	BOLING MWD	1305	29.263304	-95.937176
WQ0010878001	TEXAS DEPARTMENT OF CRIMINAL J	1301	28.992788	-95.516521
WQ0010996001	KENDLETON, CITY OF	1302	29.448163	-95.99255834
WQ0011450001	BEASLEY, CITY OF	1302	29.488136	-95.92067465
WQ0011768001	MASSEY, JIMMIE WAYNE	1305	29.011921	-95.882455
WQ0012010001	NEEDVILLE ISD	1302	29.374908	-95.795259
WQ0012618001	WADSWORTH WSC	2441	28.827964	-95.93227902
WQ0013240001	HUNGERFORD MUD NO. 1	1302	29.401125	-96.081728
WQ0013655001	NEW ULM WATER SUPPLY CORPORATION	1302	29.885291	-96.47761
WQ0013796001	8 MILE PARK, L.P.	1301	29.099548	-95.687775
WQ0014019001	WHARTON COUNTY WCID 2	1302	29.529651	-96.056301
WQ0014177001	CANEY CREEK MUD	2441	28.767615	-95.62573878
WQ0014581001	BRAZORIA, CITY OF	1301	29.015551	-95.586212
WQ0014893001	COLUMBIA-BRAZORIA ISD	1301	29.073273	-95.61802493
WQ0015393001	LIGHTHOUSE RV PARK WWTP	2441	28.764459	-95.94303026

Table 4.2. Twenty-seven permitted private, industrial and municipal WWTFs in Basin 13. Note, WQ0000721000 is listed three times in the table, but should only be counted once. This facility is listed three times as it discharges into three distinct segments in the basin.

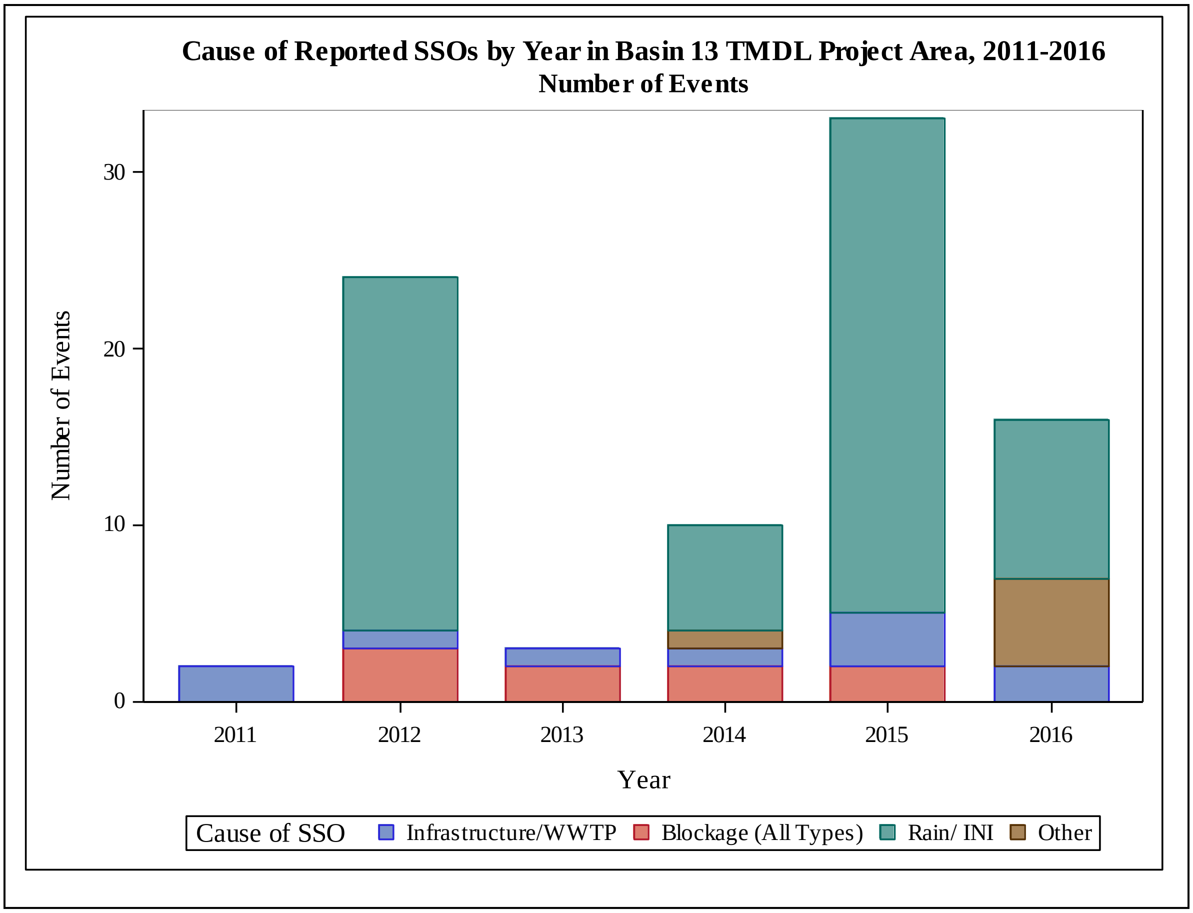


Figure 4.4. Basin 13 SSOs by number of SSO events by reported cause 2011-2016.

The four-year period is relatively short to identify trends, however assuming accurate reporting, it would appear the basin is affected by I/I, and water quality planning should consider steps to address this issue. I/I suggest the influence in climate for the region that has recently transitioned from drought to a more wet period between 2011 and 2016.

4.3.1.3 TPDES Regulated Stormwater

Land based sources not attributed to WWTFs and their conveyance systems fall into two categories of stormwater, regulated and unregulated. Regulated stormwater is permitted by the state under TPDES and is considered a point source by the state. Stormwater from unregulated areas is considered a non-point source and will be discussed under unregulated sources below. There are currently no municipal separate storm sewer systems (MS4) located in this basin. Additionally, dry weather discharges and illicit discharges, those discharges attributed to leaking sanitary pipes connected to the storm sewer, would not be regulated under a MS4 permit.

4.3.1.4 Other Regulated Sources

Aquaculture production, concentrated animal feeding operations (CAFOs), and livestock manure composting are a few permitted activities that could potentially contribute to FIB in the basin. Reviewing the TCEQ's Central Registry (TCEQ Central Registry, 2016) for wastewater general permits did not produce active aquaculture production or livestock manure composting permits. There was one active CAFO permit in Segment 1305 Caney Creek Above Tidal to produce egg-laying hens.

4.3.2 Unregulated Sources

Unregulated sources of FIB are often considered nonpoint sources in that they come from diffuse sources rather than a single source. Failing OSSFs, certain agricultural activities, urban runoff not covered under a permit, and pet wastes are examples of unregulated sources.

4.3.2.1 Failing OSSFs

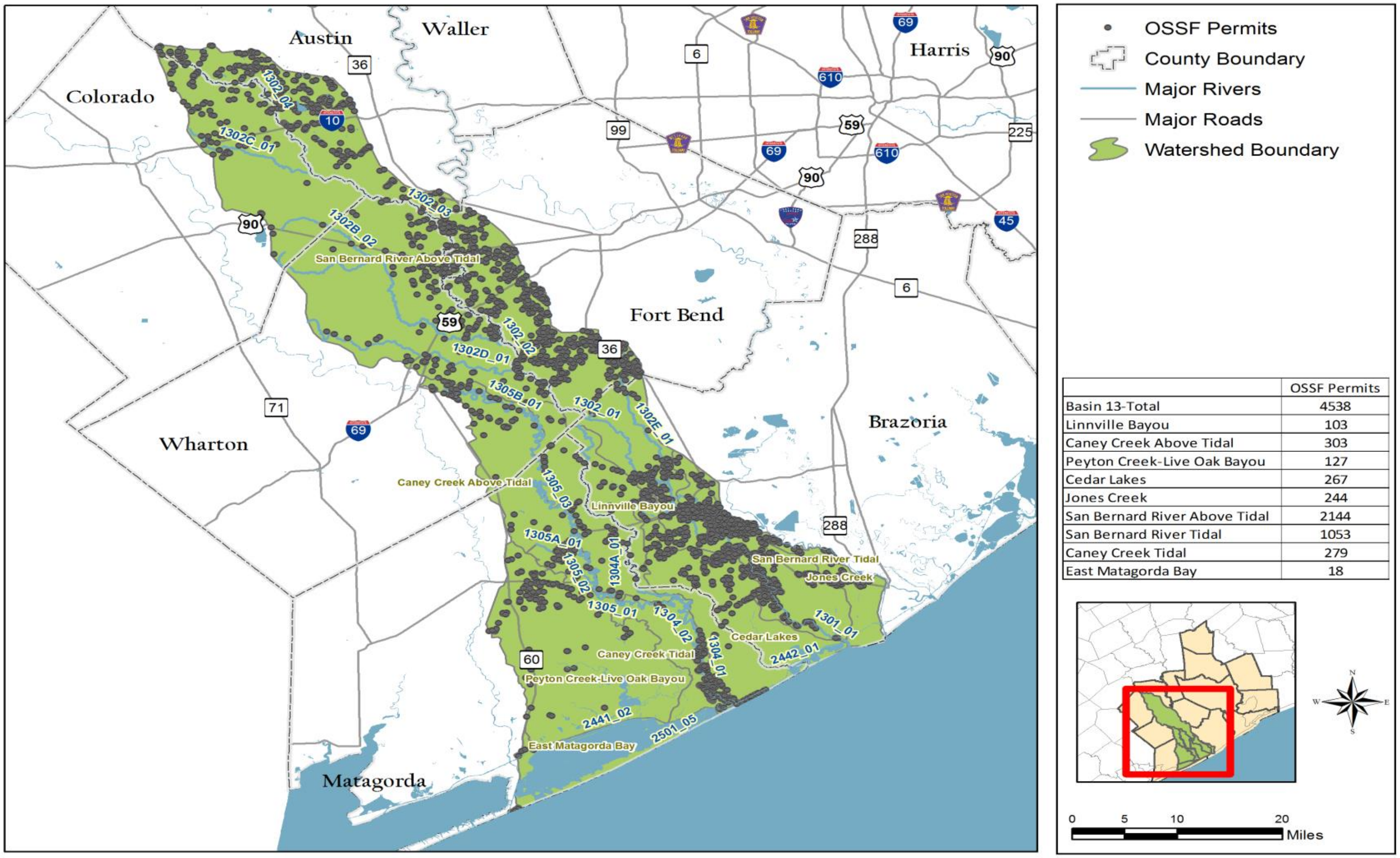
Away from municipal centers where more centralized public waste water treatment is common, rural and suburban-rural residences and stand-alone commercial and industrial businesses, within the county or a city’s extra territorial jurisdiction, are likely to use owner operated OSSFs, often referred to as septic systems. When functioning properly and sited correctly, much like WWTFs, OSSFs’ contribution of FIB is little to none.

A few studies like Reed, Stowe & Yanke (2001) suggest a 12% failure rate for OSSFs. That rate, derived from survey responses received from authorized agents (AA), falls in line with EPA’s guidance on failure rates nationally of 10% to 20% (H-GAC, 2005). AAs are local authorities who have accepted responsibility from the TCEQ to permit OSSFs and enforce laws and rules governing OSSFs on behalf of the state.

H-GAC, in coordination with AAs, compiled the number of permitted and registered OSSFs in the H-GAC service region, including Basin 13. Permitted OSSFs are presented in Figure 4.4. There are 4,538 permitted OSSFs in Basin 13, with a high concentration of OSSFs centered around and along the San Bernard River, particularly the tidal segment. This will potentially be a key management measure for implementation of the San Bernard River WPP.

Applying the 12% failure rate to 4,538, an estimated 545 systems may be failing in the basin. This estimate does not consider the unknown number of unpermitted or grandfathered systems in the basin. A failure rate of 50% was applied to these unregulated systems in development of the San Bernard WPP. The failure rate is thought to be higher due to not considering the site characteristics, e.g. soil permeability, water table, and size of leach field, when determining the type of OSSF to install, assuming an appropriate technology was available at that time of installation (San Bernard WPP, 2012).

Basin 13 - OSSF Permits



	OSSF Permits
Basin 13-Total	4538
Linnville Bayou	103
Caney Creek Above Tidal	303
Peyton Creek-Live Oak Bayou	127
Cedar Lakes	267
Jones Creek	244
San Bernard River Above Tidal	2144
San Bernard River Tidal	1053
Caney Creek Tidal	279
East Matagorda Bay	18

Figure 4.4. Permitted OSSFs in Basin 13.

4.3.2.2 Agriculture

Agriculture production remains a large economic base for the counties in Basin 13. Figure 3.4 and Table 3.3 presented the current state of two agricultural related land cover types, Cultivated Cropland and Pasture/Hay. Those two types make-up 51% of the basin. Agriculture is a non-permitted activity that potentially contributes FIB during production. FIB from agriculture can reach waterbodies from livestock grazing and land applications of manure as fertilizer during crop production. Table 4.4 contains county livestock figures for 2012 compiled by the United States Department of Agriculture Census of Agriculture (USDA, 2012).

USDA Livestock Census by County - 2012					
County	**Cattle and Calves**	**Hogs and Pigs**	**Sheep and Lambs**	**Equine**	**Poultry**
Brazoria	78907	4218	1435	4572	6033
Matagorda	53283	47	304	1141	1261
Wharton	57168	131	395	1687	242
Fort Bend	32731	693	255	2579	2938
Austin	60555	102	427	4072	26677
Colorado	60408	136	404	1494	13532

Table 4.4. County-level livestock figures for counties found in Basin 13.

State and federal voluntary programs work with agriculture producers to address nutrient, sediment, and bacteria impairments and concerns, including:

- Environmental Quality Incentives Program (EQIP) – The Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA) delivers “financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air, and related natural resources on agricultural land and non-industrial private forestland” (NRCS, 2016).
- Agricultural Conservation Easement Program (ACEP) – The NRCS provides financial and technical assistance through the ACEP program to help conserve agricultural lands and wetlands and their related benefits, e.g. preserving working lands, wildlife habitat, open space, threatened and endangered species, and improving water quality (NRCS, 2016).
- Water Quality Management Plan Program (WQMP) – The Texas State Soil and Water Conservation Board (TSSWCB) manages the program with the stated goal “to abate agricultural and/or silvicultural nonpoint source pollutant contributions to impaired or threatened waters…” (TSSWCB, 2016). There are 176 active WQMPs in the basin, 157 in the San Bernard watershed and 19 in Caney Creek/Linville Bayou watershed (TSSWCB personal communication, 2016).

4.3.2.3 Pets

Pets are another common unregulated source of FIB in urban and rural settings. A lack of dense urban setting in this basin make pets less of a potential source for bacteria contributions. Estimated rates of dog and cat ownership for each household have been developed and can be applied to generate an estimate for the number of dogs and cats found in Basin 13. Using the rates of 0.584 and 0.638 for dog and cat ownership per household (AVMA, 2012) and a 2015 household figure of 31,000 households in Basin 13 (American Community Survey, 2010-2014) yields an estimated population of 18,104 dogs and 19,778 cats in the basin.

4.3.2.4 Wildlife and Migratory Waterfowl

FIB can also come from wildlife and migratory waterfowl as bacteria are common in the intestines of all warm-blooded animals. All wildlife is attracted to the water, increasing the likelihood of direct deposition of bacteria and for FIB to be washed off adjacent land during rainfall. Feral hogs have been identified as a large contributor to FIB, including direct fecal deposits, due to their desire to wallow in mud and spend time in and around water to escape the heat. While wildlife inhabits all parts of the basin, areas that remain undeveloped are key reservoirs for wildlife. Development only accounts for 2% of the land cover in the basin, meaning large areas remain available for wildlife use (Figure 3.4, Table 3.3).

5 BACTERIA ANALYSIS TOOLS

Traditional water quality assessment begins with analyzing data using spatial and temporal trends. These basic analyses are often followed by more technical analysis that seeks to correlate variables to better explain relationships, and/or understand cause and effect. For this project, H-GAC was asked to begin this more technical analysis by generating load duration curves and exploring bacteria loading related to variations in land cover. Once AUs are identified for further TMDL study, the next steps, not covered by this report, will be to start quantifying bacteria loadings and determine potential load reductions needed in each AU to meet the contact recreation standard.

5.1 METHOD

5.1.1 Station Selection

Monitoring data obtained from the SWQMIS database for each monitoring station located in above tidal segments in Basin 13 were examined to determine the data adequacy for LDC development. The stations containing an adequate number of monitoring data were identified by examining the consistency of recorded flow and bacteria data. Stations with observed flow and bacteria data consistent for more than three years at regular intervals and currently in operation were selected for LDC development. If a station had consistent observations of bacteria data with inconsistent or no flow records, they were also considered in developing LDCs, but required additional measures to estimate representative flow.

To identify the most appropriate station to import the flow records for use in LDC development at those stations that are lacking flow data, two selection criteria were used:

1. total catchment area upstream to the station and land use; and
2. land cover characteristics of upstream catchment.

If the upstream catchment area and land characteristics of two catchments are similar, then, the flow conditions from the two stations were considered as comparable and can be used in the other station. To identify the catchment area upstream to each selected station, catchment delineation analysis was conducted using elevation, stream network, and monitoring stations data in a GIS environment.

5.1.1.1 Catchment Area Delineation

The datasets used for catchment delineation (Figure 5.1) were the USGS 10-meter Digital Elevation Model (DEM) released in 2013, the H-GAC CRP stream network, and CRP monitoring station locations geospatial data. The analysis was performed in ESRI's ArcGIS 10.2 Environment with Spatial Analyst extension.

First, the DEM was reconditioned using the CRP stream networks. The DEM reconditioning function modified the DEM by imposing the stream network features into it. Due to low slope in Basin 13, burning of stream network into the DEM is essential to determine accurate drainage catchment areas. After that, the Fill tool in the Hydrology toolbox is used to remove any imperfections (sinks) in the digital elevation model. A sink is a cell that does not have an associated drainage value. Drainage values indicate the direction water will flow out of the cell, and are assigned during the process of creating a flow direction grid for the landscape. The flow direction was estimated using Flow Direction toolbox in

Spatial Analyst. A flow direction grid assigns a value to each cell to indicate the direction of flow, the direction that water will flow from that cell based on the underlying topography of the landscape. The flow accumulation was then estimated. The flow accumulation calculates the flow into each cell by identifying the upstream cells that flow into each downslope cell. After the flow accumulation, catchment outlets (pour points) were placed. The catchment outlets in this delineation analysis are the selected monitoring stations. After snapping the catchment outlets, the catchments were delineated using the Watershed tool in Spatial Analyst. Finally, the delineated catchments were overlaid with existing CRP watersheds to merge with the boundaries in large CRP watersheds. This step was done to maintain consistency in common boundaries with CRP watersheds.

5.1.1.2 Land Use/Land Cover Analysis

Land use and cover directly influence hydrology and water quality of a catchment. In this analysis, NOAA, Coastal Change Program (C-CAP) 2006 and 2011 datasets with 22 land classes were combined for statistical analysis. The combinations, and variable names, are found in Table 5.1.

Class Name (original)	Combined Class	Variable Name
Bare Land	Natural Land Cover	Natural
Cultivated Crops	Cultivated Crops	Crops
Deciduous Forest	Natural Land Cover	Natural
Developed, High Intensity	Developed, High Intensity	Dev_High
Developed, Low Intensity	Developed, Low Intensity	Dev_Low
Developed, Medium Intensity	Developed, Medium Intensity	Dev_Med
Developed, Open Space	Developed, Open Space	Dev_Open
Estuarine Aquatic Bed	Estuarine Wetland	Wetland_est
Estuarine Emergent Wetland	Estuarine Wetland	Wetland_est
Estuarine Forested Wetland	Estuarine Wetland	Wetland_est
Estuarine Scrub/Shrub Wetland	Estuarine Wetland	Wetland_est
Evergreen Forest	Natural Land Cover	Natural
Grassland/Herbaceous	Natural Land Cover	Natural
Mixed Forest	Natural Land Cover	Natural
Open Water	Open Water	Water
Palustrine Aquatic Bed	Palustrine Wetland	Wetland_pal
Palustrine Emergent Wetland	Palustrine Wetland	Wetland_pal
Palustrine Forested Wetland	Palustrine Wetland	Wetland_pal
Palustrine Scrub/Shrub Wetland	Palustrine Wetland	Wetland_pal
Pasture/Hay	Pasture/Hay	Pasture

Class Name (original)	Combined Class	Variable Name
Scrub/Shrub	Natural Land Cover	Natural
Unconsolidated Shore	Natural Land Cover	Natural

Table 5.1. NOAA C-CAP twenty-two land cover types combined for analysis to ten land cover types.

The land cover dataset contained a delineation of the acreage of each land cover type in the catchment associated with each monitoring station in the study area. The base 10 logarithms of acreage of each type was calculated and added to the dataset. The total area in the catchment (watershed) for each monitoring station was calculated, and the percentage of each land cover type in the catchment was calculated. The natural logarithm of the percentage of each land cover type was calculated and added to the dataset. Such information was also used in determining the catchments with similar characteristics that can be use flow data for LDC developments (Figure 5.1).

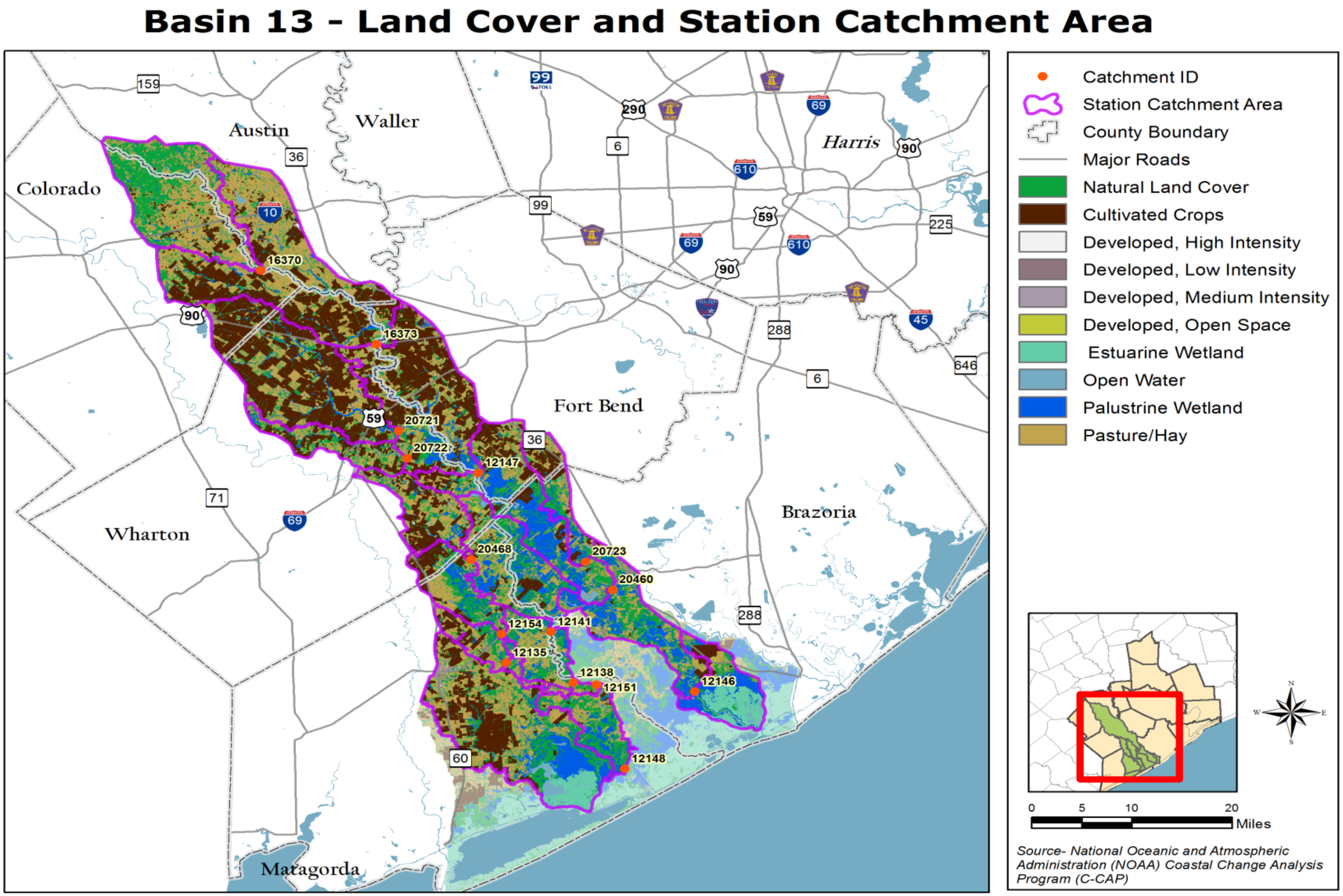
5.1.1.3 Monitoring Station Assessment

There are 24 monitoring stations within Basin 13.

- Eight stations were identified as good candidates for LDC development. They have very good consistent time series of either or both *E. coli* and enterococci observations along with flow measurements (Table 5.2).

Station ID	LOCATION
12147	San Bernard River mid channel 60 m downstream of FM 442 bridge SW of Needville
12154	Caney Creek At SH 35 Approximately 3.75 Km NE Of Van Vleck
16370	San Bernard River immediately downstream of FM 3013 on the Colorado-Austin County line approximately 15km SW of Sealy
16371	Gum Tree Branch at Wharton CR 252 approximately 5.9km SE of Lissie
16373	San Bernard River immediately downstream of US90A in East Bernard
20721	West Bernard Creek at Wharton CR 225 in East of Hungerford
20722	Peach Creek at Wharton CR 117/Chudalla Road/Archer Road 89 meters South of the intersection of Wharton CR 117/Chudalla Road/Archer Road and Wharton CR 121/ Wharton CR 119/Donaldson Road in East of Wharton
20723	Mound Creek at Brazoria CR 450/Jackson Settlement Road 1.22 kilometers upstream of FM 1301 In West of West Columbia

Table 5.2. LDCs created for eight monitoring stations in Basin 13.



Source- National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP)

Figure 5.1. Basin 13 catchment area delineated with land cover analysis using 10 land cover types. Catchments developed for LDC development and correlation analysis.

There were three stations that recently started monitoring (from late 2013). Since they do not have enough monitoring records to develop LDCs, further monitoring is recommended to do TMDLs (Table 5.3).

12135	Hardeman Slough Immediately Downstream Of Allenhurst Rd Ne Of FM 2540 Near Allenhurst Community
12138	Linville Bayou 35 M Downstream Of Sims Road Approximately 5.20 Km Upstream Of Mouth
12151	Caney Creek Immediately Upstream Of Concrete Bridge 210 M Downstream Of Linville Bayou Confluence And Adjacent To FM 521

Table 5.3. Recent monitoring stations in Basin 13 where LDCs could not be created.

- Four stations were identified as having good consistent monitoring of either *E. coli* or enterococci, but no flow measurements (Table 5.4).

12141	Linville Bayou 35 M Upstream of FM 324/Hasema Road
12146	San Bernard River Tidal East bank immediately Upstream of FM 2611
12148	Caney Creek Tidal mid channel at Chambless Rd
20460	San Bernard River Tidal at SH 35 Southwest Of West Columbia

Table 5.4. Monitoring stations in Basin 13 with adequate bacteria data but lack flow measurements.

- Stations 12146, 12148, and 20460 are in tidal segments. Therefore, no further flow monitoring is recommended.
- Station 12141 is the only freshwater station identified as needing either matching flow from another station or further monitoring. The catchment area for this station is 48930 acres, consisting mainly of agricultural and forested lands. There was no other station catchment identified that matches catchment 12141. Therefore, it is recommended to collect flow and bacteria measurements for this station.
- There were seven historical stations in the given data list where no monitoring was done between 2002 and 2012. Therefore, they were not considered for further analysis.

5.1.1.4 Flow Duration Curve Development

The first step of developing a LDC is the development of flow duration curve (FDC) to identify the ranges of flow regimes. The observed flow records were arranged in descending order and ranked from 1 to N. Then the flow exceedance frequency (x-value of each point) was estimated by calculating the historical exceedance frequency of the measured flow, or the percent of historical observations that equal or exceed the measured flow using the following formula:

$$F = 100 * \frac{R}{N+1}$$

where F is the frequency of occurrence (express as % of time a flow value is equaled or exceeded), R is the rank, and N is the number of observations.

The sorted flow rate was plotted against the exceedance probability in a semi-log curve to generate the FDC. A common way to look at the duration curve is by dividing it into five zones based on percent exceedance, representing high flows (10 % exceedance), moist condition

(10% to 40 % exceedance), mid-range flows (40% to 60 % exceedance), dry condition (60% to 90% exceedance), and low flows (90% to 100% exceedance) (USEPA, 2007). In our LDC developments, we have adopted the EPA guide in determining the flow regimes in all LDCs of this study.

5.1.1.5 Load Duration Curve

The monitored bacteria concentrations were first paired with flow data in the FDC and then the daily loads of bacteria were estimated using the following formula:

*Daily Load (cfu/day) = Bacteria concentration (cfu/100mL) * flow (cfs) * conversion factor*

where the conversion factor is 24465715.2

Calculated daily loads were then added to the FDC semi-log plot as a scatter plot diagram. Other than the monitored bacteria daily load points there are two other curves generally added to a LDC. First, is the load regression (LR) curve. LR curve shows the general trend of the monitored constituents based on a regression analysis. This curve helps to identify whether the constituent load is below or above the total allowed maximum daily load. It is useful in estimating the load reduction needed to maintain an unimpaired waterbody in each flow regime. The second important piece of information in a LDC is the standard curve, which shows the allowable maximum daily limit of constituent loading to maintain the stream unimpaired.

5.1.1.6 Load Regression Curve

The LR curve developed in this study is based on EPA's LoadEst methodology. The LoadEst program is a FORTRAN-based, standalone program that generates the regression model for estimating the stream load of a specific constituents at a location. The calibration and estimation procedure in LoadEst are based on three statistical estimation methods. They are Adjusted Maximum Likelihood Estimation (AMLE), Maximum Likelihood Estimation (MLE), and Least Absolute Deviation (LAD). In this study, we used AMLE model to correct the first order bias and to estimate the instantaneous load of bacteria.

The AMLE equation is given as
Ln(Load) = a0 + a1 LnQ

where:
    Load = constituent load [kg/d]
    LnQ = Ln(Q) - center of Ln(Q).

After the model was set up and the calibration, header, and estimation files were generated with appropriate information, the LoadEst program was run for both the constituents: *E. coli* and enterococci. Then the load regression curves were developed and added to the semi-log plots that include FDC and observed loading data.

5.1.1.7 Water Quality Standard Curve:

Generally, a LDC is consisted with one or two water quality standards or allowable maximum daily load curves. In this analysis, we have included two standard lines to represent Geomean and Single sample standards. The criterion for each standard line is given as:

E. coli:
Geomean: 126 MPN/100 mL
Single Sample: 399 MPN/100 mL

Enterococci:
Geomean: 35 MPN/100 mL
Single sample: 104 MPN/100 mL.

The daily load for standard lines were estimated based on following formula:
*TMDL (counts/day) = criterion * flow (cfs) * unit conversion factor.*

5.1.1.8 Load Duration Curve Review

Figure 5.2 brings the LDC together with all components: Flow Duration Curve, Geometric Mean and Single Grab Standard Curves, Observed Data, and the Load Regression Curve. LDC were developed for eight monitoring stations in Basin 13. Appendix D contains segment and AU summaries for the basin. Each summary contains LDCs created for the monitoring stations where sufficient bacteria and flow data were available. Reviews concerning individual station LDCs are saved for the segment summaries in Appendix D.

The LDCs can be used to develop future load reductions during TMDL development. Using the flow regime 0% to 10% High Flows, 10% to 40% Moist Conditions, 40% to 60% Intermediate Conditions, 60% to 90% Dry Conditions and 90% to 100% Dry Conditions, the LDCs can be viewed as periods where the bacteria load meets the standard (i.e. the regression curve is below the geometric mean) and periods where it exceeds the standard (i.e. the regression curve is above the geometric mean). Additionally, individual observed data can be contrasted with the Single Grab Standard Curve to determine the relation of either above or below the single grab standard during a flow regime. This can be useful in calculating load reductions during TMDL development, but can also be useful in visually depicting reduction requirements to the public and conveying whether dry weather conditions or wet weather conditions present the biggest challenge in meeting the standard (e.g. dry weather inputs from WWTFs or wet weather sources, like stormwater).

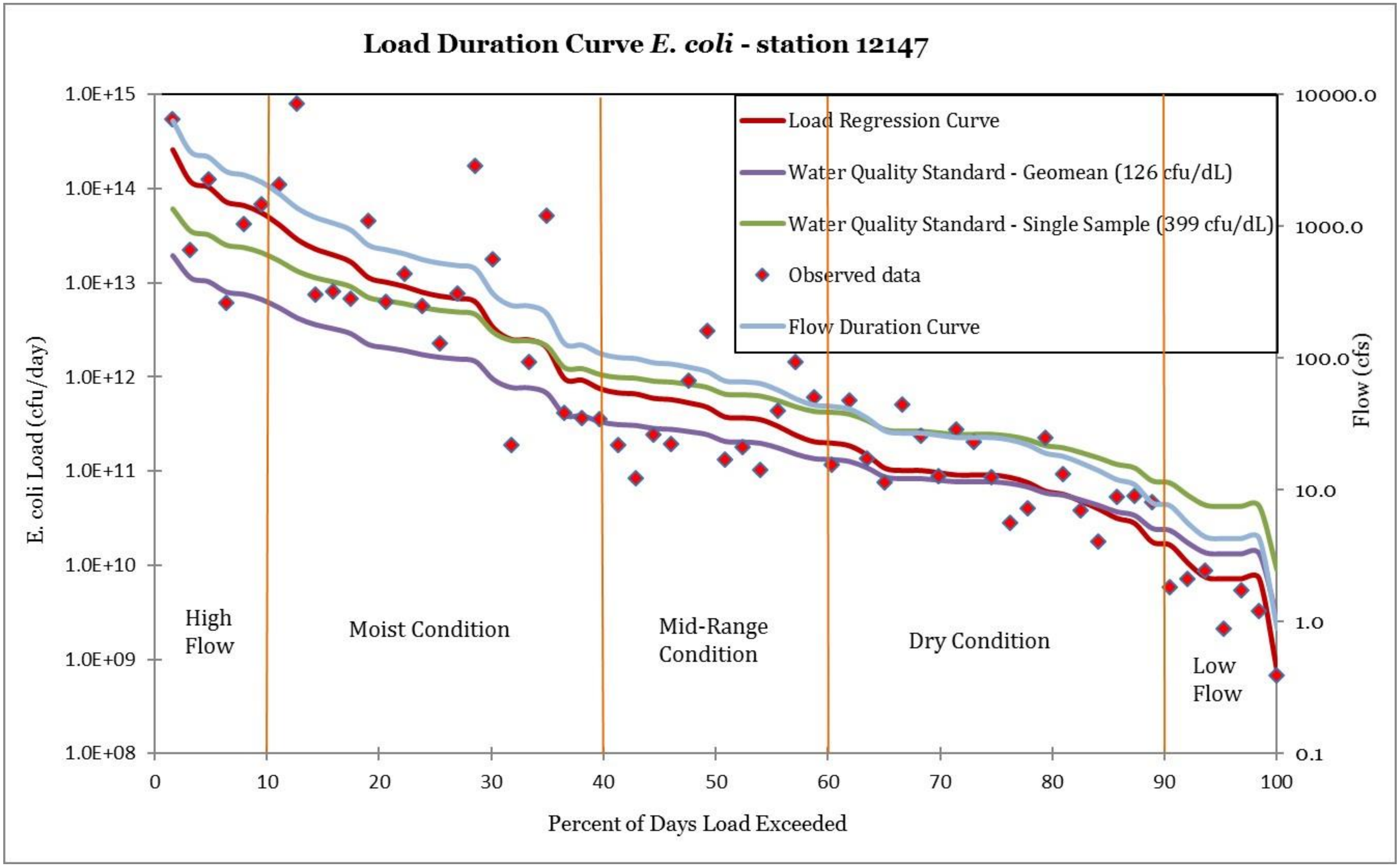


Figure 5.2. *E.coli* Load Duration Curve developed for station 12147 on segment 1302, San Bernard River .

5.1.2 Bacteria vs. Days Since Last Rain Plots

To assist with segment and AU bacteria analysis and to provide a surrogate when an LDC could not be developed (i.e. tidal waters or insufficient flow data) bacteria results were plotted against the number of days since the last significant rainfall (as determined by the collecting staff) reported in SWQMIS for the sample event. These plots provide an opportunity to look at the bacteria data in relationship to the standard (red dashed line) and to potentially gauge the weather conditions, wet or dry, that the segment was in at the time the sample was taken. Figure 5.3 is an example of a plot developed for the Caney Creek Above Tidal, Segment 1305, for bacteria data collected by CRP from 2002 to 2016.

The weakness with using the Bacteria vs. Days Since Last Rain is that it is more difficult to discern the weather condition of the segment at the time the sample was taken. While streamflow is a good predictor of condition, a bacteria sample taken 10 or 20 days since last measurable rain could have been collected when the segment is still in a wet or even a high flow condition just as a sample collected one day since last rainfall could have been collected during dry or even a low flow condition. Interpretations must therefore be considered weak and conclusions limited in scope.

5.1.3 Statistical Analysis of Land Cover and Water Quality Load

5.1.3.1 Land Cover Data

The land cover data was processed following the method described in 4.1.1.2.

5.1.3.2 Precipitation Data

A list of NOAA weather stations in the study area was assembled, and the stations with data that spanned the period 2000-2016 were identified (Table 3.2). Precipitation data from these stations were calculated, and the station nearest to each monitoring station in the study area was determined using SAS PROC DISTANCE. NOAA data collected at the closest station was joined to the land cover data for each monitoring station and were downloaded on May 24, 2016. Total precipitation in inches on the previous day and the total for the previous three days were calculated and added to the record for each date.

5.1.3.3 Water Quality Data

Water quality data collected between June 1, 2000, and November 31, 2016, for all stations within the study area were extracted from a dataset of SWQMIS water quality data maintained by H-GAC. The data in the H-GAC dataset were downloaded from TCEQ on May 16, 2017.

Land cover data from 2006 and 2011 were joined to the water quality dataset. Data collected before 2009 were joined with the 2006 land cover dataset, and those collected 2009-2016 were joined with the 2011 land cover data. The NOAA rainfall data were then joined to the dataset.

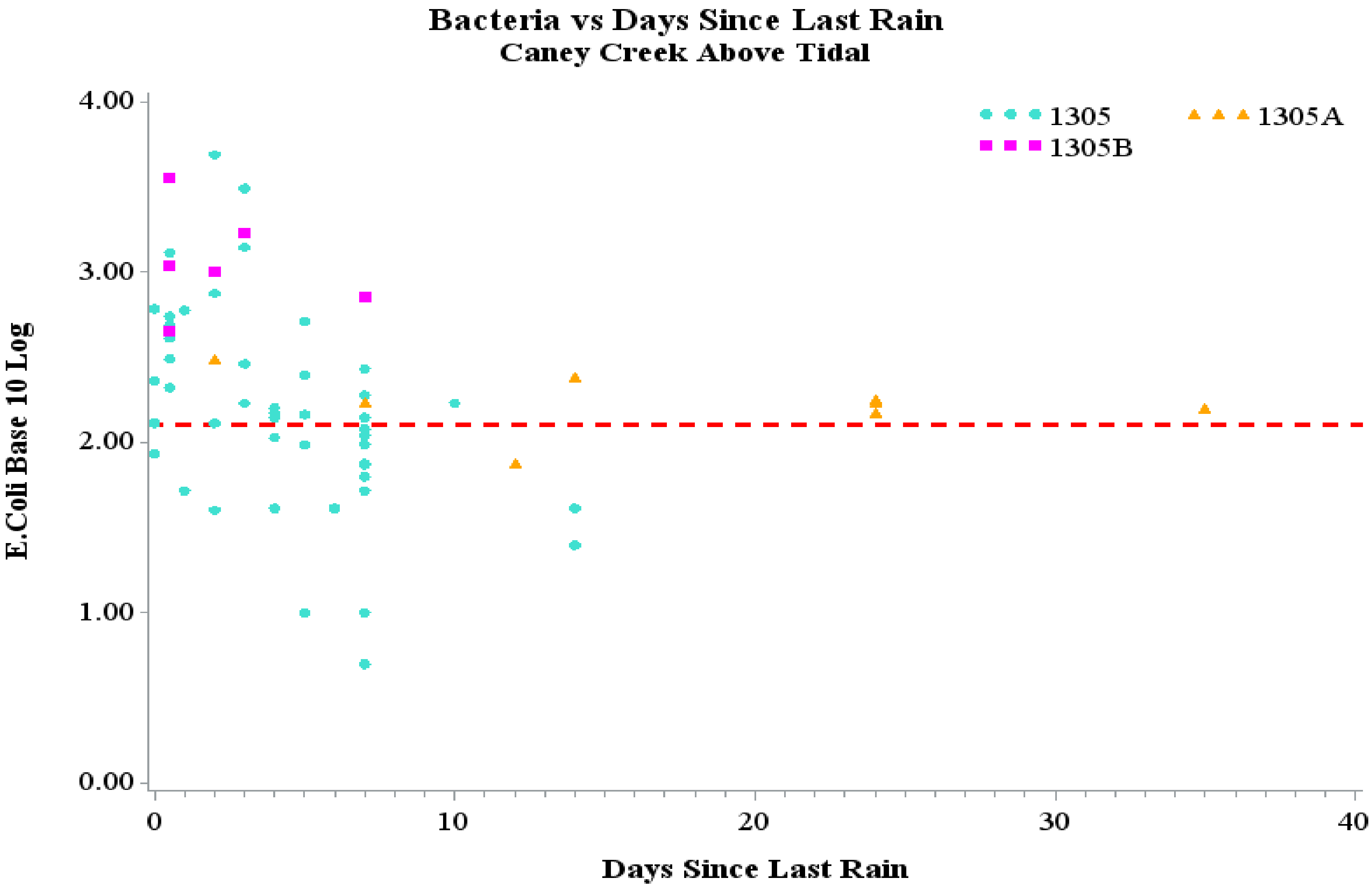


Figure 5.3. Bacteria vs. Days Since Last Rain for bacteria samples collected by CRP from the Caney Creek Above Tidal segment of Basin 13. Red dashed line represents the log of the state's geometric mean standard of 126 MPN/100mL..

A set of variables was selected for Basin 13 (Table 5.5). Two categorical variables were created: a “Wet / Dry” variable was created from the routine water quality parameter, “Days Since Last Rain” and indicated whether there had been significant rainfall within three days (coded “Wet”) or not (“Dry”). A dominant land use variable was created to identify any land use that accounted for more than 40 percent of the catchment (coded “AGR”, “DEV” or “UND”).

Variable Name	**Comment**	**Source**
Ammonia_N	mg/L	SWQMIS
Crops	Cropland, acres	NOAA (2006 and 2011 data)
Crops_pct	Cropland, percent of catchment area	NOAA (2006 and 2011 data)
Days_Since_Last_Rain		SWQMIS
Dev_High	High intensity development, acres	NOAA (2006 and 2011 data)
Dev_High_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Dev_Low	Low intensity development, acres	NOAA (2006 and 2011 data)
Dev_Low_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Dev_Med	Medium intensity development, acres	NOAA (2006 and 2011 data)
Dev_Med_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Dev_Open	Open developed land, acres	NOAA (2006 and 2011 data)
Dev_Open_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Dissolved_Oxygen	mg/L	SWQMIS
EC_log	Natural logarithm of *E. coli*	SWQMIS (calculation by H-GAC)
E__Coli	MPN/100 mL	SWQMIS
End_Date	Sample date	SWQMIS
Enterococci	MPN/100 mL	SWQMIS
GF_est	Unpermitted OSSFs (number in catchment, , estimated)	H-GAC OSSF Database
NH3_log	Natural logarithm of NH3	SWQMIS (calculation by H-GAC)
Natural	All forest types, shrubs, grassland, bare land - acres	NOAA (2006 and 2011 data)

Variable Name	Comment	Source
Natural_pct	Above, as percentage of catchment	NOAA (calculated by H-GAC)
PRCP	Precipitation on day of sampling (inches)	NOAA NCDC
Pasture	Pasture, acres	NOAA (2006 and 2011 data)
Pasture_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Secchi_Transparency	meters	SWQMIS
Specific_Conductance	Microseimens / cm	SWQMIS
TPhos_log	Natural logarithm of total phosphorus	SWQMIS (calculation by H-GAC)
TSS_log	Natural logarithm of total suspended solids	SWQMIS (calculation by H-GAC)
Temperature	Degrees C	SWQMIS
Total_Phosphorus	mg/L	SWQMIS
Total_Suspended_Solids	mg/L	SWQMIS
Water	Water, acres	NOAA (2006 and 2011 data)
Water_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Wetland_est	Estuarine wetland, acres	NOAA (2006 and 2011 data)
Wetland_est_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
Wetland_pal	Palustrine wetlands, acres	NOAA (2006 and 2011 data)
Wetland_pal_pct	Above, percent of catchment area	NOAA (calculated by H-GAC)
ent_log	Natural logarithm of enterococci	SWQMIS (calculation by H-GAC)
flow_comp	Streamflow , CFS	SWQMIS or USGS
flow_log	Natural logarithm of streamflow	SWQMIS (calculation by H-GAC)
lcyr	Year land cover dataset was released (2006 or 2011)	NOAA
log10flow	Bas e10 logarithm of streamflow	SWQMIS or USGS – calculation by H-GAC
log_Crops	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Dev_High	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Dev_Low	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Dev_Med	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)

Variable Name	Comment	Source
log_Dev_Open	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Natural	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Pasture	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Water	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Wetland_est	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
log_Wetland_pal	Base 10 logarithm of (acres + 1)	NOAA (calculated by H-GAC)
logdate	Base 10 logarithm of collection data	SWQMIS (calculation by H-GAC)
logload		Surrogate for load (Calculation by H-GAC)
lu_dom	Dominant land use (type > 40 percent of catchment; AGR, NAT, DEV)	Calculation by H-GAC from NOAA data
ossf_n	Total OSSFs in catchment (permitted + estimated unpermitted)	H-GAC OSSF Database
pH		SWQMIS
pr_3day	Total precipitation in three days prior to sampling (inches)	NOAA NCDC (calculation by H-GAC)
pr_prevday	Total precipitation on the day prior to sampling (inches)	NOAA NCDC (calculation by H-GAC)
seg_type	Freshwater stream, tidal stream, or estuary	SWQMIS
spcon_log	Natural logarithm of specific conductance	SWQMIS (calculation by H-GAC)
station_id		SWQMIS
total_catch	Total area of catchment, acres	NOAA (calculated by H-GAC)
wet_dry	Wet = significant rain within 3 days ; dry = > 3 days since significant rainfall(taken from field data in CRP database- 72053, days since significant rainfall	SWQMIS (calculation by H-GAC)
Dev_high	Sum of dev_high_pct and dev_med_pct	Calculated by H-GAC
Dev_low	Sum of dev_low_pct and dev_open_pct	Calculated by H-GAC
Nat2	Sum of natural_pct, wetland_pal_pct, wetland_est_pct	Calculated by H-GAC

Table 5.5. Variables identified in Basin 13 used to perform load correlation analyses.

5.1.3.4 Statistical Analysis

The focus of the statistical analysis is the relationship between *E. coli* load and land cover characteristics. Because the bacteria load is dependent upon flow, only sample events with an associated flow value were analyzed. To appropriately scale the variables, which is important for mixed model procedures, the actual load (expressed in MPN/day, for example) was not used. A surrogate variable that is proportional to the total load ("logload") was created by multiplying the natural log of *E. coli* density (expressed as MPN/100 mL prior to log transformation) by the base 10 logarithm of instantaneous flow.

Statistical analyses included the following:

- Nonparametric correlation analysis (Spearman analysis)
- SAS PROC MIXED
    - Mixed models are developed using generalized least squares / maximum likelihood estimation methods rather than ordinary least squares (OLS, used in regression and GLM/ANCOVA). Generalized least squares estimation relaxes the requirements of independent and normally distributed errors that must hold if inference and parameter estimation by OLS are to be valid. Mixed models can include random components that account for variance in data collected at different monitoring stations and / or serial correlation between repeated observations at the same station, and produce more "generalizable" parameter estimates.
    - Repeated measures or random coefficients mixed models were fit (if possible) to the data
- SAS PROC GLM (general linear model, analysis of covariance)
    - After a model was fit using PROC MIXED, it was evaluated with PROC GLM to produce fit plots and R^2 calculations (Figure 5.5).
- SAS PROC REG: Multiple Regression
    - Models that included land cover data and temporal trends were fit using multiple regression.

- The relationship between WWTF effluent discharge, SSO events and volume, and bacteria results at the segment level was examined using Spearman correlation.
    - Due to data limitations, the analysis was limited to data collected from 2011 through 2015
    - WWTF discharge data was taken from Discharge Monitoring Report data provided by TCEQ
    - SSO data was provided by TCEQ. The relative geometric mean (the geometric mean as a multiple of the standard for the segment-specific indicator bacterium) was calculated from routine water quality monitoring data obtained from SWQMIS
        - All bacteria data (*E. coli* in non-tidal and enterococci in tidal segments) collected in the TMDL project area were used.

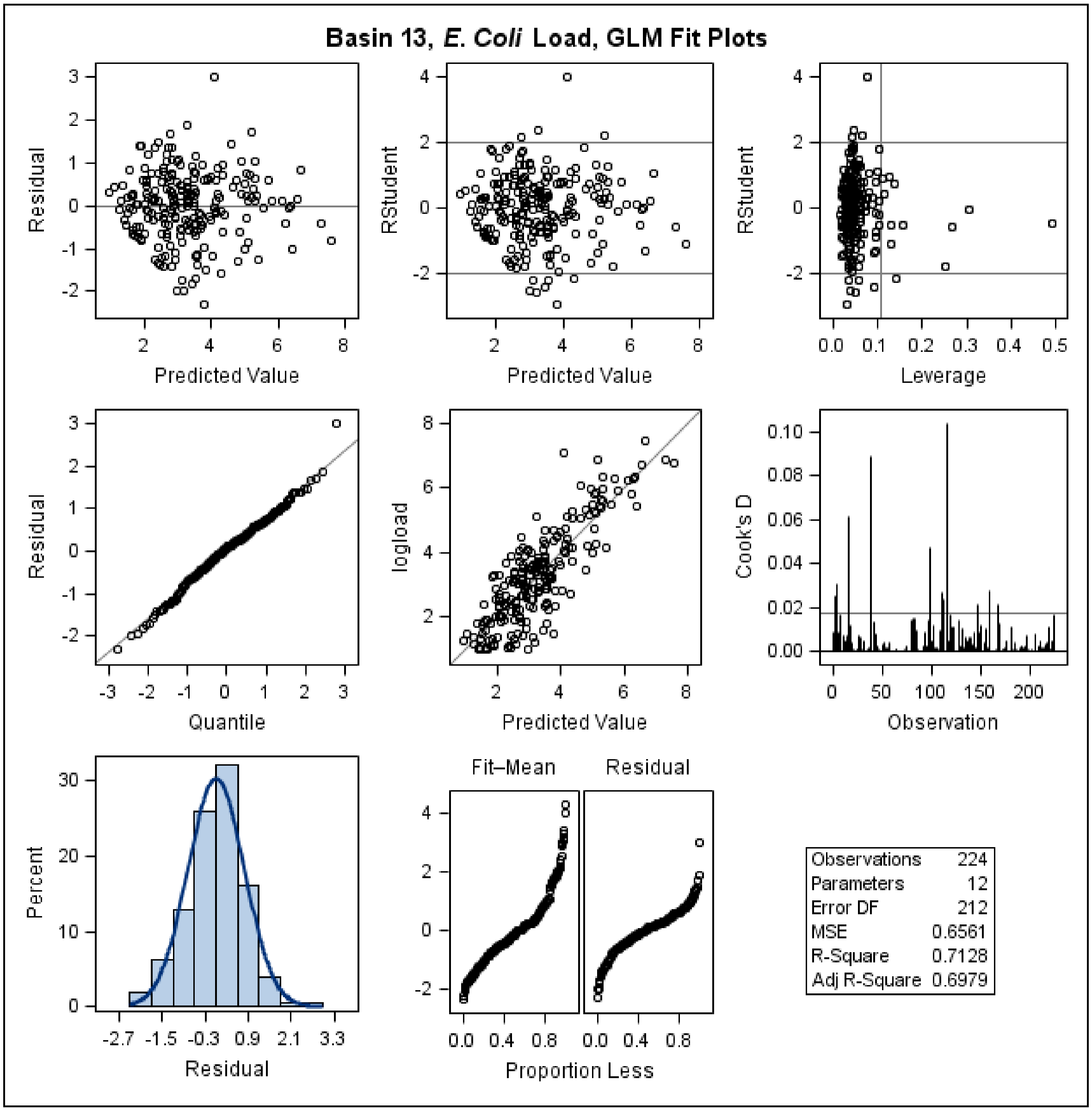
5.1.3.5 Summary of Statistical Analysis: E. coli Load as a Function of Land Cover

The basin 13 dataset contained 224 observations from 10 monitoring stations, collected between 1/25/2001 and 4/21/2015. Each observation included instantaneous flow.

- Correlation analysis
    - *E. coli* loads are positively correlated with the percentage of cropland in the Basin 13 watersheds (r = 0.456).
    - The loads are negatively correlated with pasture (r= -0.256) and undeveloped natural area (r = -0.362).
- Regression analysis with land cover and rainfall / wet weather variables
    - Correlation analysis may not provide information about how the distribution of other land cover types affects the relationship between a specific land cover type and the *E. coli* load. Multiple regression modeling can account for the influence of one type when all other types are held constant at their mean value.
    - Regression of the *E. coli* load on all land cover types, including rainfall variables (precipitation total in the previous three days and wet/dry condition) and their interaction with land cover types identified several statistically significant relationships with *E. coli* loads:
        - High intensity developed area and medium intensity developed area are associated with higher *E. coli* loads.

- Low intensity development and undeveloped natural area are associated with lower *E. coli* loads.
- The strength of the association with the percentage of pasture land falls between those these two groups.
- The contribution of medium intensity land uses is significantly higher during wet weather.
- These variables account for roughly 40 percent of the variation in *E. coli* loads (adjusted $R^2 = 0.398$).
- When the collection date is included in the model, the results suggest that loading is increasing over time.

- A repeated measures mixed-model to predict the *E. coli* load was developed from a large suite of candidate variables (land cover data, several water quality parameters, derived categorical variables, precipitation data, and interactions between rain events and land cover).
  - Ten variables were found to be statistically significant predictors of *E. coli* loads (Table 5.6)
  - The percentage of cropland is the most important predictor of increased bacteria loading, but the presence of pasture is also associated with higher loads
  - Undeveloped natural areas are significant contributors during rain events.
  - *E. coli* loads are higher in catchments with more permitted OSSFs.
  - The model explains almost 70 percent of the variation in loads (adjusted $R^2 = 0.698$).



Observations	224
Parameters	12
Error DF	212
MSE	0.6561
R-Square	0.7128
Adj R-Square	0.6979

Figure 5.4 Basin 13 *E. Coli* load, GLM Fit Plots.

Summary Analysis				
Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-13.48893435	9.27359680	-1.45	0.1473
Time (trend)	-1.06381981	0.29460334	-3.61	0.0004
Total suspended solids (natural log)	0.44009002	0.06391609	6.89	<.0001
3-day rain total	0.99138681	0.21752608	4.56	<.0001
Temperature	-0.03619630	0.00976546	-3.71	0.0003
Specific conductance (natural log)	-1.20698994	0.19851727	-6.08	<.0001
Permitted OSSFs (n)	0.00609055	0.00196521	3.10	0.0022
Cropland (percent)	0.26002596	0.08959108	2.90	0.0041
Pasture (percent)	0.22373051	0.09045891	2.47	0.0142
Undeveloped area (percent)	0.23347055	0.08856044	2.64	0.0090
Undeveloped area (percent) / 3-day rain total interaction	-0.01141885	0.00563787	-2.03	0.0441
Dominant Land Use: Agriculture	-0.98678231	0.38846178	-2.54	0.0118
Dominant Land Use: Undeveloped	0.00000000	.	.	.

Table 5.6 Summary analysis for ten variables considered statistically significant predictors of *E. coli.*

- No statistically significant correlations were found between reported DMR or SSO data and segment annual geometric means in Basin 13.

6 SEGMENT SPECIAL STUDIES

In year one, H-GAC recommended TCEQ consider collecting additional water quality monitoring and establish new monitoring stations for six AUs in the Caney Creek watershed, Segments 1304 and 1305, one AU in Live Oak Bayou, 2441A_01 and one AU in Coushatta Creek, 1302C_01. It was recommended the monitoring should include the addition of a continuous flow monitoring station for Caney and Linville creeks dependent on locations with actual flow. The upper portions of Caney and Linville creeks are intermittent. It was also recommended that Basin 13 monitoring locations be reviewed by the region's CRP coordinated monitoring program to ensure geographic coverage and that established AUs are being assessed.

6.1 CANEY CREEK

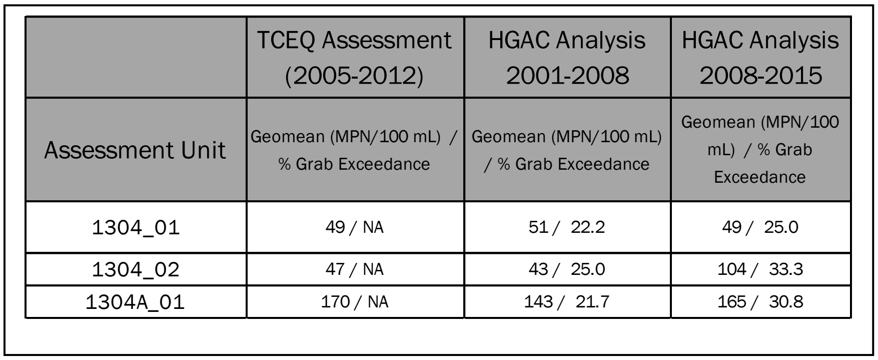
The Caney Creek watershed is comprised of two segments, Caney Creek Tidal (1304) Caney Creek Above Tidal (1305). Segment 1304 is predominantly rural and undeveloped and the small communities of Hawkinsville, Sargent, and Bay City are nearby. Residential homes with dock access line Caney Creek Tidal in the southern reaches of the watershed, most of which are serviced by OSSFs. The dominant land use in the area is agricultural with cattle grazing and horse farms commonly seen throughout. Small, scattered plots of wetland and forested lands are also present, especially in the southern portion of the watershed. Segment 1305 is primarily rural with most land used for agricultural purposes. The cities of Wharton, Boling-lago, and Van Vleck reside close by and represent the only small developed portions of the watershed. A large area of undeveloped forested land and wetland is present in the south-central part of the watershed with other small plots scattered throughout the area.

6.1.1 Water Quality Issues

In 2016, H-GAC reviewed the 2014 IR and data collected since 2012. Results of that review can be found in Appendix D. A summary is provided below. While there was sufficient data to determine impairments in 1304_01 and 1305_02 there was insufficient flow data to perform an LDC analysis. The watershed characteristics of Caney Creek are significantly different from the adjacent San Bernard River, where there is a continuous USGS flow gauge. H-GAC determined that continuous flow data from Caney Creek was needed to better characterize the impairment and to base watershed management actions. Also, for three AUs in Caney Creek, 1305_01, 1305_03 and 1305A_02, additional bacteria monitoring was needed.

6.1.1.1 Tidal Segment

The 2014 IR lists the downstream assessment unit of Segment 1304, 1304_01 and a tributary (1304A_01) as impaired for contact recreational use due to elevated levels of enterococci. The upstream assessment unit 1304_02 is designated as a concern for near nonattainment. H-GAC more recent seven-year assessment suggest the conditions in 1304_02 have worsened. TCEQ assessment data and H-GAC analyses are summarized in Table 6.1.



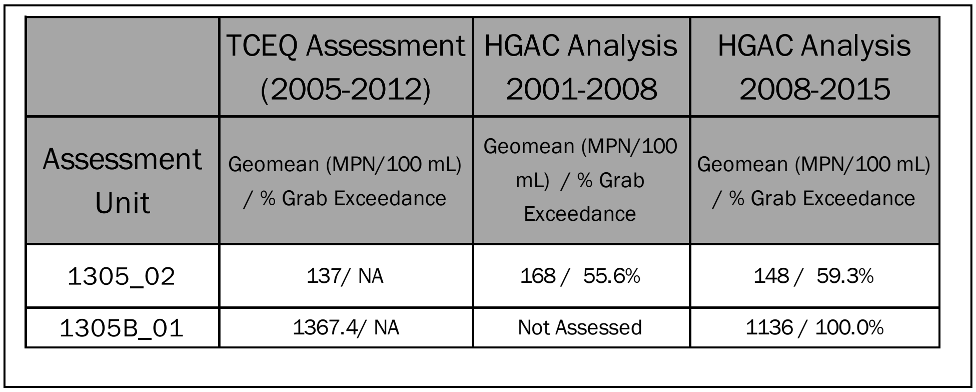
Assessment Unit	TCEQ Assessment (2005-2012) Geomean (MPN/100 mL) / % Grab Exceedance	HGAC Analysis 2001-2008 Geomean (MPN/100 mL) / % Grab Exceedance	HGAC Analysis 2008-2015 Geomean (MPN/100 mL) / % Grab Exceedance
1304_01	49 / NA	51 / 22.2	49 / 25.0
1304_02	47 / NA	43 / 25.0	104 / 33.3
1304A_01	170 / NA	143 / 21.7	165 / 30.8

Table 6.1 TCEQ and H-GAC bacteria analyses for Segment 1304. Linville Bayou, 1304a_01 is a freshwater non-tidal tributary and its FIB is *E. coli* with the standard of 126 MPN/100 mL.

Regression analysis of revealed no significant change in bacteria levels over time during the period of record; however, most samples collected exceed the water quality standard for enterococci. Moving bacteria geomeans for Linnville Bayou, 1304A_01, have also remained above the standard since 2013; however, only seven samples have been collected during the period of record. Additional data is necessary to better evaluate variations in bacteria levels in Linnville Bayou.

6.1.1.2 Above Tidal Segment

The 2014 IR lists the classified assessment unit 1305_02 as impaired for contact recreation use due to elevated levels of *E. coli.* Hardeman Slough (1305B_01) was not assessed in 2014. Sampling began in 2013, and the *E. coli* data collected suggests that this water body is also impaired for recreational use. Regression analysis of *E. coli* data did not reveal a statistically significant trend over time, but the majority of samples collected during the period of record continue to exceed the 126 MPN/100 mL standard. Moving seven-year bacteria geometric mean plots for the main segment show mean *E. coli* concentrations fluctuation near the standard reference line, but has mainly remained above the standard since 2005. The TCEQ assessment data and H-GAC analysis are summarized in Table 6.2.



Assessment Unit	TCEQ Assessment (2005-2012) Geomean (MPN/100 mL) / % Grab Exceedance	HGAC Analysis 2001-2008 Geomean (MPN/100 mL) / % Grab Exceedance	HGAC Analysis 2008-2015 Geomean (MPN/100 mL) / % Grab Exceedance
1305_02	137/ NA	168 / 55.6%	148 / 59.3%
1305B_01	1367.4/ NA	Not Assessed	1136 / 100.0%

Table 6.2 TCEQ and H-GAC bacteria analyses for Segment 1305.

6.1.1.3 *Recent Monitoring Data*

H-GAC gathered recent date for the seven-year period 2010 to 2016 for review. The data was for all stations in 1304 and 1305 (Table 6.3). The geometric mean continues to confirm bacteria impairments in the segments. The rolling seven-year geometric mean trend based on the 2010 to 2016 data assessment period is presented in Figure 6.1.

Segment	Earliest Data	Most Recent Data	Number of Results in GM Calculation	Geometric Mean (MPN/100 mL)
Caney Creek Above Tidal	1/28/2010	10/13/2016	27	155.5
Caney Creek Tidal	1/28/2010	10/20/2016	36	55.1

Table 6.3 Most recent assessment period, 2010 to 2016 including number of data results and geometric mean.

6.1.1.4 *Additional Monitoring and Continuous Flow*

Based on the information gathered by H-GAC and a review of the 2014 IR, H-GAC identified that additional data is necessary for three Segment AUs in Caney Creek, 1305_01, 1305_03, and 1305A_01. Additional water quality monitoring will be conducted in these AUs to minimize data gaps and better evaluate bacteria loadings throughout the entire basin. Figure 6.2 shows the location of current CRP and TCEQ monitoring locations that were used for H-GAC's initial analyses, as well as the three new stations, 12153, 12155, and 20468, that are subject to additional monitoring specific to this project. A flow gauge will be installed at the monitoring station located at Caney Creek at Highway 457 (station ID 12153). The selected Basin 13 monitoring locations were reviewed by TCEQ and by the region's CRP coordinated monitoring program to ensure geographic coverage and that established AUs are being assessed.

The goal was to collect a total of nine samples in 2017 at each of the three monitoring stations; four routine monitoring events that include the full suite of CRP conventional parameters collected on a quarterly basis, and five additional monitoring events that only include collection of bacteria and total suspended solids (TSS). The quarterly routine monitoring at all three stations includes the collection of basic field parameters using a calibrated datasonde, as well as the collection of bacteria, conventional chemical parameters and instantaneous flow. Additional bacteria monitoring at the three selected sites only collected basic field parameters using a calibrated datasonde, bacteria, and TSS.

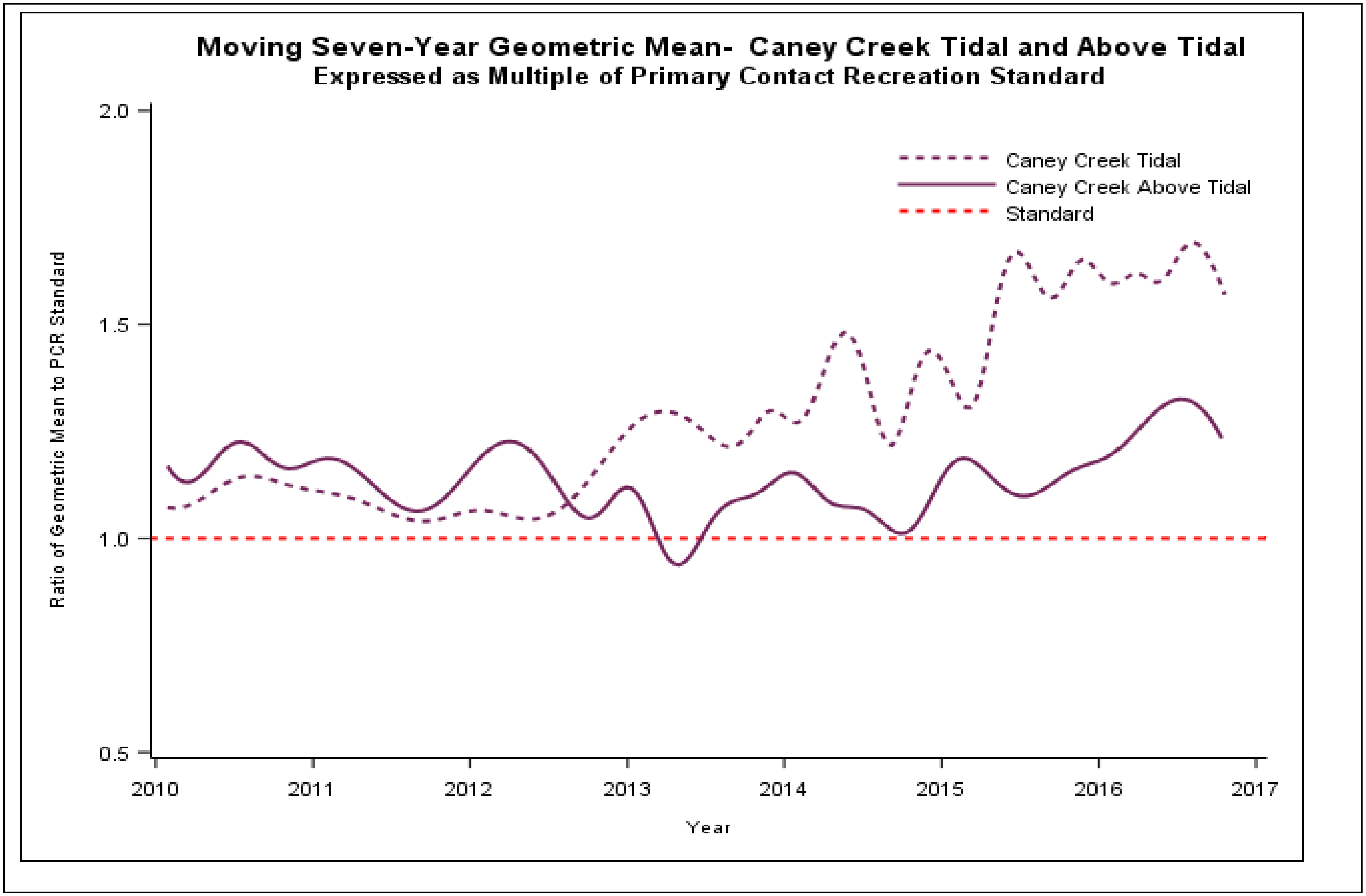
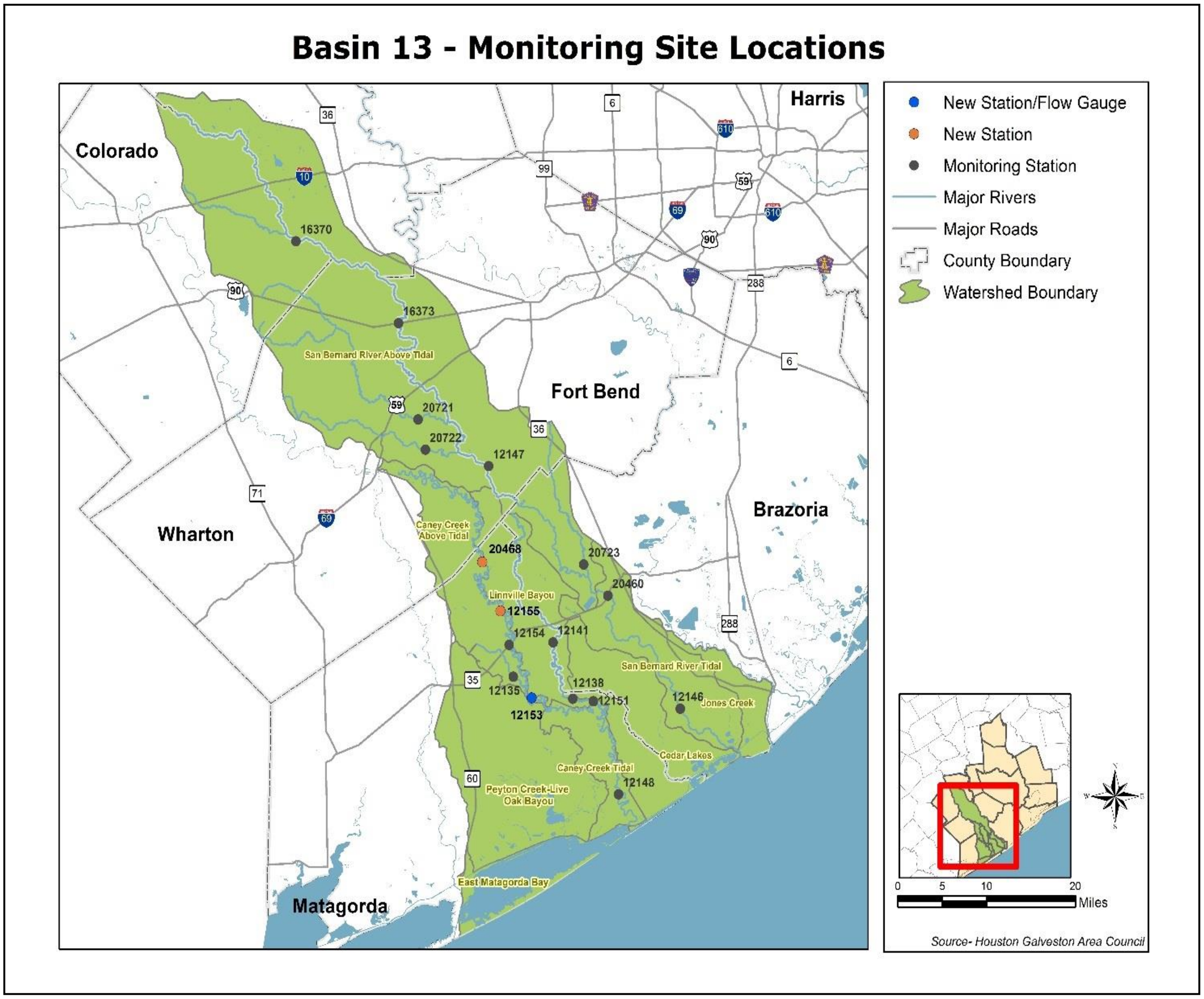


Figure 6.1 Rolling seven-year geometric mean for Segment 1305 for the period of 2010 to 2017.



Source- Houston Galveston Area Council

Figure 6.2 Three new monitoring stations established in Segment 1305 to provide additional bacteria monitoring and continuous flow monitoring (station 12153).

The Amazon Bubbler water level gauge was installed at station 12153, Caney Creek at Highway 457, to monitor continuous instream flow in lieu of instantaneous flow measurements. Once the gage was installed, initial instantaneous flow data at varying stream stages, along with other detailed physical parameters, was collected and will be used to create a stage-discharge rating curve. The rating curve information will be used to estimate continuous instream flow at this location based on the gauge's water level measurements taken every 15 minutes. This data will then be used in year three to develop hydrographs that provide the information necessary to conduct Load Duration Curve (LDC) analysis for Caney Creek Tidal and Above Tidal.

6.1.1.5 Additional Monitoring Data Analysis

The nine sample collection events were completed during Year Two. Analysis will follow in Year Three. The water level gauge was installed in February and began transmitting real-time data using a HDR GOES satellite transmitter with internal GPS. Gauge level in feet was measured on the quarter hour and transmitted via satellite to a data housing site at: https://stormcentral.waterlog.com/public/EIH. In Year

Three, the gauge height and ambient flow monitoring will be used to generate the stage discharge rating curve and estimate continuous instream flow.

6.1.2 Geographic Analysis

During Year Two, H-GAC began to build the data library of potential bacteria sources. The data library includes geospatial information, e.g. land cover, wastewater treatment facility locations, and onsite sewage facility locations. A catalogue of potential sources and their locations is useful in watershed planning with stakeholders when identifying potential water quality improvement measures.

6.1.2.1 Land Cover

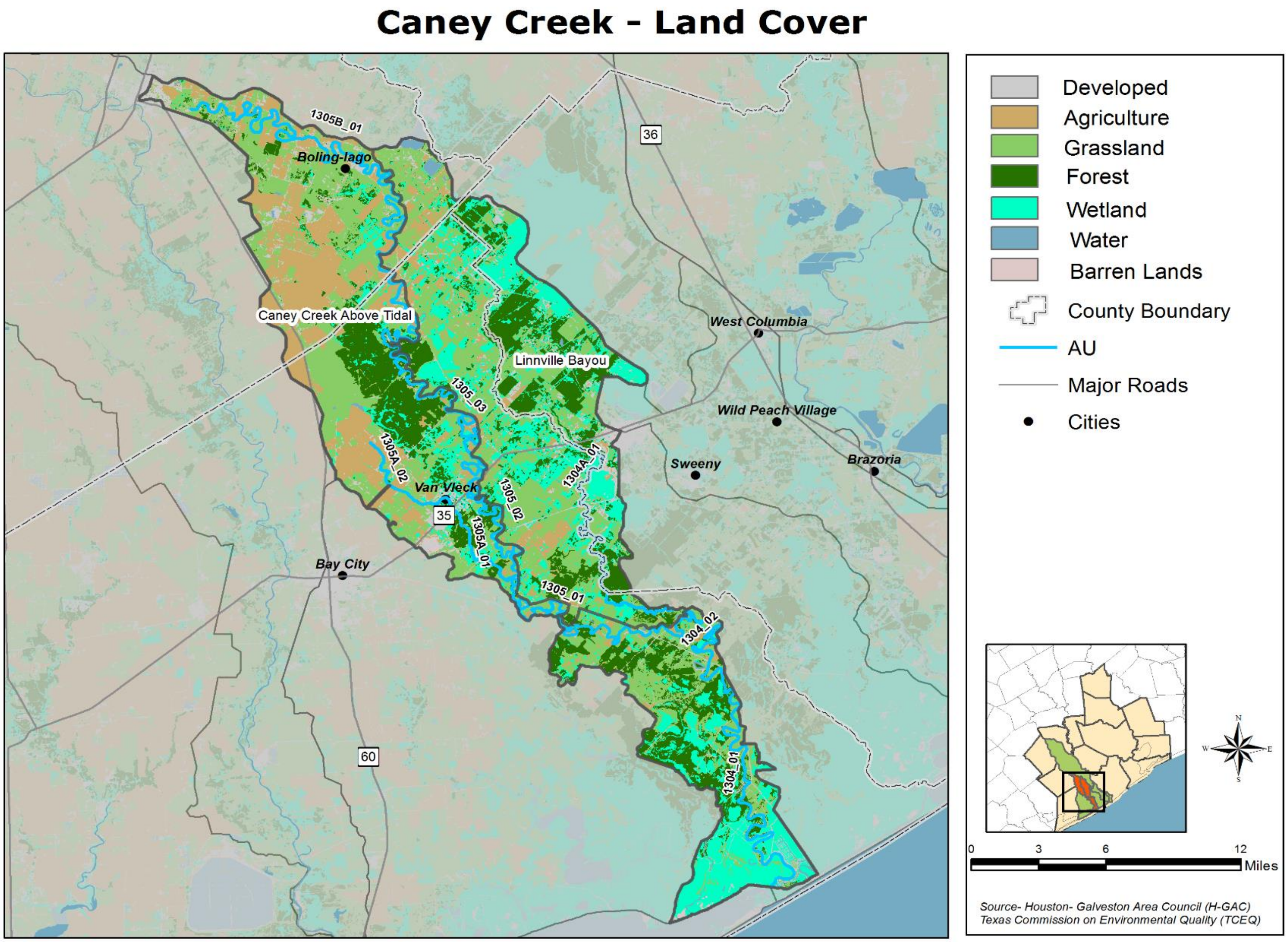
Land cover can be used to describe the current state and trends in natural and man-made landscapes contained within a watershed. Stormwater flowing off of different land cover types potentially carry bacteria to Caney Creek. Figure 6.3 is the current land cover for Caney Creek from data taken from NOAA's CCAP program. The Caney Creek watershed contains 211,299.5 acres of land. Agricultural uses, made up of cultivated cropland and pasture/grassland covers, make up the bulk of the land cover at 52% or 109,737.48 acres. The second largest land cover type is natural cover at 42% or 89,069.76 acres. Natural cover contains barren, forest/shrub, open water, and wetland. Developed land cover types include: High Intensity, Medium Intensity, Low Intensity and Open Space. Developed land cover is 6% of the land cover at 12,492.20 acres.

6.1.2.2 Wastewater Treatment Outfalls

Wastewater treatment facilities and the wastewater collection system are potentially direct sources of bacteria if not fully treated or the collection system fails. The TCEQ Permit Central Registry and the EPA ICIS dataset maintain wastewater permits and outfall locations. H-GAC used Caney Creek wastewater permit information to develop a Caney Creek wastewater outfall map, Figure 6.4. In year three, permit information, including permitted flow and bacteria permit limits will be used to develop loading allocations for Caney Creek.

6.1.2.3 OSSF Locations

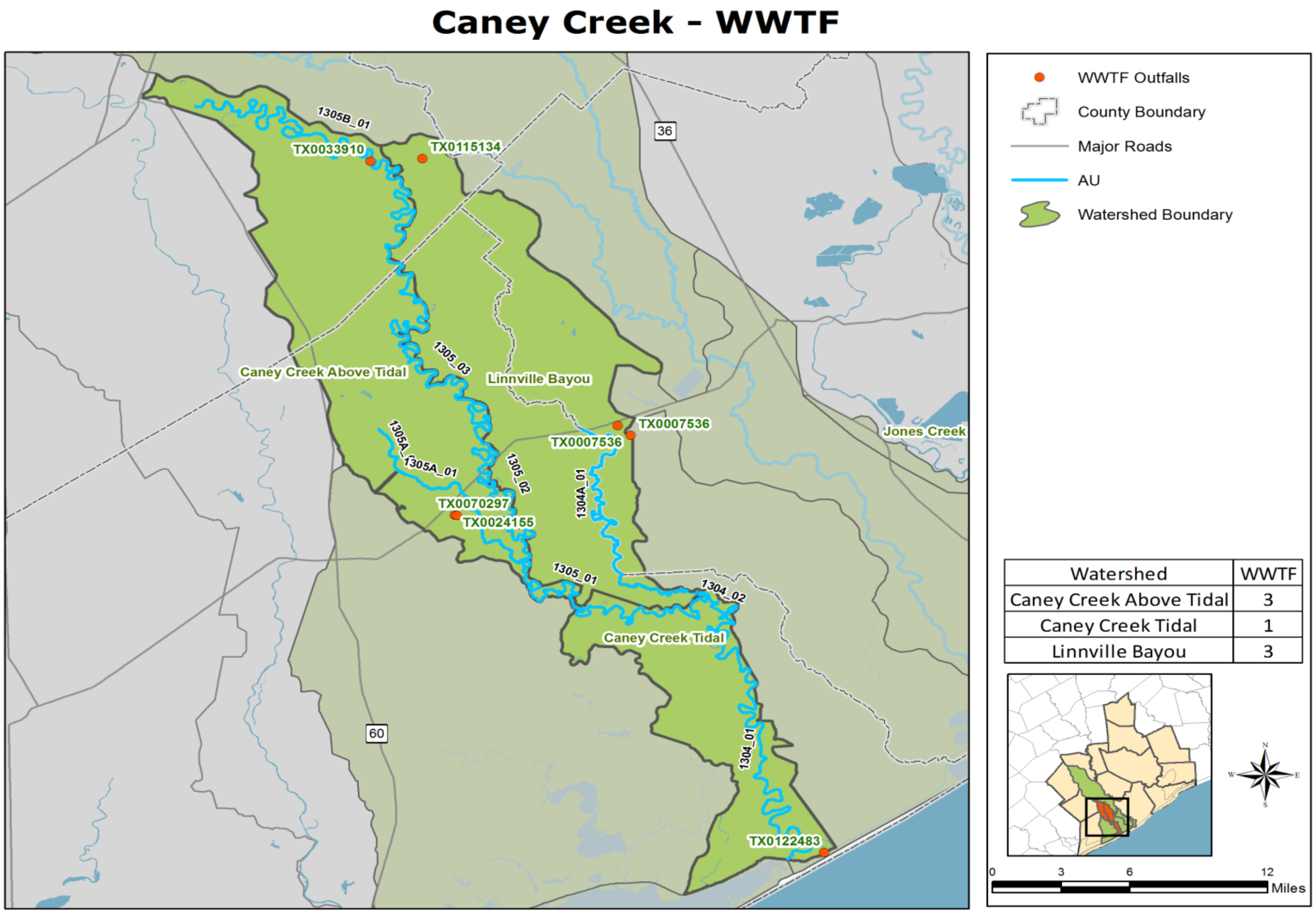
Watershed residents not on centralized wastewater treatment, are likely using an onsite treatment. Permitted OSSFs were started in 1989. Systems installed prior to 1989 are considered grandfathered and are difficult to track. Permitted OSSF locations can be tracked and H-GAC has worked with authorized agents to develop mapping applications. Figure 6.5 presents the location of 685 permitted OSSFs in Caney Creek and identifies those within a 500 ft. buffer. It is generally thought that failing systems closest to waterbodies present the greatest bacteria concern. There are 166 OSSFs within 500 ft. of the mainstem of Caney Creek, Linnville Bayou, Hardeman Slough and Waterhole Creek.



Source- Houston- Galveston Area Council (H-GAC)
Texas Commission on Environmental Quality (TCEQ)

Figure 6.3

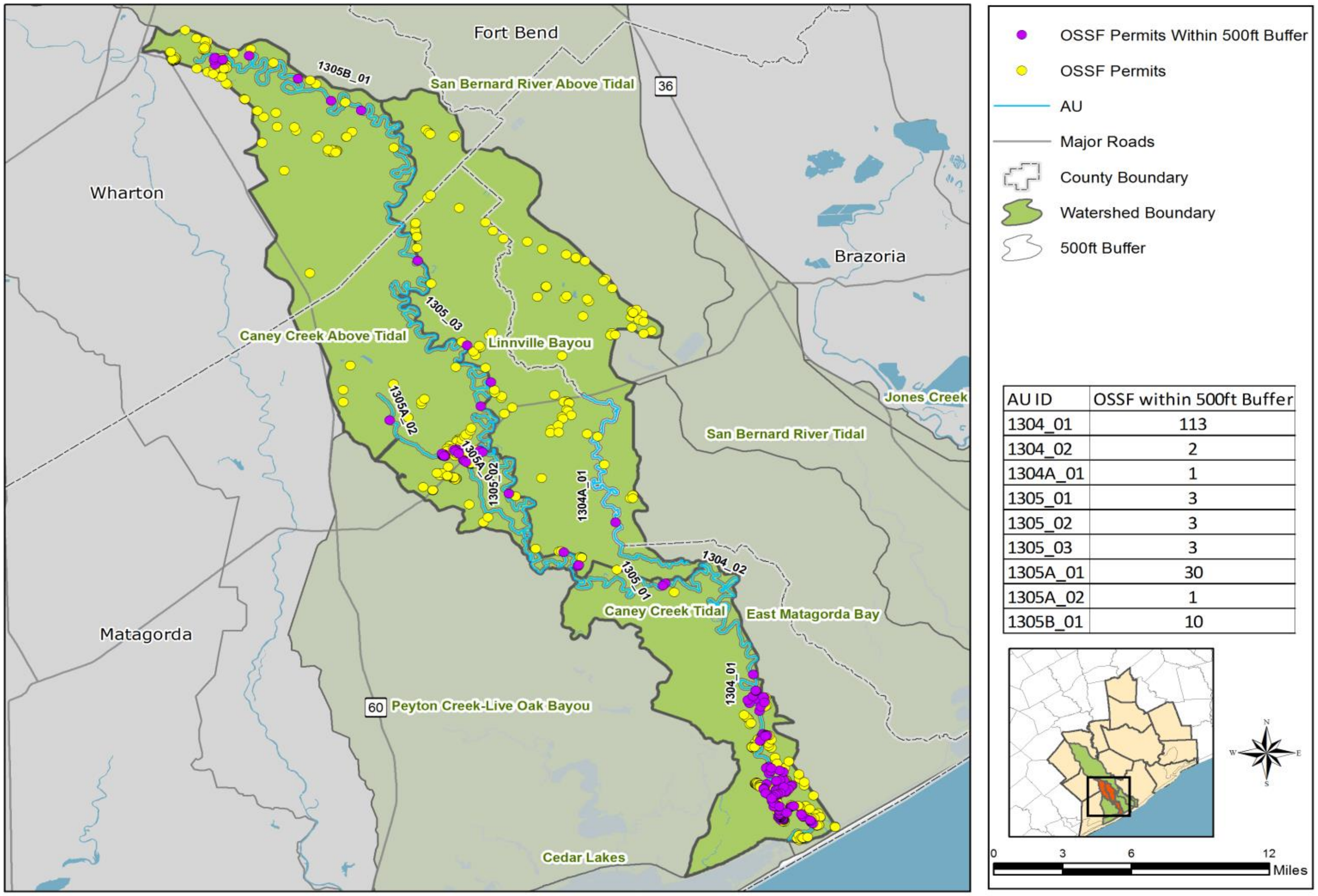
Caney Creek watershed land cover analysis for seven land cover classifications based on NOAA C-CAP data.



Watershed	WWTF
Caney Creek Above Tidal	3
Caney Creek Tidal	1
Linnville Bayou	3

Figure 6.4 WWTF outfalls in the Caney Creek watershed.

Caney Creek - OSSF Permits



AU ID	OSSF within 500ft Buffer
1304_01	113
1304_02	2
1304A_01	1
1305_01	3
1305_02	3
1305_03	3
1305A_01	30
1305A_02	1
1305B_01	10

Figure 6.5 OSSF permits in the Caney Creek watershed, including those within 500 feet of Caney Creek and major tributaries to Caney Creek.

7 CONCLUSIONS AND RECOMMENDATIONS

Basin 13 land use was still consistent with a rural and agriculture dominant land cover with large areas of natural and wetland cover. Development makes up 2% of the basin. The area's population is not expected to grow significantly over the coming years. During the characterization of Basin 13, four segments and 20 AUs were reviewed. Basin 13 data including GIS and bacteria data were assessed and presented in previous sections. Additionally, H-GAC was asked to develop LDCs for AUs that had sufficient bacteria and flow data were available. The results of that effort were reviewed in section 5 and are provided in Appendix D.

The main goal of this project was to distill this information down to provide the TCEQ, local decision-makers, and the public with greater understanding of how bacteria is affecting water bodies in this basin and suggest possible management planning measures to address impairments and data gaps over the coming years.

7.1 CONCLUSIONS

Results of the data reviewed, GIS analysis and generated LDCs for this Characterization Report suggests water quality for the basin is influenced by high concentrations of bacteria which could affect public health of those involved in contact recreation. The following general observations were found:

1. Agriculture production appears to be a good predictor of bacteria loadings in the basin, likely based on the large proportion of the land in the basin dedicated to agriculture (section 5, pg. 57).
2. While agriculture may be a good predictor of bacteria loadings, LDCs developed (Figure 5.2, pg. 43) during this project suggest the influence of wastewater treatment, specifically OSSFs. The LDCs exhibit load regression curves that extend above the geometric mean standard curve and in some cases the single grab standard curve (1302A_01) into dry conditions and sometimes into no flow conditions.
3. To confirm point 2 above, a repeated mixed measures model evaluating *E. coli* loads found *E. coli* to be higher in areas with high incidents of OSSFs (section 5, pg. 57). The clustering of OSSFs located in the basin around AUs on the San Bernard River as shown in Figure 4.4 on page 33 lend weight to the conclusion of OSSFs as a potential contributor to the bacteria impairments listed for the San Bernard River. Modeled loadings made for the San Bernard River WPP also support this conclusion.

7.2 RECOMMENDATIONS

Based on the 2014 IR, approximately 53% of the basin does not meet the contact recreation standard as nine of the 17 AUs in the 2014 *Integrated Report* are listed in Category 5. Seven of the nine AUs listed in Category 5 were given a 5b assessment, suggesting the need for water quality standards review. The other two were given a 5c assessment, suggesting the need for additional data or new information. Six of these AUs fall in the San Bernard River watershed and potentially will be addressed by a draft WPP that is in line to be approved by reviewing agencies.

The remaining 12 AUs, 47% of the basin listed in 2014 IR, were either not assessed, listed as a concern for bacteria, listed as no concern or not assessed for bacteria. To determine the 12 AUs, the 17 AUs from the 2014 IR were sorted by those AUs where the data was considered adequate. Those with adequate date were removed. Three additional AUs, 1302C_01 Coushatta Creek, 1305A_01 Hardeman Slough, and 2441A_01 Live Oak Bayou were added, as the unclassified waterbodies had been given AU designations, but were not addressed by the 2014 *Integrated Report*. These 15 AUs are listed in Table 7.1. The table includes the data qualifiers from the 2014 IR that list the available data as limited, inadequate, assessment based on reviewer judgement or were not evaluated.

During the process to develop LDCs, H-GAC reviewed bacteria data and flow data through 2015 to determine if the data was sufficient to create LDCs. Table 6.1 applies this review along with updated water quality planning efforts. H-GAC then added a column of suggested recommendation for each of the 15 AUs. Three of the AUs, 1302_02, 1302A_01, and 1302B_02, will potentially be moved from a Category 5 listing to a Category 4 listing once the San Bernard River WPP is approved. Some of the AUs given a LD or ID are expected to change as more data is collected for monitoring stations contained in the AU.

In 2016, based on the information gathered by H-GAC and a review of the 2014 IR, H-GAC recommended TCEQ consider collecting additional water quality monitoring and establish new monitoring stations for six AUs in the Caney Creek watershed, Segments 1304 and 1305, one AU in Live Oak Bayou, 2441A_01 and one AU in Coushatta Creek, 1302C_01. Monitoring was recommended to include adding a continuous flow monitoring station for Caney and Linville creeks dependent on locations with actual flow. The upper portions of Caney and Linville creeks are intermittent. Additionally, it was recommended that Basin 13 monitoring locations be reviewed by the region's CRP coordinated monitoring program to ensure geographic coverage and that established AUs are being assessed.

In 2017, actions were taken to begin to address the recommendations made in 2016. Additional monitoring and collection of flow data was completed in Caney Creek. Once the data is evaluated, next steps will include development of a TSD and to begin working with stakeholders to determine what watershed management tools should be developed. To that aim, H-GAC hosted two public meetings, November 28, 2016 and August 1, 2017 to begin acquainting stakeholders with the collection and analysis of water quality data, current impairments within the basin, actions currently being taken to address impairments and future opportunities to address the remaining impairments.

BASIN 13 2014 INTEGRATED REPORT AND H-GAC DATA REVIEW										
Seg.	**AU**	**Name**	**Parameter**	**Category**	**No. Samples Assessed**	**Geometric Mean**	**Data Set Qualifier**	**Level of Support**	**H-GAC Data Review**	**H-GAC Recommendation**
1302	1302_02	San Bernard River Above Tidal	*E. coli*	5b	0		JQ	NS	No Monitoring after 2002	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302_04	San Bernard River Above Tidal	*E. coli*						Not Assessed	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302A_01	Gum Tree Branch	*E. coli*	5b	0		ID	NA	Bacteria and Flow data good till 2014	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302B_01	West Bernard Creek	*E. coli*		14	137.89	LD	CN	Very little data.	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302B_02	West Bernard Creek	*E. coli*	5b	0		ID	NA	Historic Station	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302C_01	Coushatta Creek	*E. coli*						Not Assessed and No Data Collected.	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302D_01	Peach Creek	*E. coli*		13	100.55	LD	NC	Bacteria and Flow data good	Part of WPP, track progress, coordinate with CRP monitoring program.
	1302E_01	Mound Creek	*E. coli*		10	59.01	LD	NC	Bacteria and Flow data good	Part of WPP, track progress, coordinate with CRP monitoring program.

BASIN 13 2014 INTEGRATED REPORT AND H-GAC DATA REVIEW

Seg.	AU	Name	Parameter	Category	No. Samples Assessed	Geometric Mean	Data Set Qualifier	Level of Support	H-GAC Data Review	H-GAC Recommendation
1304	1304_02	Caney Creek Tidal	Enterococcus		8	47.22	LD	CN	Consistent after 2014	Continue to Monitor
	1304A_01	Linnville Bayou	*E. coli*	5b	11	170.23	LD	NS	One station consistent after 2014, need flow data/ intermittent stream	Continue to Monitor, add flow monitoring if possible.
1305	1305_01	Caney Creek Above Tidal	*E. coli*						Not Assessed/ 1305_02 assessed 2014 IR, less consistent flow data	**Monitoring data collected at a new station in 2017. Flow gauge installed in 2017.**
	1305_03	Caney Creek Above Tidal	*E. coli*						Not Assessed/ 1305_02 assessed 2014 IR, less consistent flow data	**Monitoring data collected at new station in 2017. Flow gauge installed in 1305_01 in 2017.**
	1305A_01	Hardeman Slough	*E. coli*						Not Assessed/ 1305_02 assessed 2014 IR, monitoring station found in AU.	Continue collecting environmental data, possibly collect continuous flow data.
	1305B_01	Caney Creek Above Water Hole Creek	*E. coli*		5	1367.35	LD	CN	Not Assessed/ 1305_02 assessed 2014 IR, less consistent flow data	**Monitoring data collected at new station in 2017. Flow gauge installed in 1305_01 in 2017.**
2441	2441A_01	Live Oak Bayou	*Enterococcus*						Not Assessed 2014 IR.	Station 15181 is located near the ICWW. No FIB have been collected since 2005. Coordinate with CRP monitoring schedule, possibly collect additional data

Table 7.1. Fifteen AUs in Basin 13 comparing 2014 Integrated Report with H-GAC data review. AD=Adequate Data, JQ=Assessor Judgement, LD=Limited Data, ID=Inadequate Data, NA=Not Assessed, NS=Not Supporting, CN=Concern, NC=No Concern.

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25. *The Handbook of Texas Online*, Merle R. Hudgins, "Wharton County," accessed on June 2, 2016 **http://www.tshaonline.org/handbook/online/articles/hcw06**. Uploaded on June 15, 2010. Modified on February 19, 2016. Published by the Texas State Historical Association.
26. USDA Census of Agriculture 2012. Accessed on June 15, 2016. https://www.agcensus.usda.gov/About_the_Census/. Last Modified on November 16, 2015. Published by the United States Department of Agriculture.

APPENDIX A

BASIN 13 STAKEHOLDER OUTREACH APPROACH

Stakeholders	Outreach Approach
Coordinate with Existing WPPs • San Bernard	Email San Bernard stakeholder group to: • Inform them of the project • Share the 1-page brochure • Provide opportunity for input / identify any potential opportunities or issues in the project area
Lower Colorado River Authority	Phone call with LCRA to: • Inform them of the project • Share the 1-page brochure for dissemination to their stakeholders • Provide opportunity for input / identify any potential opportunities or issues in the project area
Chambers of Commerce • Bay City COC & Agriculture • Eagle Lake COC • East Bernard COC • Sealy COC • Sweeny COC • Wallis COC & Agriculture • West Columbia COC	Emails to COCs to: • Inform them of the project • Share the 1-page brochure for dissemination to their stakeholders • Provide opportunity for input / identify any potential opportunities or issues in the project area
Utility Districts (as identified)	Emails to Utility Districts to: • Inform them of the project • Share the 1-page brochure for dissemination to their stakeholders • Provide opportunity for input / identify any potential opportunities or issues in the project area
Drainage Districts (as identified)	Emails to Drainage Districts to: • Inform them of the project • Share the 1-page brochure for dissemination to their stakeholders • Provide opportunity for input / identify any potential opportunities or issues in the project area
Cities (15 in project area) • *Mayor*	Letters to cities in project area to:

- *City Secretary* - *City Manager*	- Inform them of the project / Share the 1-page brochure - Offer in-person meeting or phone call to those interested in becoming more specifically involved In-person meetings to follow, depending on the interest shown by the cities
Counties - Austin - Brazoria - Colorado - Fort Bend - Matagorda - Wharton	Letters to the counties (precincts in geography and all Judges) in project area to: - Inform them of the project / Share the 1-page brochure - Offer in-person meeting or phone call to those interested in becoming more specifically involved In-person meetings to follow, depending on the interest shown by the counties
County Extension Agents *(TxAgrilife)*	Emails to each county's contact to: - Inform them of the project - Share the 1-page brochure for dissemination to their stakeholders - Provide opportunity for input / identify any potential opportunities or issues in the project area
Texas State Soil & Water Conservation Board (South East Watershed Coordinator in Wharton)	Email to TSSWCB to: - Inform them of the project - Share the 1-page brochure for dissemination to their stakeholders - Provide opportunity for input / identify any potential opportunities or issues in the project area
Port of Freeport	Phone call with Port to: - Inform them of the project - Provide opportunity for input / identify any potential opportunities or issues in the project area

APPENDIX B

BASIN 13 OUTREACH BROCHURE

Brazos-Colorado Coastal Basin

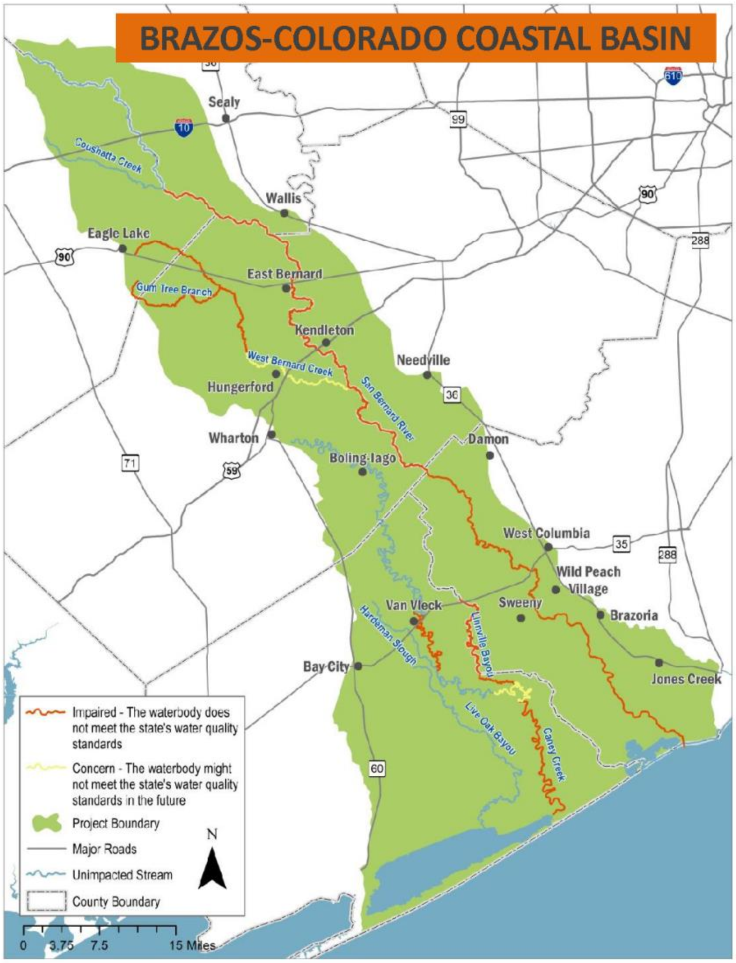
The Houston-Galveston Area Council (H-GAC) is working with local partners to reduce elevated bacteria levels in the basin.

What is a Basin?

A basin is an area of land, often associated with a river, where rainfall collects, then flows to a bay or ocean. Rainwater collected in the Brazos-Colorado Coastal Basin travels to the Gulf of Mexico.

How's the Water?

Many of the bayous and streams within this basin have high bacteria levels. According to standards set by the Texas Commission on Environmental Quality (TCEQ), these waterways may not be suitable for recreational activities, such as swimming.



San Bernard River at FM 3013, Colorado County

Where Do Bacteria Come From?

Bacteria in the water can come from many sources. These include: failing on-site sewage facilities or septic tanks, animals, and polluted stormwater runoff.

How Can We Address the Problem?

H-GAC, through funding from the TCEQ, is developing a partnership with local governments and community organizations in the Brazos-Colorado Coastal Basin to better understand the sources of bacteria and develop cost-effective voluntary solutions.

The input of local leaders will be crucial to the success of this effort, and we want you to be a part of the conversation.

To Learn More

Visit www.h-gac.com/go/basin13 to learn more about the project, or e-mail Steven.Johnston@h-gac.com to schedule a meeting to discuss how you can help reduce bacteria in Brazos-Colorado Coastal Basin.

TCEQ

Houston-Galveston
Area Council

APPENDIX C

BASIN 13 SEGMENT AND ASSESSMENT UNITS

2014 Texas Integrated Report (TCEQ, 2015) Basin 13 Segment and Assessment Units Summary Report									
Segment	**Assessment Unit**	**Name**	**Assessment Unit Description**	**Parameter**	**Standards Criteria (MPN/100 mL)**	**Category**	**Data Date Range**	**No. of Samples in AU**	**AU Geometric Mean (MPN/100 mL)**
1301	1301_01	San Bernard River Tidal	Entire Segment	Enterococcus	35	5c	2005-2012	50	50.49
1302	1302_01	San Bernard River Above Tidal	From the confluence with the Intracoastal Waterway in Brazoria County to confluence with Peach Creek	*E. coli*	126	5b	2005-2012	35	192.79
	1302_02	San Bernard River Above Tidal	From the confluence with Peach Creek to the unnamed tributary at NHD RC 12090401001535 at N-96.03, W29.51	*E. coli*	126	5b	2005-2012	0	
	1302_03	San Bernard River Above Tidal	From the confluence with unnamed tributary at NHD RC 12090401001535 at N-96.03, W29.51 to confluence with Coushatta Creek	*E. coli*	126	5b	2005-2012	48	141.69
	1302_04	San Bernard River Above Tidal	From the confluence with Coushatta Creek to the upstream end of segment	*E. coli*	126				
	1302A_01	Gum Tree Branch	Entire Segment	*E. coli*	126	5b	2005-2012	0	

2014 Texas Integrated Report (TCEQ, 2015) Basin 13 Segment and Assessment Units Summary Report									
Segment	**Assessment Unit**	**Name**	**Assessment Unit Description**	**Parameter**	**Standards Criteria (MPN/100 mL)**	**Category**	**Data Date Range**	**No. of Samples in AU**	**AU Geometric Mean (MPN/100 mL)**
	1302B_01	West Bernard Creek	From the confluence with the San Bernard River Above Tidal to the confluence with Clarks Branch	*E. coli*	126		2005-2012	14	137.89
	1302B_02	West Bernard Creek	From the confluence with Clarks Branch to the upper end of segment	*E. coli*	126	5b	2005-2012	0	
	1302C_01	Coushatta Creek	From the confluence with the San Bernard River Above Tidal upstream to a point 4.6 km upstream of I-10	*E. coli*	126				
	1302D_01	Peach Creek	From the confluence with the San Bernard River in Wharton Co. to the headwaters approximately 8 km upstream of FM-102 in Wharton County	*E. coli*	126		2005-2012	13	
	1302E_01	Mound Creek	From the confluence with the San Bernard River in Brazoria County to the headwaters approximately 400 m upstream of TX Hwy 36 in Ft. Bend County	*E. coli*	126		2005-2012	10	59.01

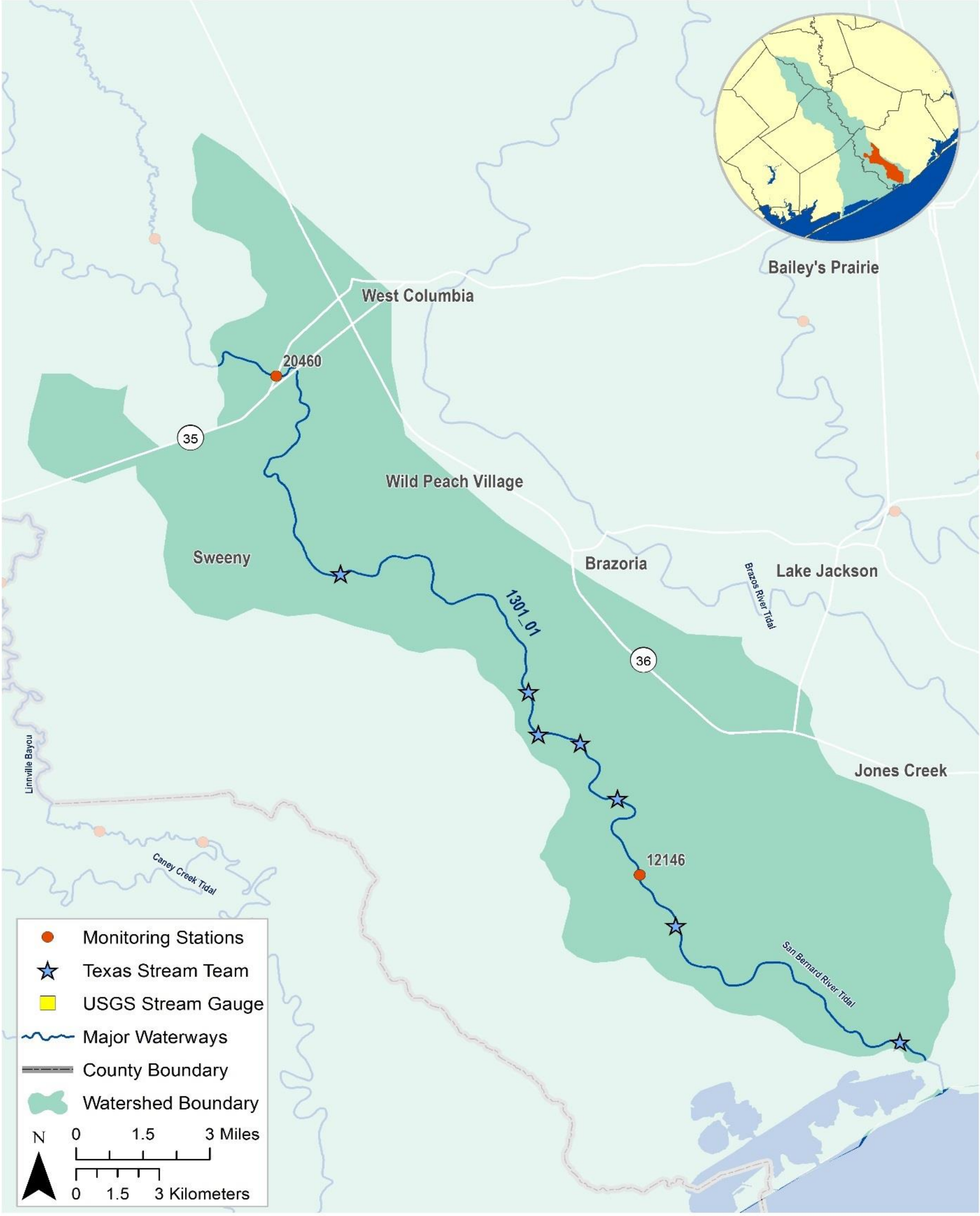
2014 Texas Integrated Report (TCEQ, 2015) Basin 13 Segment and Assessment Units Summary Report									
Segment	Assessment Unit	Name	Assessment Unit Description	Parameter	Standards Criteria (MPN/100 mL)	Category	Data Date Range	No. of Samples in AU	AU Geometric Mean (MPN/100 mL)
1304	1304_01	Caney Creek Tidal	From the downstream end of segment to the confluence with Dead Slough	Enterococcus	35	5c	2005-2012	64	49.28
	1304_02	Caney Creek Tidal	From the confluence with Dead Slough to the upstream end of segment	Enterococcus	35		2005-2012	8	47.22
	1304A_01	Linnville Bayou	Entire Water Body	*E. coli*	126	5b	2005-2012	11	170.23
1305	1305_01	Caney Creek Above Tidal	From the downstream end of the segment to the confluence with Hardeman Slough	*E. coli*	126				
	1305_02	Caney Creek Above Tidal	From the confluence with Hardeman Slough to the confluence with Snead Slough	*E. coli*	126	5b	2005-2012	27	137.03
	1305_03	Caney Creek Above Tidal	From the confluence with Snead Slough in Matagorda Co. to the upper end of segment at the confluence with Water Hole Creek in Matagorda Co.	*E. coli*	126				

2014 Texas Integrated Report (TCEQ, 2015) Basin 13 Segment and Assessment Units Summary Report									
Segment	**Assessment Unit**	**Name**	**Assessment Unit Description**	**Parameter**	**Standards Criteria (MPN/100 mL)**	**Category**	**Data Date Range**	**No. of Samples in AU**	**AU Geometric Mean (MPN/100 mL)**
	1305A_01	Hardeman Slough	From the confluence with Caney Creek to 0.3 km upstream of Matagorda County Rd. 110.	*E. coli*	126				
	1305B_01	Caney Creek Above Water Hole Creek	From the confluence with Water Hole Creek in Matagorda Co. (at the upper end of Segment 1305) to the headwaters approximately 43 miles at Old Caney Rd. in Wharton Co.	*E. coli*	126		2005-2012	5	1367.35
2441	2441A	Live Oak Bayou	Entire AU from the confluence with the ICWW to the headwaters west of CR 2540	*Enterococcus*	35				

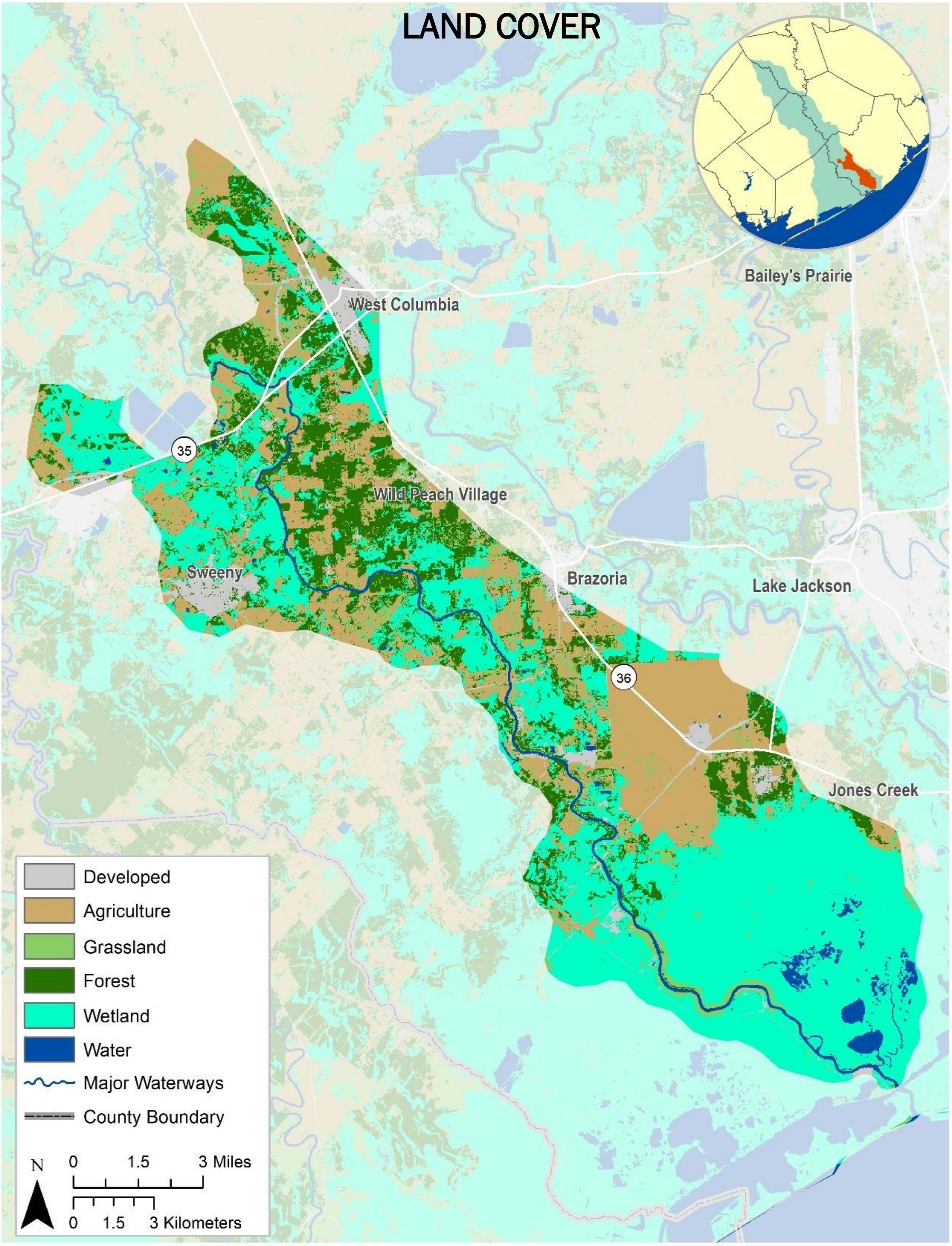
APPENDIX D

SEGMENT AND AU SUMMARIES

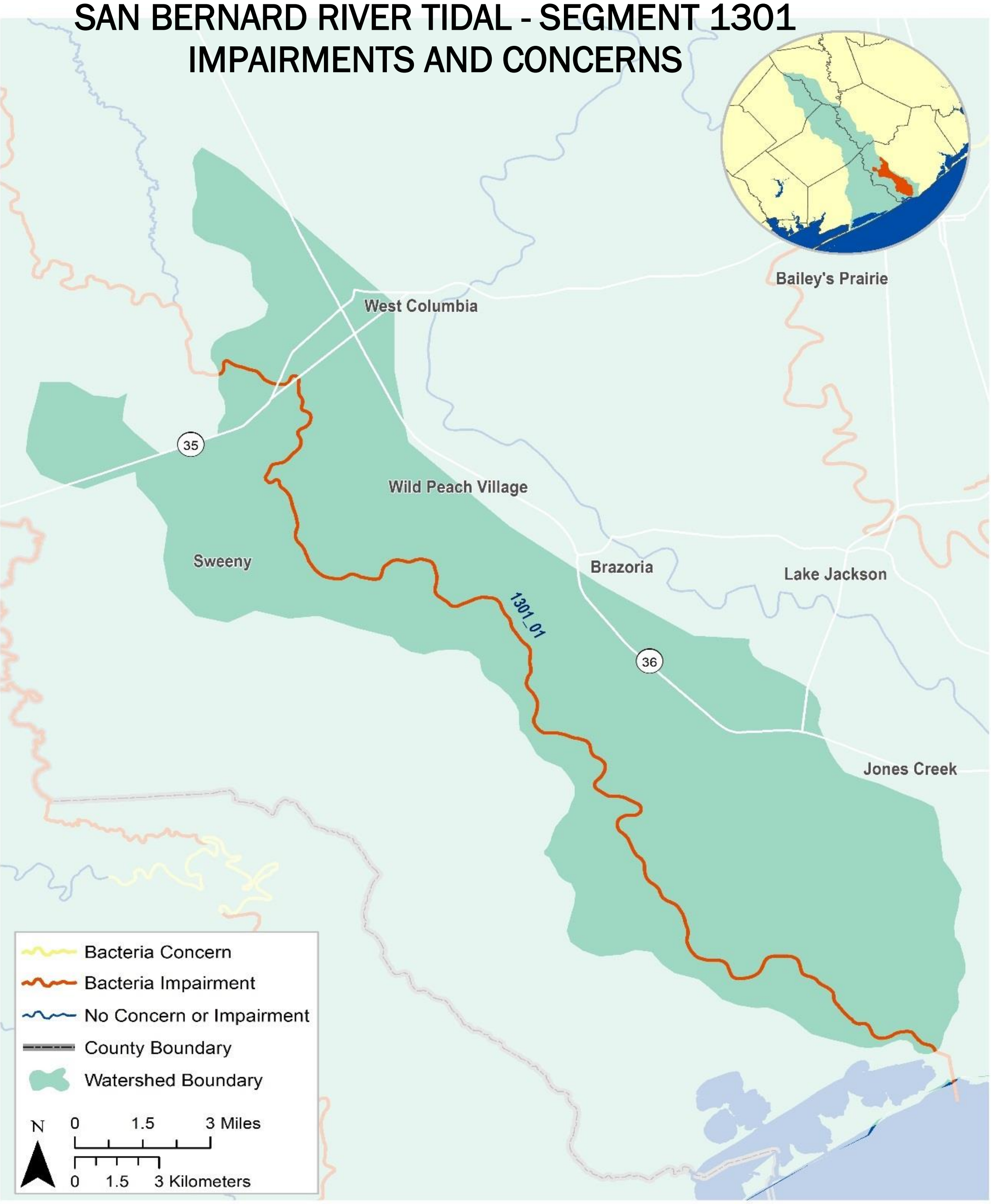
B1 SAN BERNARD RIVER TIDAL - SEGMENT 1301



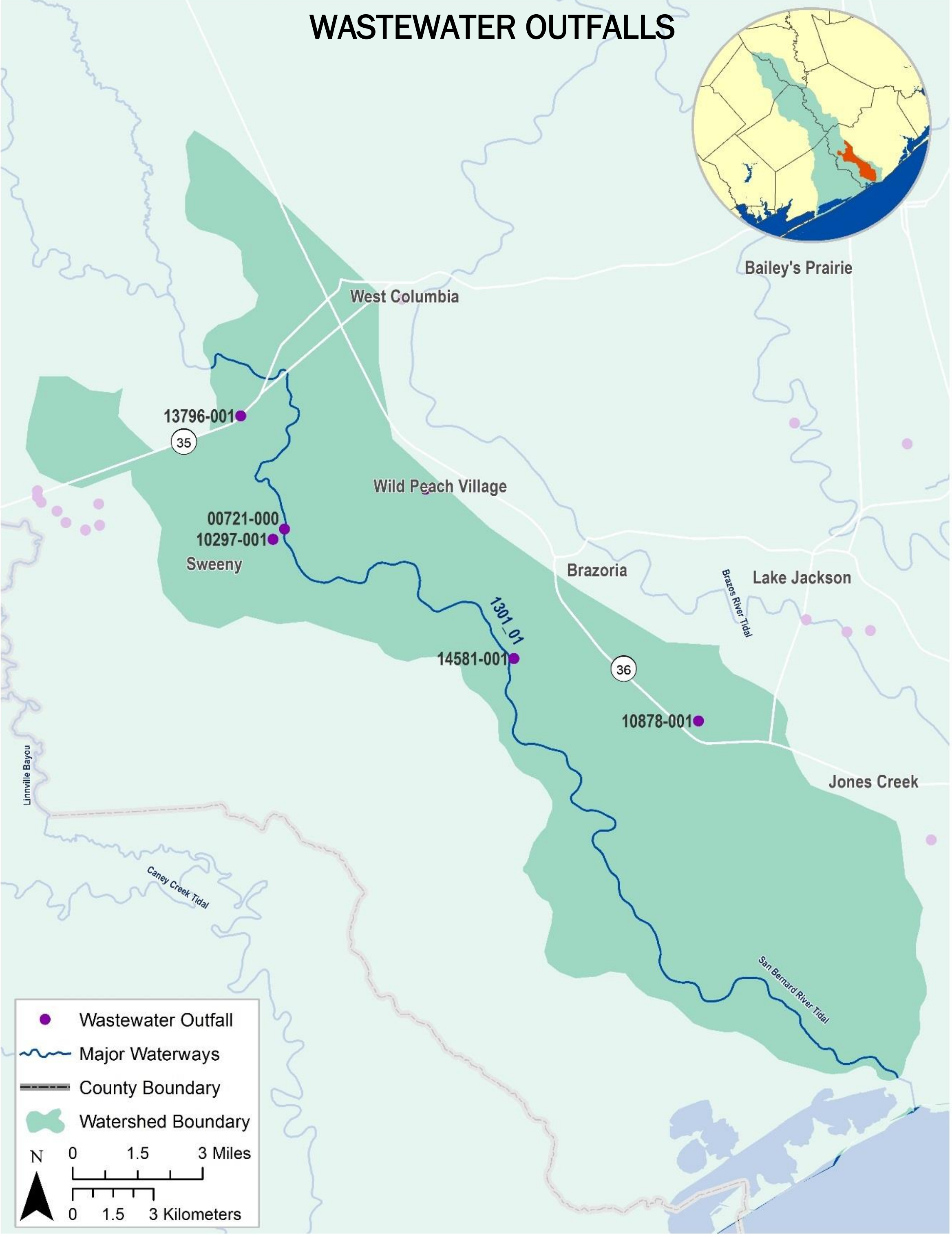
SAN BERNARD RIVER TIDAL - SEGMENT 1301
LAND COVER



SAN BERNARD RIVER TIDAL - SEGMENT 1301
IMPAIRMENTS AND CONCERNS



SAN BERNARD RIVER TIDAL - SEGMENT 1301 WASTEWATER OUTFALLS



Segment Number:	**1301**	**Name:**	**San Bernard River Tidal**		
Length:	34 miles	**Watershed Area:**	131 square miles	**Designated Uses:**	Primary Contact Recreation 1; High Aquatic Life
Number of Active Monitoring Stations:	2	**Texas Stream Team Monitors:**	7	**Permitted Outfalls:**	6
Description:	Segment 1301 (Tidal Stream w/ high ALU): From the confluence with the Intracoastal Waterway in Brazoria County to a point 3.2 km (2.0 mi) upstream of SH 35 in Brazoria County				

Percent of Stream Impaired or of Concern

Segment ID	Bacteria
1301	100

Segment 1301

Standards	Tidal Stream	Screening Levels	Tidal Stream
Temperature (°C/°F):	35 / 95	Ammonia-N (mg/L):	0.46
Dissolved Oxygen *(24-Hr Average)* (mg/L):	4.0	Nitrate-N (mg/L):	1.10
Dissolved Oxygen *(Absolute Minima)* (mg/L):	3.0	Orthophosphate Phosphorus (mg/L):	0.46
pH (standard units):	6.5-9.0	Total Phosphorus-P (mg/L):	0.66
Enterococci (MPN/100mL) (grab):	104	Chlorophyll *a* (µg/L):	21
Enterococci (MPN/100mL) (geometric mean):	35		

FY 2016 Active Monitoring Stations				
Site ID	**Site Description**	**Frequency**	**Monitoring Entity**	**Parameter Groups**
12146	San Bernard River at FM 2611	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll a
20460	San Bernard River Tidal at SH 35	Quarterly	EIH	Field, Conventional, Bacteria

Water Quality Issues Summary				
Issue	**2014 Assessment** *I – Impaired* *C – Of Concern*		**Possible Causes / Influences / Concerns Voiced by Stakeholders**	**Possible Solutions / Actions To Be Taken**
Elevated Levels of Indicator Bacteria	1301	I	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Constructed stormwater controls failing ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Poorly operated or undersized WWTFs ▪ Waste haulers illegal discharges/improper disposal ▪ WWTF non-compliance, overflows, and collection system by-passes	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ Improve construction oversight to minimize TSS discharges to waterways ▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Increase monitoring requirements for self-reporting ▪ Require all systems to develop and implement a utility asset management program and protect against power outages at lift stations ▪ Address wildlife, particularly feral hogs.

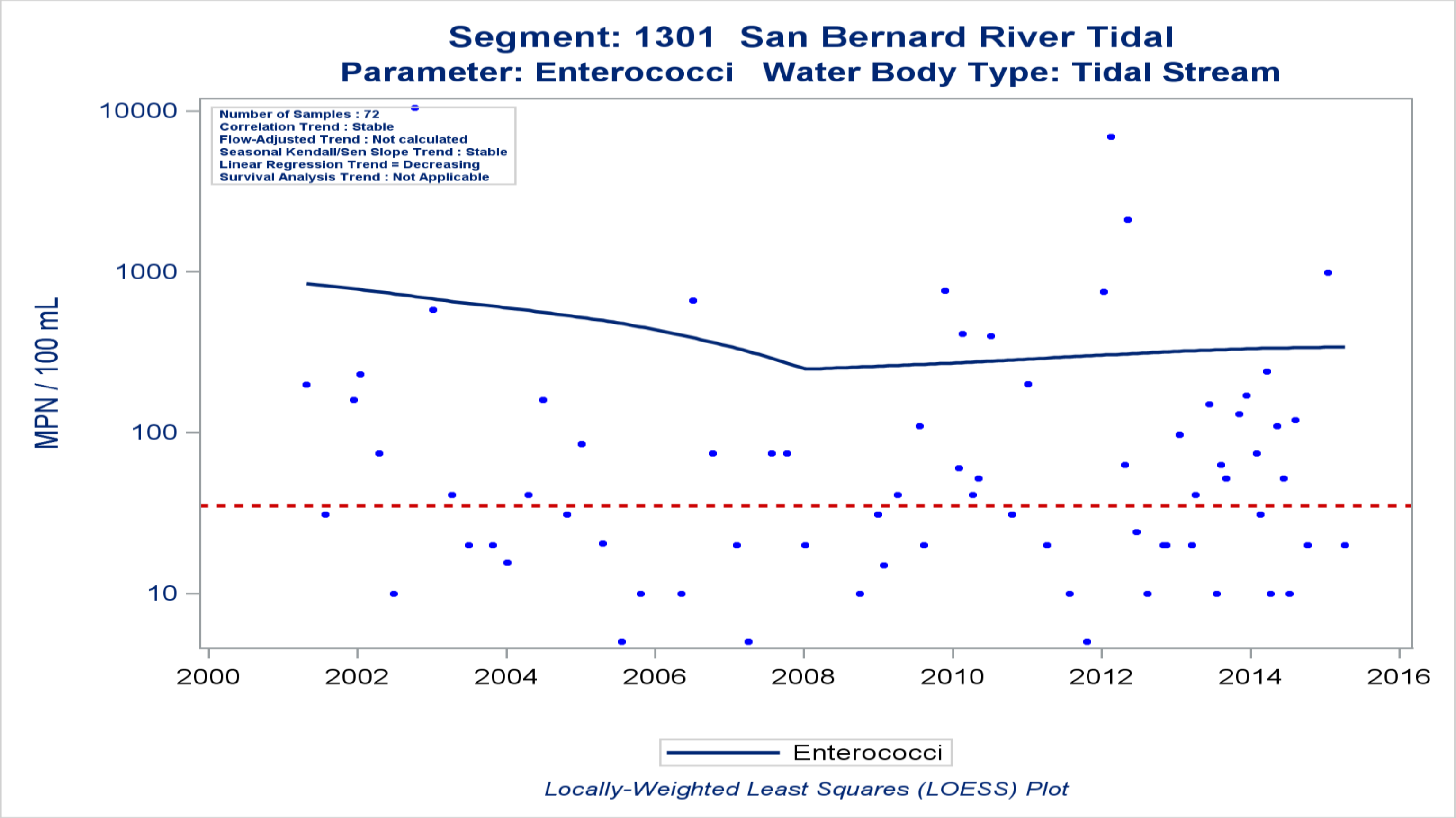
Segment Discussion:

Watershed Characteristics: The watershed is predominantly undeveloped with the exception of a few small towns including West Columbia, Wild Peach Village, Sweeny, Brazoria, and Jones Creek. Although there has not been a lot of development in the watershed, land that was previously grassland is now cultivated land, and some areas that were previously classified as forested land are now classified as woody wetlands. Of note, much of this tidal segment contains a thin ring of residential development, much like a lake, with the majority of residents on OSSFs (Figure 4.5). A large portion of the lower watershed by the mouth of the river is wetlands. The Justin Hurst Wildlife Management Area and the San Bernard National Wildlife Refuge are located in this segment.

Water Quality Issues: Contact recreation use is impaired by elevated levels of bacteria. The TCEQ Assessment geometric mean for enterococci in AU 1301_01 is 50.5, which is significantly higher than the standard of 35 MPN/100ml. The H-GAC 2008 – 2015 analysis calculated a geometric mean of 60, with 62% of the samples having a grab exceedance over the standard.

Special Studies/Projects: A Watershed Protection Plan (WPP) was completed for this segment, December 2012. WPP was approved by the TCEQ and EPA in June 2017. The WPP can be found at: http://www.h-gac.com/community/water/watershed_protection/san-bernard-river.aspx. H-GAC is working with the TCEQ's TMDL program to facilitate stakeholder efforts to address bacteria impairments and provide water quality improvement outreach and training.

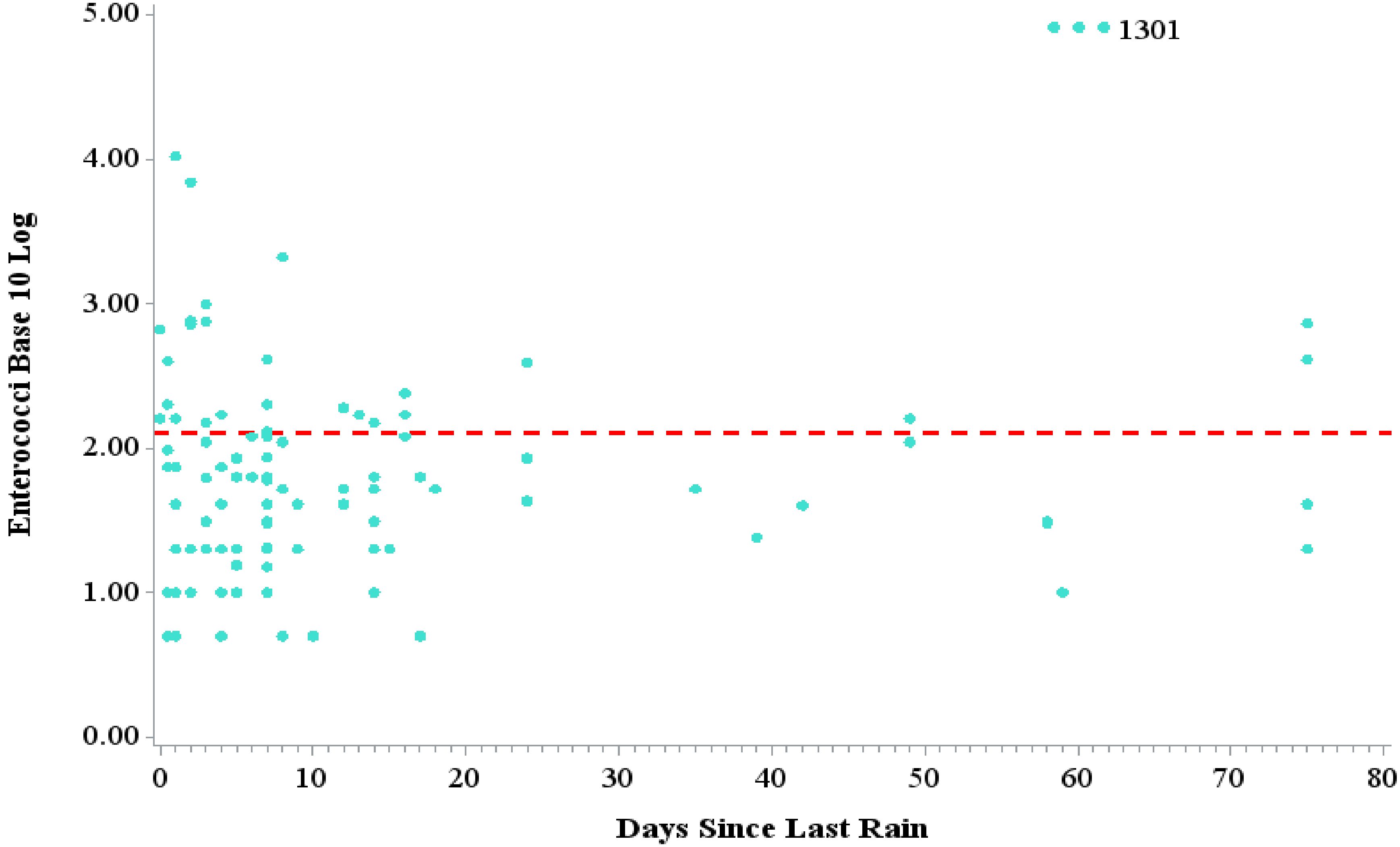
Trends: Enterococci levels, figure below, remain stable throughout the watershed with the majority of samples exceeding the 35 MPN/100 mL standard (Red dashed line).


Segment: 1301 San Bernard River Tidal
Parameter: Enterococci Water Body Type: Tidal Stream
Number of Samples : 72
Correlation Trend : Stable
Flow-Adjusted Trend : Not calculated
Seasonal Kendall/Sen Slope Trend : Stable
Linear Regression Trend = Decreasing
Survival Analysis Trend : Not Applicable
MPN / 100 mL
10000
1000
100
10
2000
2002
2004
2006
2008
2010
2012
2014
2016
Enterococci
Locally-Weighted Least Squares (LOESS) Plot

LDC Discussion

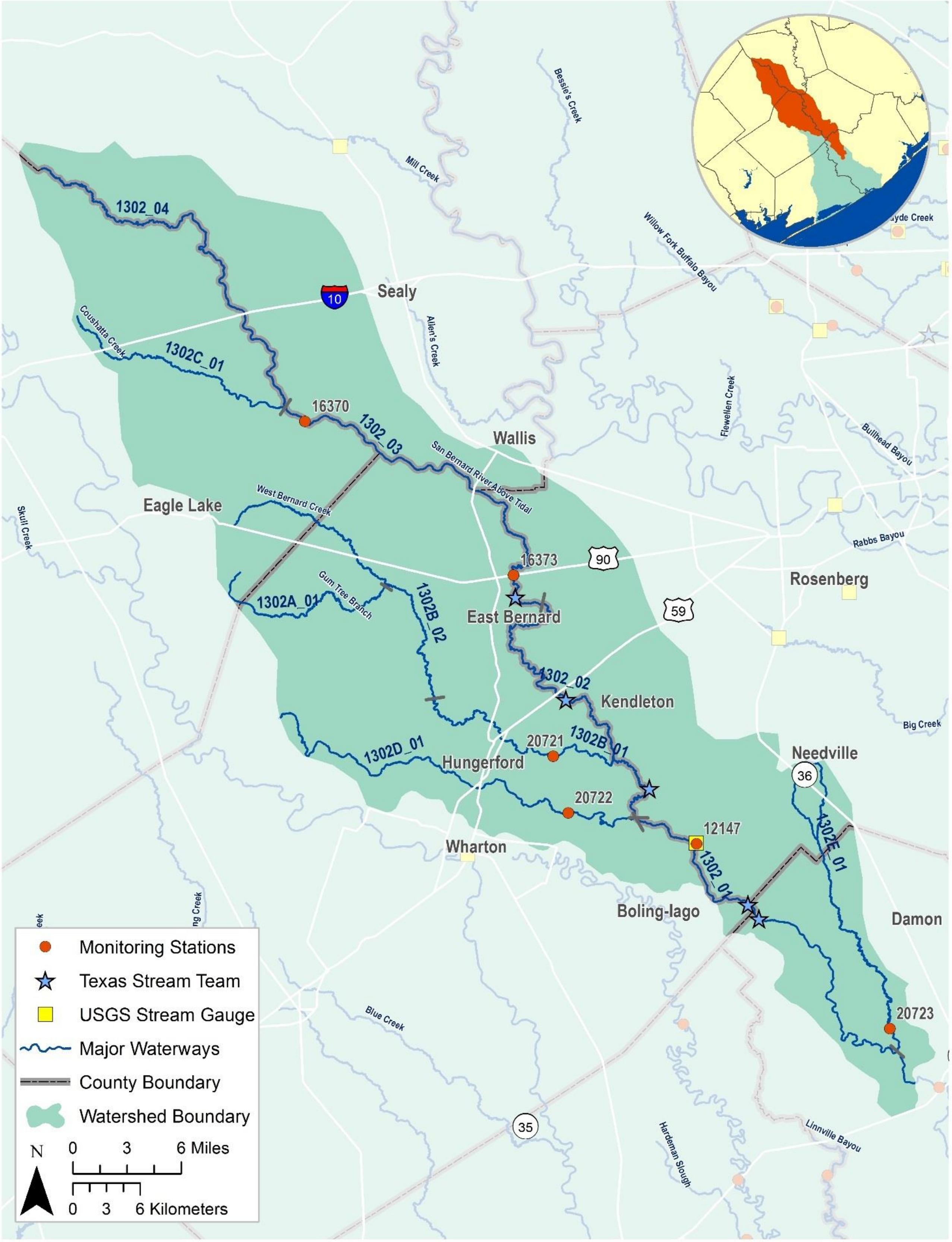
While there was sufficient bacteria data to complete a LDC, the tidal influence prohibited development of a simple LDC for this segment for this report. Using the Days Since Last Rain plot as a surrogate until a more complex LDC or model can be developed suggests that bacteria declines as bacteria data is collected the greater number of days since last rainfall. Most data after seven days since last rain appear to meet the standard (red dashed line). Days Since Last Rain is problematic as a surrogate as the bacteria data collected cannot be framed within the ambient conditions present as derived by flow conditions (i.e. extreme wet, wet, moderate, dry, extreme dry). A data point could be collected thirty days since the last rain event even while conditions for the watershed are still considered wet. Likewise, a bacteria sample could be collected a day after a rain event while the pervasive conditions are drought for the watershed. As Days Since Last Rainfall cannot be used to explain the watersheds conditions when the data was collected, it is a far weaker argument compared to the use of LDCs, to say that bacteria loads are less of a problem during dry conditions due to bacteria generated by waste water treatment facilities or failing OSSFs.

Bacteria vs Days Since Last Rain
San Bernard River Tidal

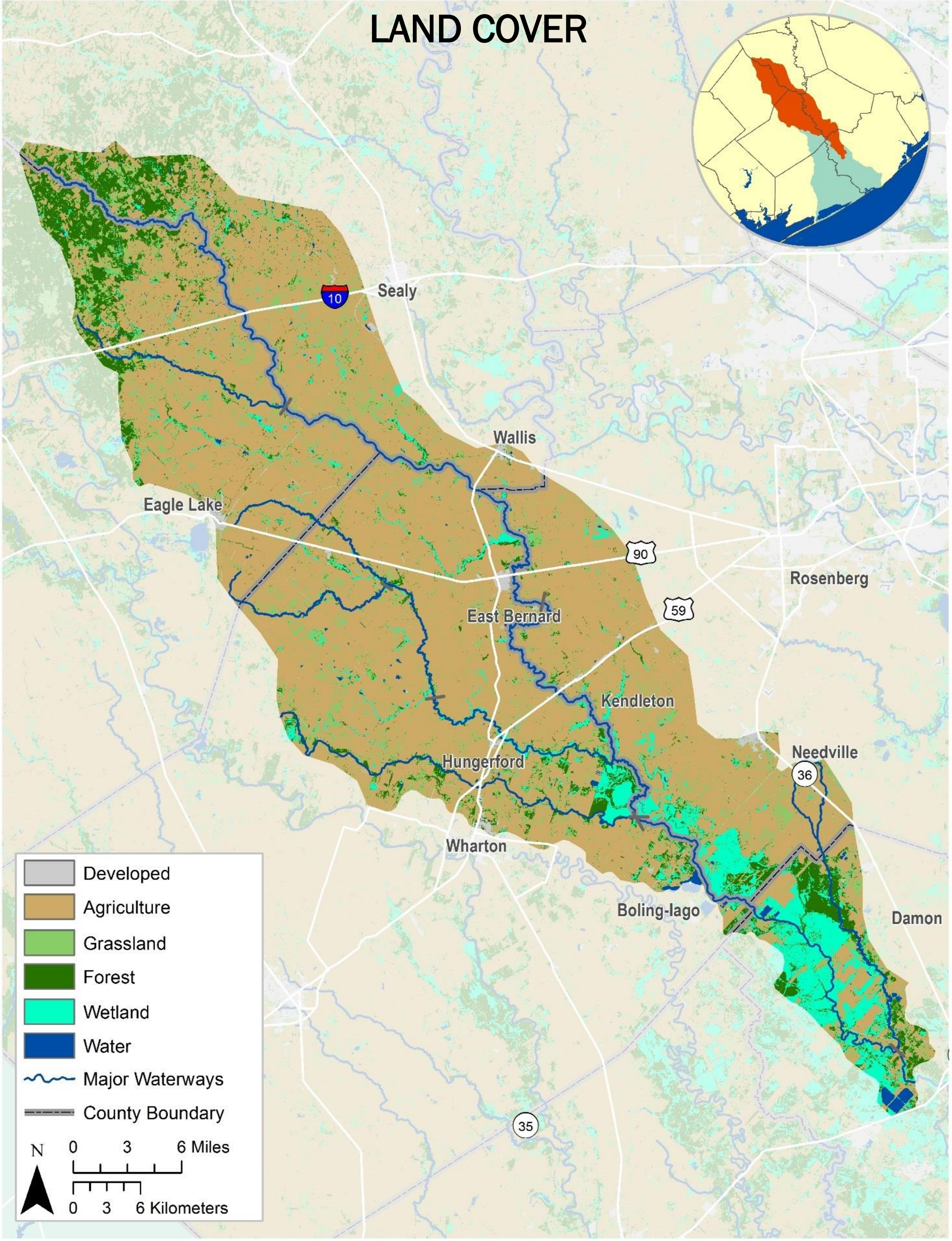


Recommendations
Add sites, at least temporarily, to gather the data necessary to complete the modeling and complete the watershed protection plan
Address concerns found in this segment summary through stakeholder participation and by completing the watershed protection plan.
Continue collecting water quality data to support actions associated with any future watershed protection plan development and possible modeling.
Pursue a new local partner to Clean Rivers Program to collect additional data that would help better isolate problem areas.
Address stakeholder interest in collecting volunteer bacteria monitoring for this segment.

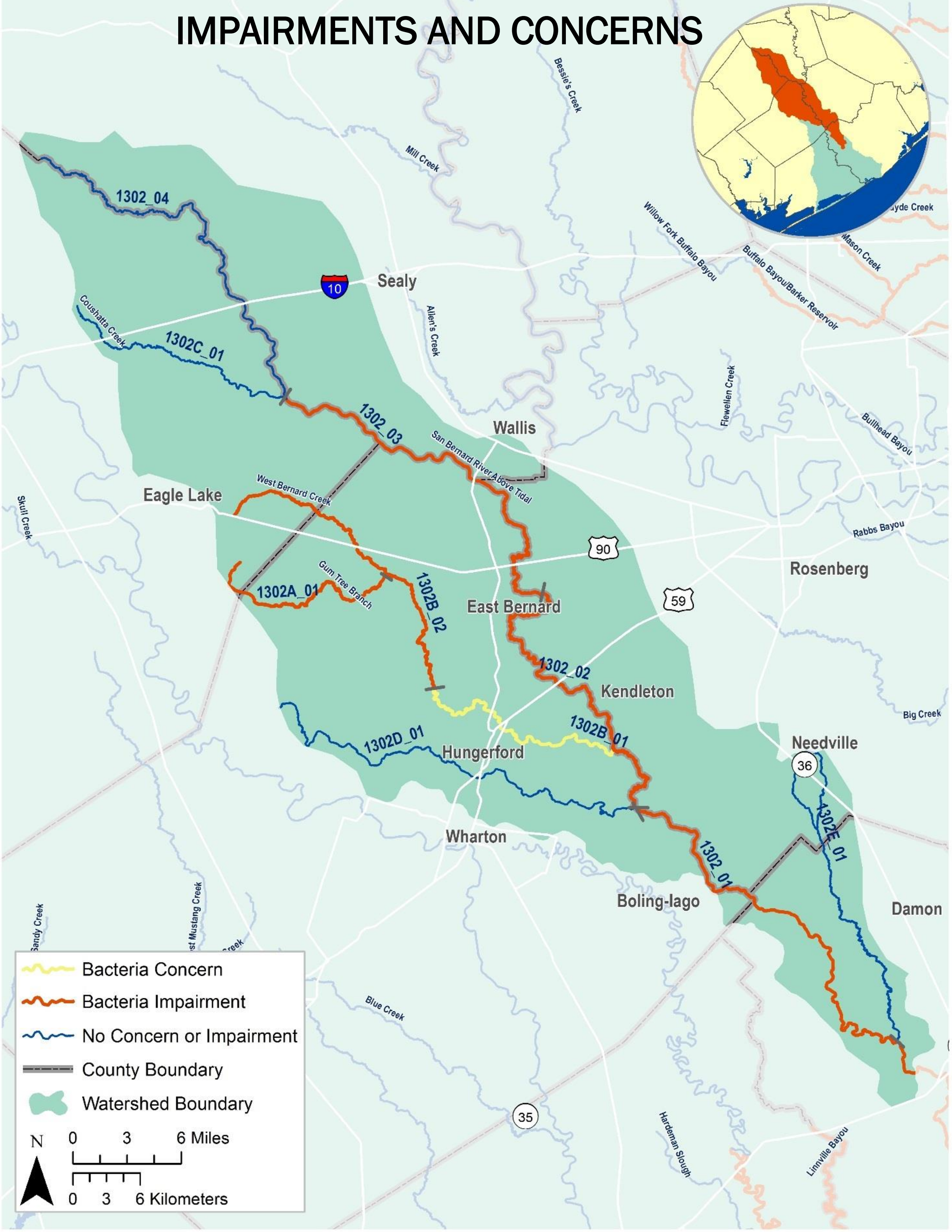
B2 SAN BERNARD RIVER ABOVE TIDAL - SEGMENT 1302



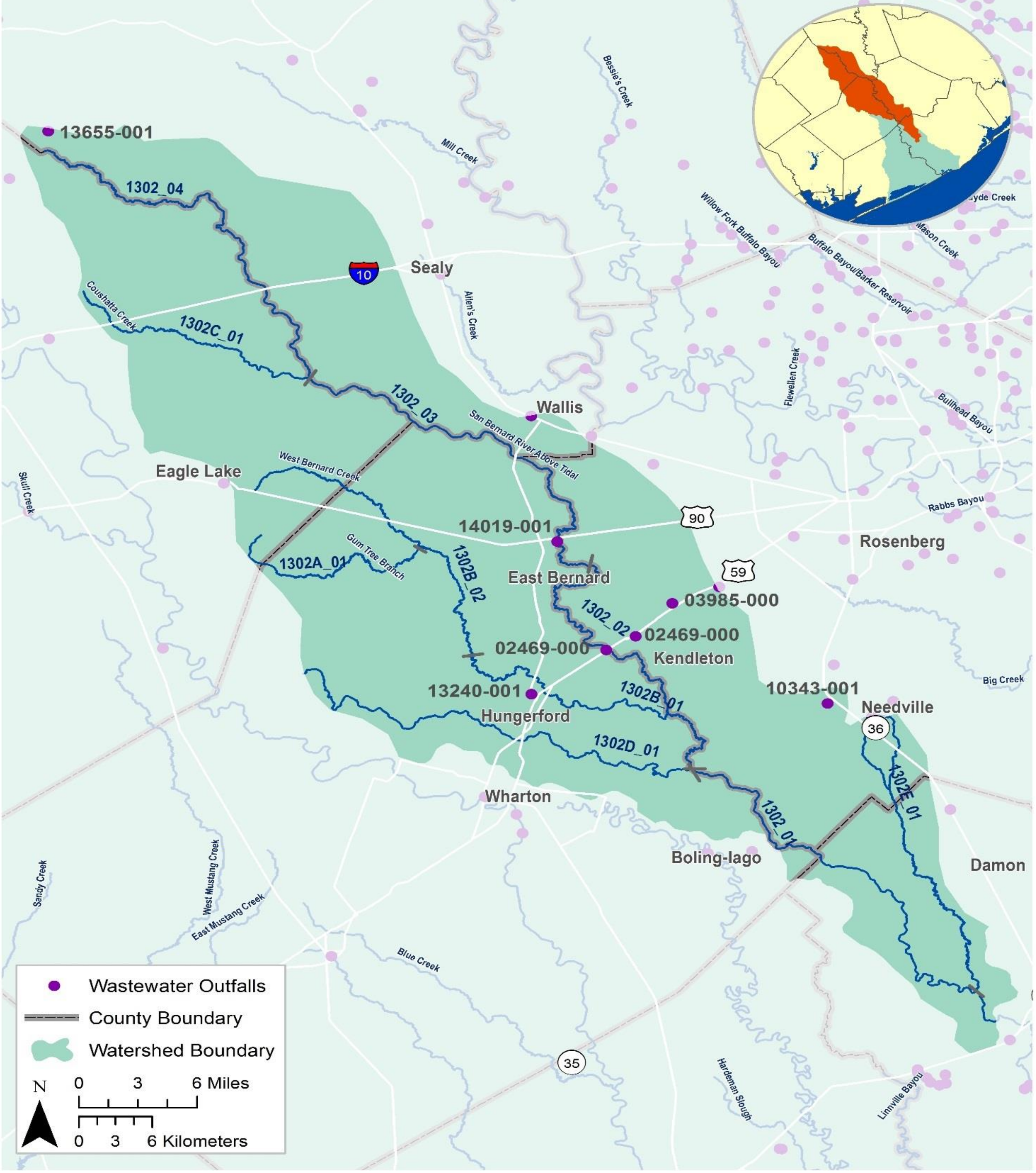
SAN BERNARD RIVER ABOVE TIDAL - SEGMENT 1302 LAND COVER



SAN BERNARD RIVER ABOVE TIDAL - SEGMENT 1302 IMPAIRMENTS AND CONCERNS



SAN BERNARD RIVER ABOVE TIDAL - SEGMENT 1302
WASTEWATER OUTFALLS



Segment Number:	**1302**	**Name:**	**San Bernard River Above Tidal**

Length	110 miles	**Watershed Area:**	864 square miles	**Designated Uses:**	Primary Contact Recreation 1; High Aquatic Life; Public Water Supply

Number of Active Monitoring Stations:	6	**Texas Stream Team Monitors:**	5	**Permitted Outfalls:**	10

Description:	Segment 1302 (Perennial Stream w/ high ALU): From a point 3.2 km (2.0 mi) upstream of SH 35 in Brazoria County to the county road southeast of New Ulm in Austin County Segment 1302A (Perennial Stream w/ high ALU): Gum Tree Branch (unclassified water body) — From the confluence with West Bernard Creek near Wharton CR 252 to the headwaters approximately 15 miles upstream near RR 102 Segment 1302B (Perennial Stream w/ high ALU): West Bernard Creek (unclassified water body) — From the confluence with the San Bernard River Above Tidal downstream of US Highway 59 to the headwaters approximately 40 miles upstream near FM 1093 Segment 1302C (Perennial Stream w/ high ALU): Coushatta Creek (unclassified water body) – From the confluence with the San Bernard River Above Tidal upstream to a point 4.6 km upstream of I-10 Segment 1302D (Perennial Stream w/ high ALU): Peach Creek (unclassified water body) – From the confluence with the San Bernard River in Wharton County to the headwaters approximately 8 km upstream of FM 102 in Wharton County

Percent of Stream Impaired or of Concern	
Segment ID	**Bacteria**
1302	74.6
1302A	100
1302B	100

Segment 1302

Standards	Perennial Stream	Screening Levels	Perennial Stream
Temperature (°C/°F):	32 / 90	Ammonia (mg/L):	0.33
Dissolved Oxygen *(24-Hr Average)* (mg/L):	5.0	Nitrate-N (mg/L):	1.95
Dissolved Oxygen *(Absolute Minima)* (mg/L):	3.0	Orthophosphate Phosphorus (mg/L):	0.37
pH (standard units):	6.5-9.0	Total Phosphorus (mg/L):	0.69
E. coli (MPN/100 mL) (grab):	399	Chlorophyll *a* (µg/L):	14.1
E. coli (MPN/100 mL) (geometric mean):	126		
Chloride (mg/L as Cl):	200		
Sulfate (mg/L as SO_4):	100		
Total Dissolved Solids (mg/L):	500		

FY 2016 Active Monitoring Stations

Site ID	Site Description	Frequency	Monitoring Entity	Parameter Groups
12147	San Bernard River at FM 442	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll *a*, Flow
16370	San Bernard River at FM 3013	Quarterly	EIH	Field, Conventional, Bacteria, Flow
16373	San Bernard R at US 90a	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll *a*, Flow
20721	West Bernard Creek at CR 255	Quarterly	EIH	Field, Conventional, Bacteria, Flow
20722	Peach Creek at CR 177	Quarterly	EIH	Field, Conventional, Bacteria, Flow
20723	Mound Creek at CR 450	Quarterly	EIH	Field, Conventional, Bacteria, Flow

Water Quality Issues Summary

Issue	2014 Assessment *I – Impaired* *C – Of Concern*	Possible Causes / Influences / Concerns Voiced by Stakeholders	Possible Solutions / Actions To Be Taken
Elevated Levels of Indicator Bacteria	1302_01 I 1302_02 I 1302_03 I 1302_04	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Poorly operated or undersized WWTFs ▪ Waste haulers illegal discharges/improper disposal ▪ WWTF non-compliance, overflows, and collection system by-passes	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operations and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Require all WWTFs to develop and implement a utility asset management program and protect against power outages at lift stations ▪ Address wildlife, particularly feral hogs.
	1302A I	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Poorly operated or undersized WWTFs ▪ Waste haulers illegal discharges/improper disposal ▪ WWTF non-compliance, overflows, and collection system by-passes	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operations and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Require all WWTFs to develop and implement a utility asset management program and protect against power outages at lift stations ▪ Address wildlife, particularly feral hogs.

	1302B_01 **C** 1302B_02 **I**	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Poorly operated or undersized WWTFs ▪ Waste haulers illegal discharges/improper disposal ▪ WWTF non-compliance, overflows, and collection system by-passes	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Address wildlife, particularly feral hogs. ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operations and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Require all WWTFs to develop and implement a utility asset management program and protect against power outages at lift stations

Segment Discussion:

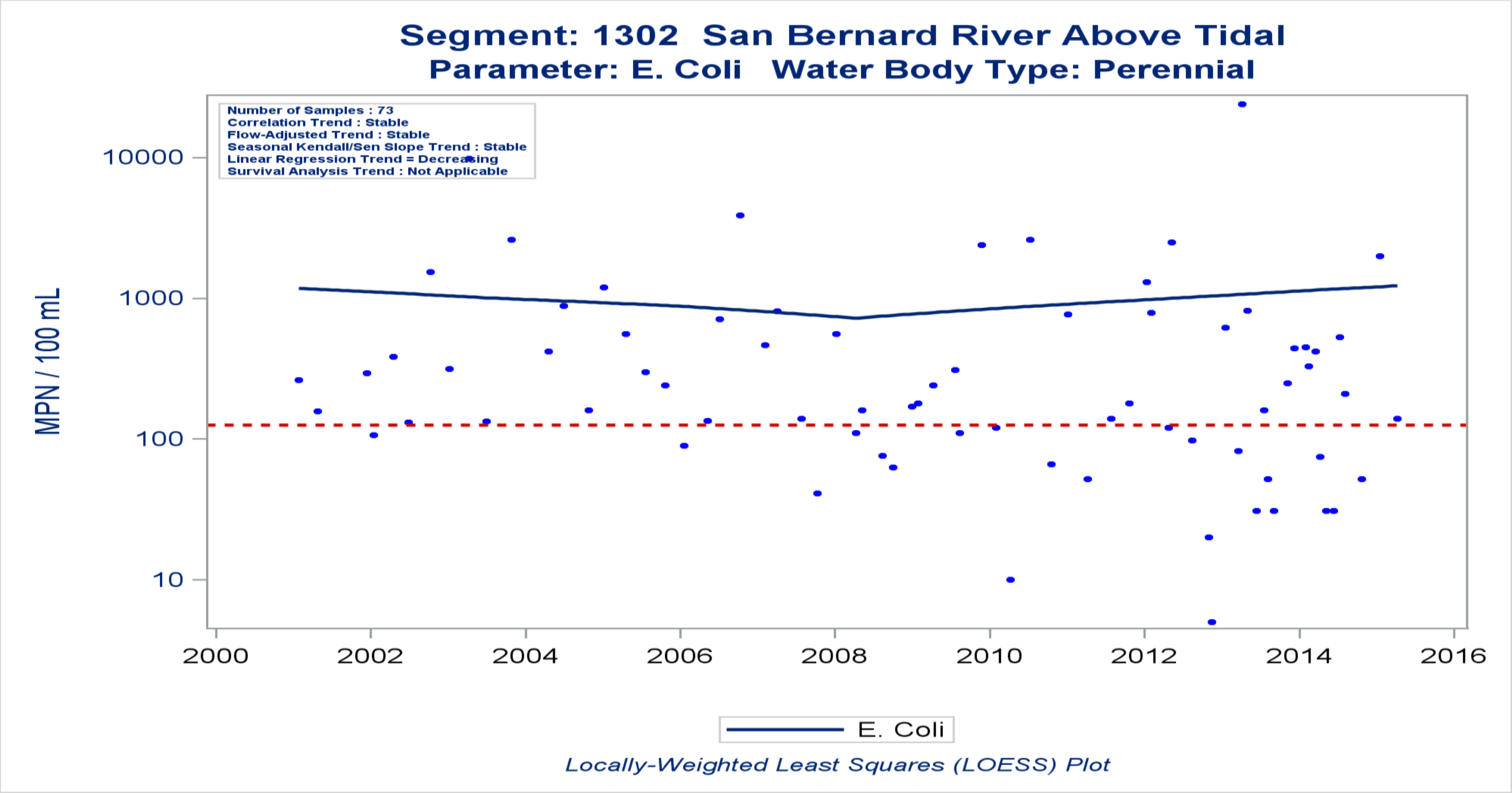
Watershed Characteristics: The watershed is sparsely populated and contains the small towns of East Bernard, Kendleton, Needville, Wallis, Hungerford, and Eagle Lake. The Attwater Prairie Chicken National Wildlife Refuge is located near Eagle Lake. The vast majority of the watershed is classified as agricultural with plots of wetland and forested areas scattered throughout, especially in the northern and southern portions of the watershed. The area has experienced more single-family development in rural areas, causing large tracts of land to be divided up into smaller parcels. Projected population growth in the area will continue to spur development where cultivated land used to predominate, though not nearly as fast as other areas of the H-GAC CRP region.

Water Quality Issues: The 2014 Texas Integrated Report (IR) lists the three assessment units of the classified water body (segment 1302) and two (1302A and 1302B) of the five tributaries as impaired for contact recreational use due to elevated levels of *E. coli*. The unclassified segment 1302D_01 was not designated impaired or as a concern of nonattainment for the 2014 IR; however, recent sampling events suggest that this water body is impaired for recreational use. The TCEQ assessment data and H-GAC analyses are summarized below:

Assessment Unit	TCEQ Assessment (2005-2012)	HGAC Analysis 2001-2008	HGAC Analysis 2008-2015
	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance
1302_01	192.7930213	356 / 41.4	184 / 27.3
1302_03	141.6906594	263 / 23.3	146 / 25.3
1302B_01	137.8894167	NA / NA	200 / 21.2
1302D_01	100.5532531	NA / NA	214 / 57.6
1302E_01	59.00966596	NA / NA	103 / 12.9

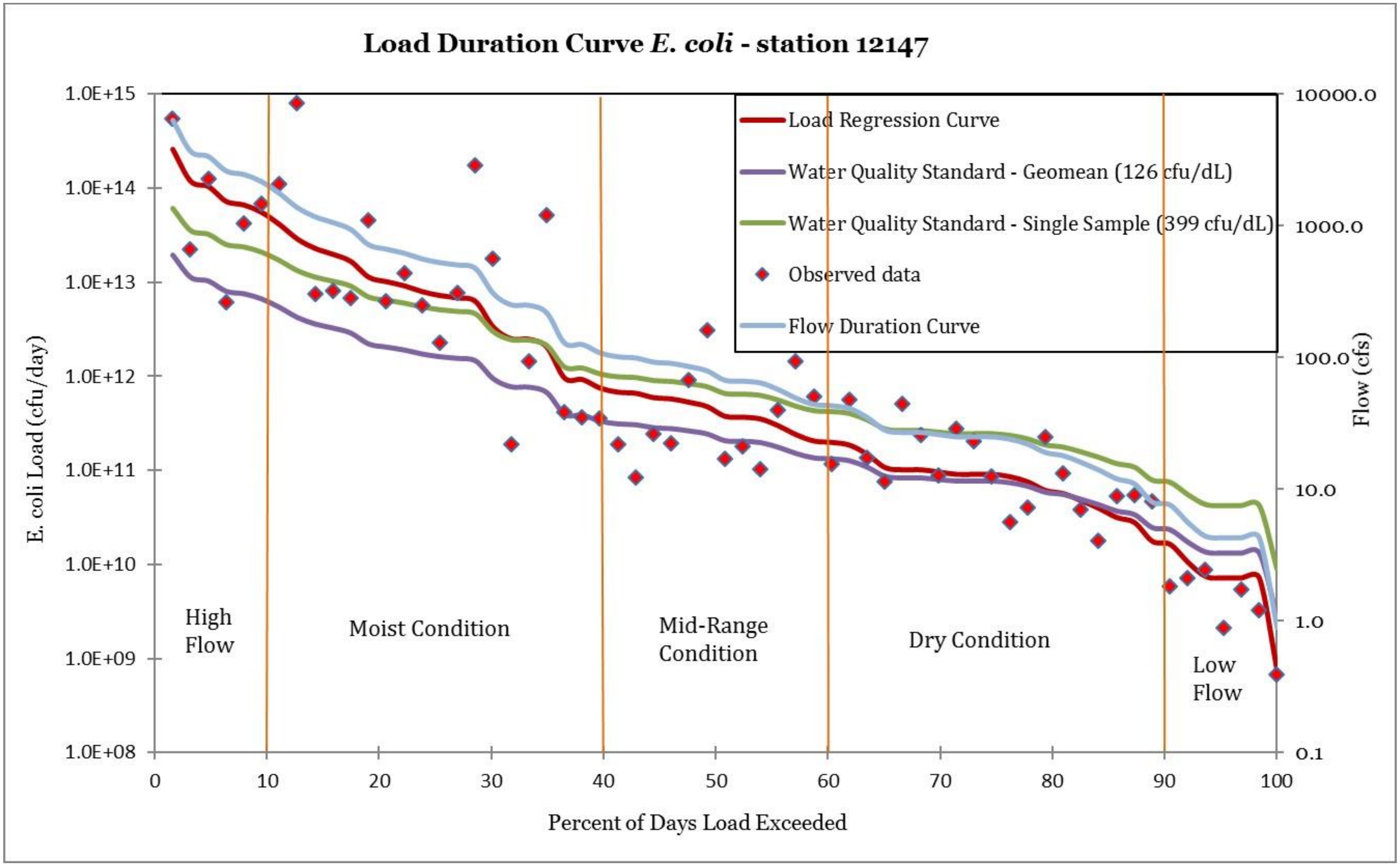
Special Studies/Projects: A Watershed Protection Plan (WPP) was completed for this segment, December 2012. WPP was approved by the TCEQ and EPA in June 2017. The WPP can be found at: http://www.h-gac.com/community/water/watershed_protection/san-bernard-river.aspx. An RUAA was completed in July 2011 for this segment and include three AUs, 1302, 1302A and 1302B.The RUAA is being evaluated by the TCEQ Standards Program and the public comment period on the study has closed. Documents related to the RUAA can be found at: https://www.tceq.texas.gov/waterquality/standards/ruaas/ruaasbrazoscolorado. H-GAC is working with the TCEQ's TMDL program to facilitate stakeholder efforts to address bacteria impairments and provide water quality improvement outreach and training.

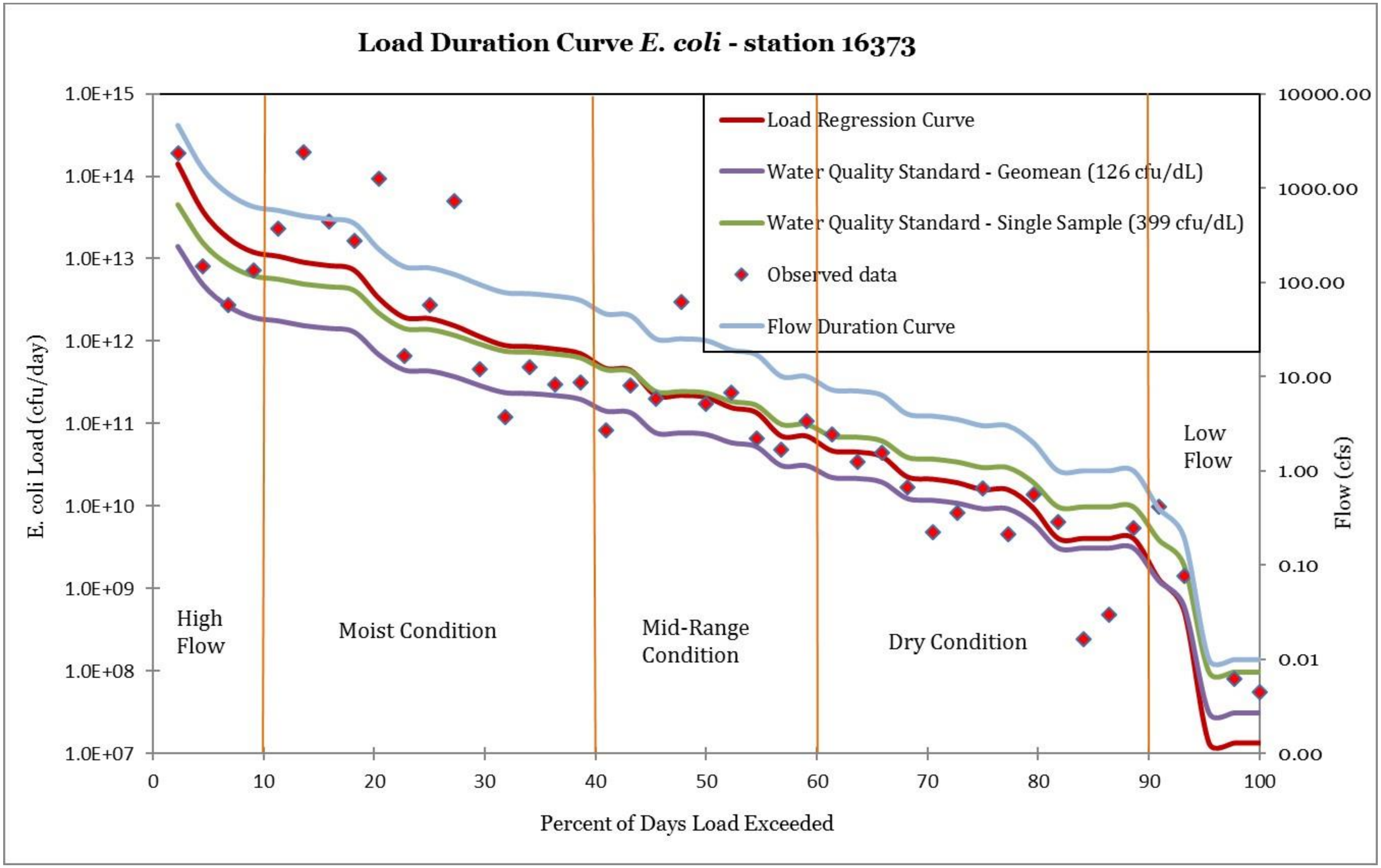
Trends: *E. coli* concentrations have remained stable over time with the majority of samples still well above the 126 MPN/100 mL water quality standard.

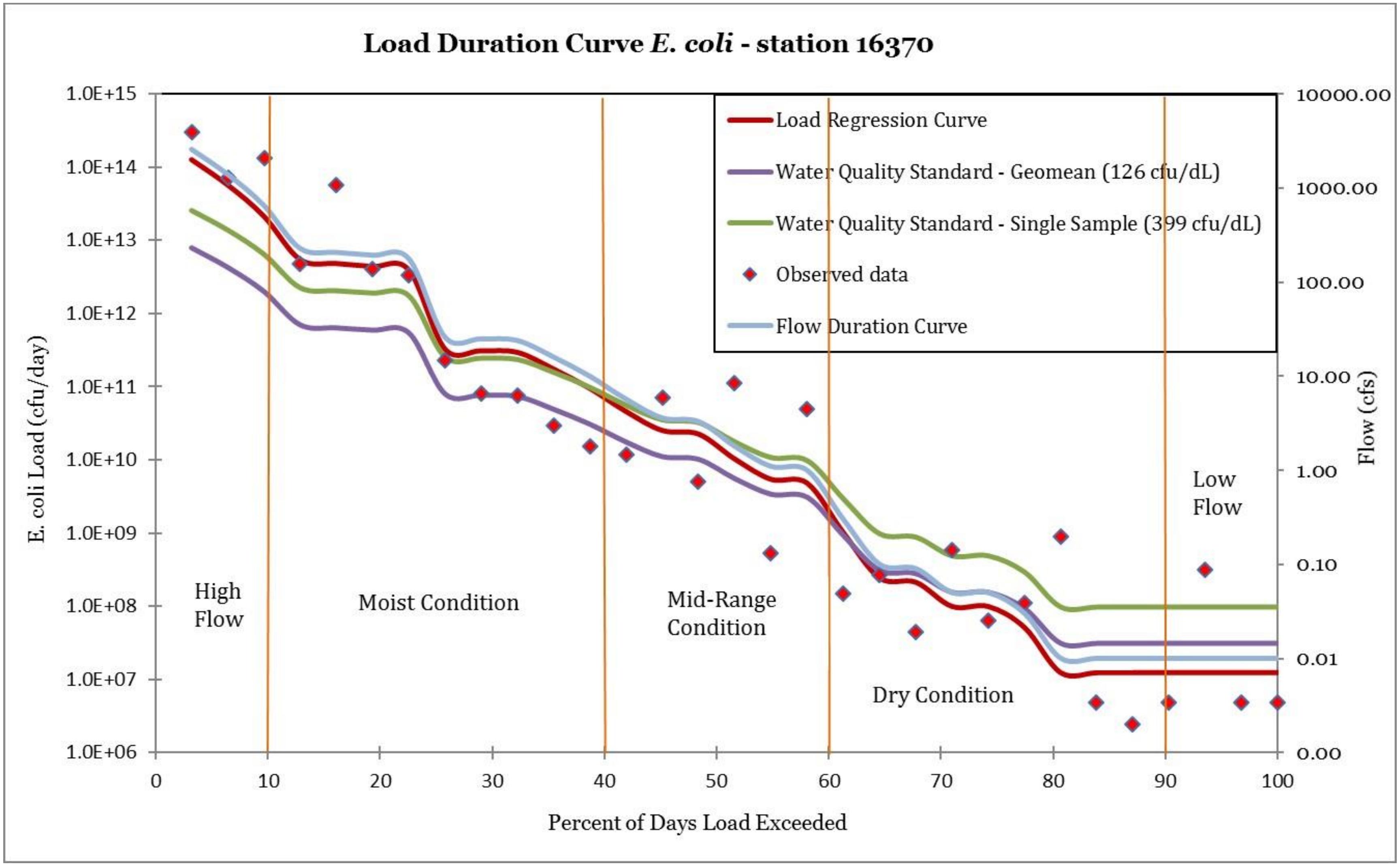

Segment: 1302 San Bernard River Above Tidal
Parameter: E. Coli Water Body Type: Perennial
Number of Samples : 73
Correlation Trend : Stable
Flow-Adjusted Trend : Stable
Seasonal Kendall/Sen Slope Trend : Stable
Linear Regression Trend = Decreasing
Survival Analysis Trend : Not Applicable
MPN / 100 mL
10000
1000
100
10
2000
2002
2004
2006
2008
2010
2012
2014
2016
E. Coli
Locally-Weighted Least Squares (LOESS) Plot

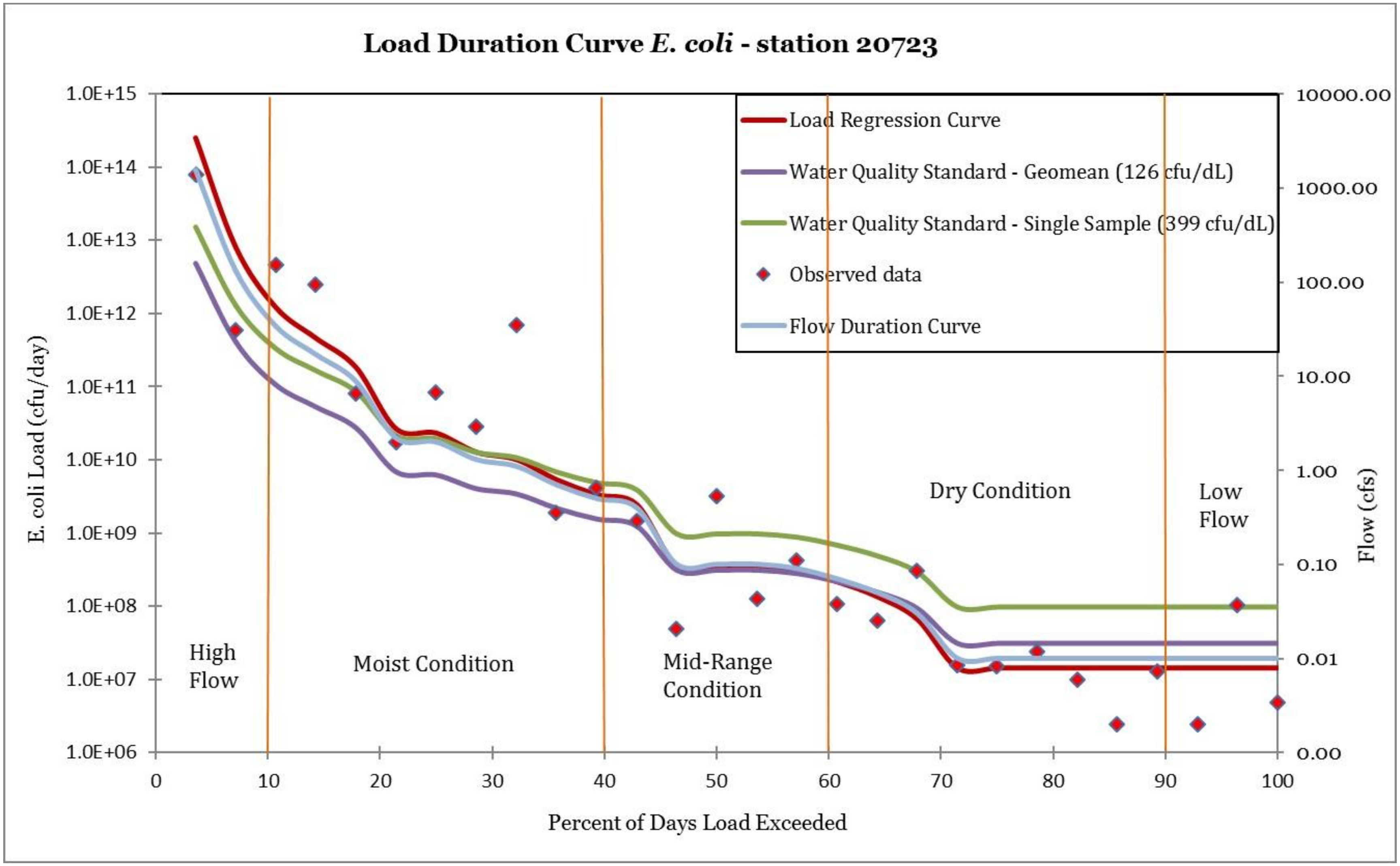
Load Duration Curves

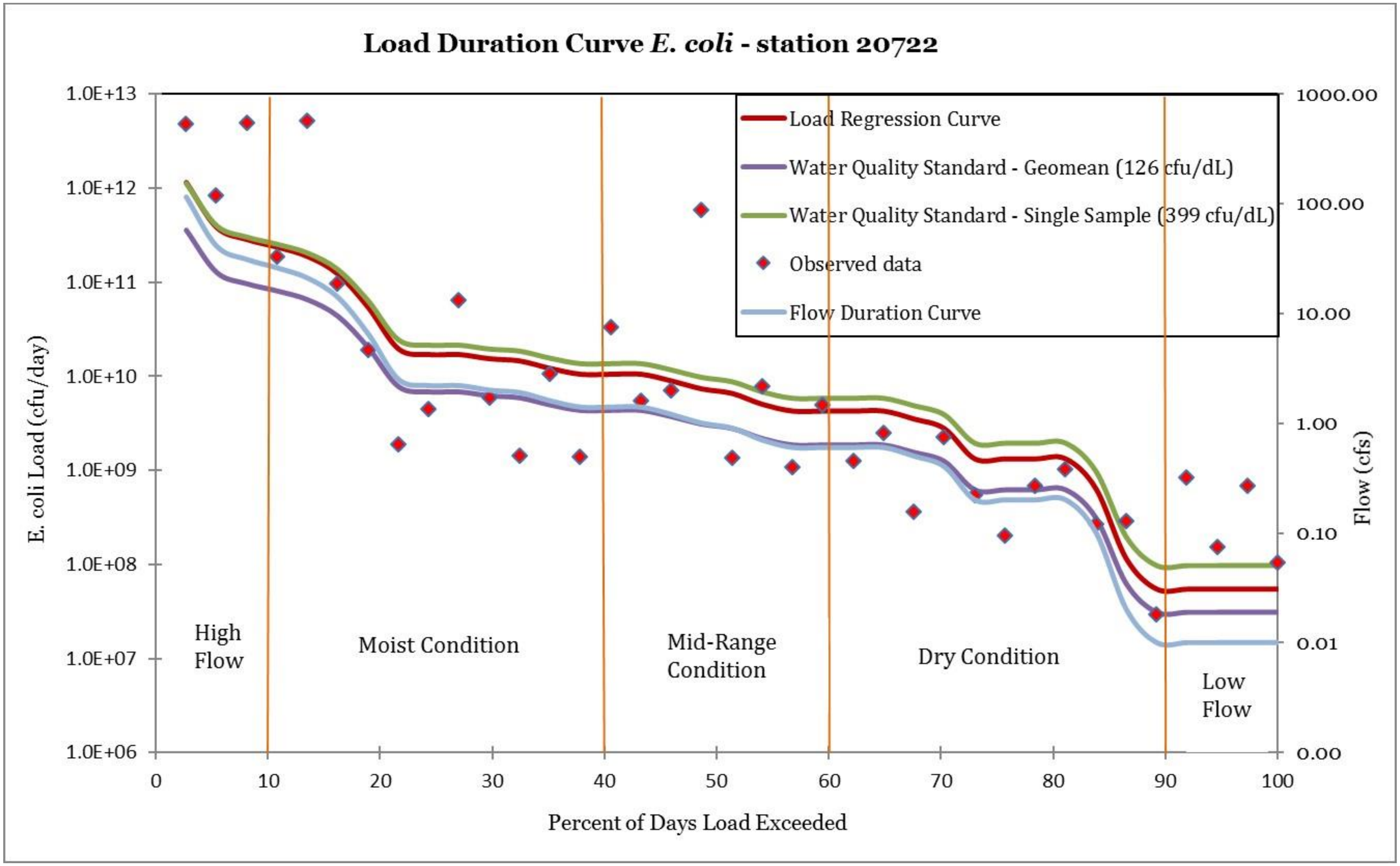
Available flow data and bacteria date were sufficient to complete a LDC for six monitoring stations in this segment. Using the results of the LDC and the Days Since Last Rainfall, factors affecting bacteria levels in this segment do not appear to correlate strongly with waste loads from waste water treatment facilities and on-site sewage facilities (OSSF) during dry periods, but they could be factors. Reading the LDC, the Load Regression Curve for bacteria data plotted exceeds the geomean standard and single grab standard approximately 30 percent of the time during the wettest period. The bacteria regression curve quickly falls below the Single Standard curve following the highest flow period and falls below the Geomean Standard curve during moderate to dry conditions nearly 70% of days load exceeded where it remains as conditions shift to dry. Station 20722 is the most interesting of the grouping. At low flows there does appear to be dry weather factors causing exceedances. If wastewater treatment and OSSF were contributing to exceedances, then the expected LDC load regression curve would be found continually above the standard during dry weather conditions. The Days Since Last Rainfall support this as the observed data after seven days exceeds the standard fairly regularly. Data for AU 1302D corresponds well with the results from LDC graph for 20722, the same station on Peach Creek.

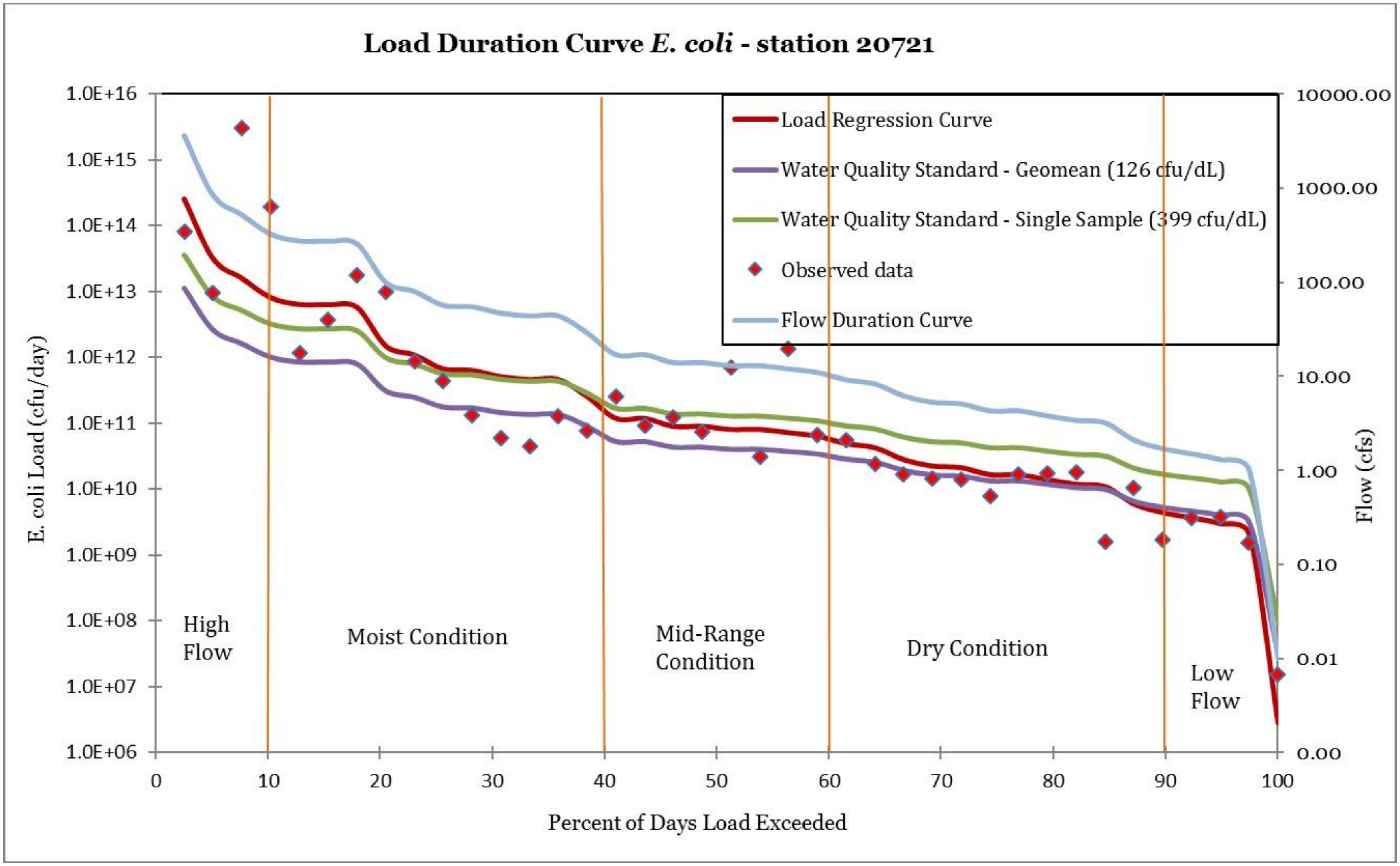

Load Duration Curve *E. coli* - station 12147

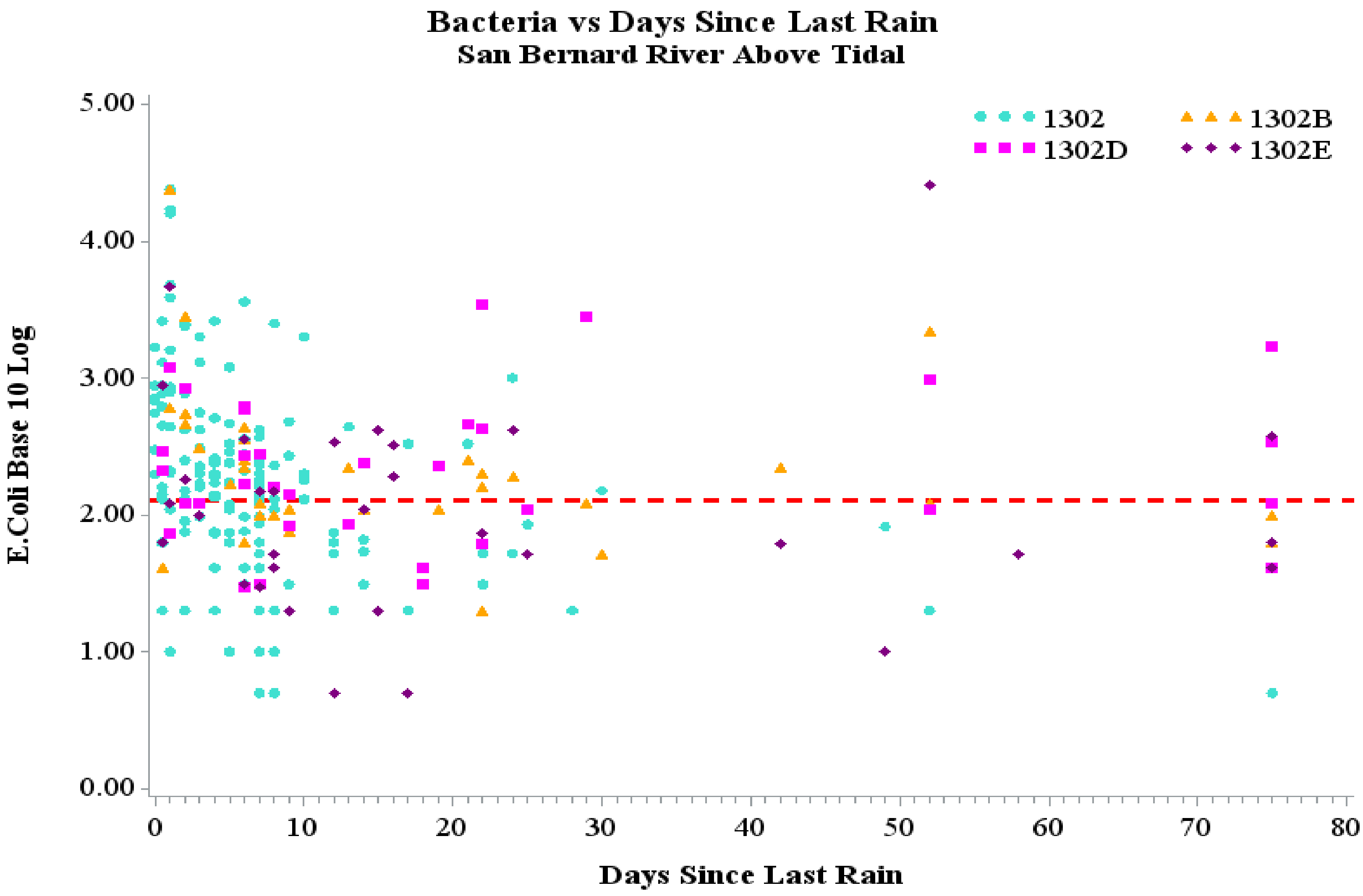

Load Duration Curve *E. coli* - station 16373
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve
E. coli Load (cfu/day)
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
Flow (cfs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow


Load Duration Curve *E. coli* - station 16370
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve
E. coli Load (cfu/day)
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
Flow (cfs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow


Load Duration Curve *E. coli* - station 20723
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve
E. coli Load (cfu/day)
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
Flow (cfs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow

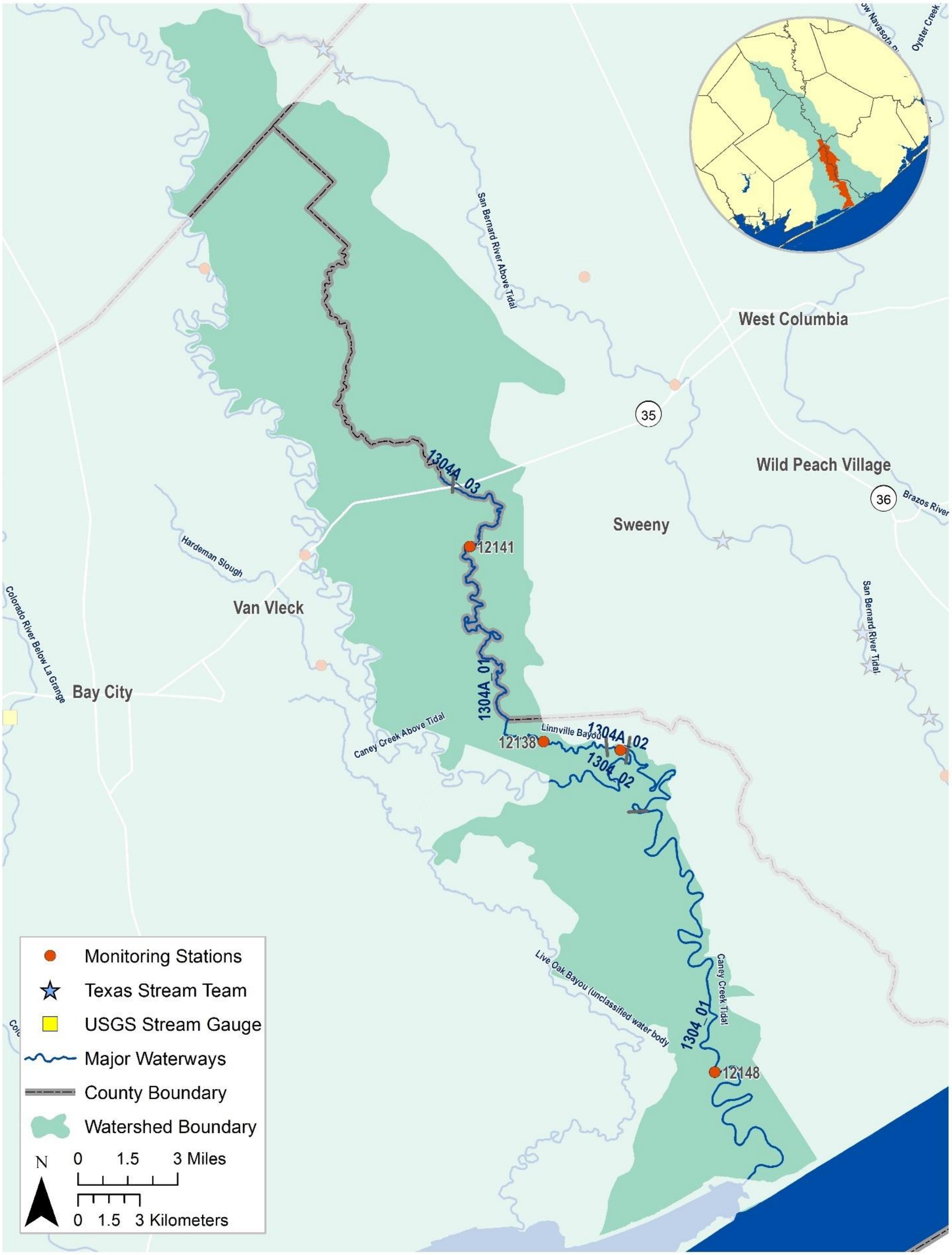

Load Duration Curve *E. coli* - station 20722
E. coli Load (cfu/day)
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
Flow (cfs)
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow


Load Duration Curve *E. coli* - station 20721
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve
E. coli Load (cfu/day)
1.0E+16
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
Flow (cfs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow


Bacteria vs Days Since Last Rain
San Bernard River Above Tidal
1302
1302B
1302D
1302E
E.Coli Base 10 Log
5.00
4.00
3.00
2.00
1.00
0.00
0
10
20
30
40
50
60
70
80
Days Since Last Rain

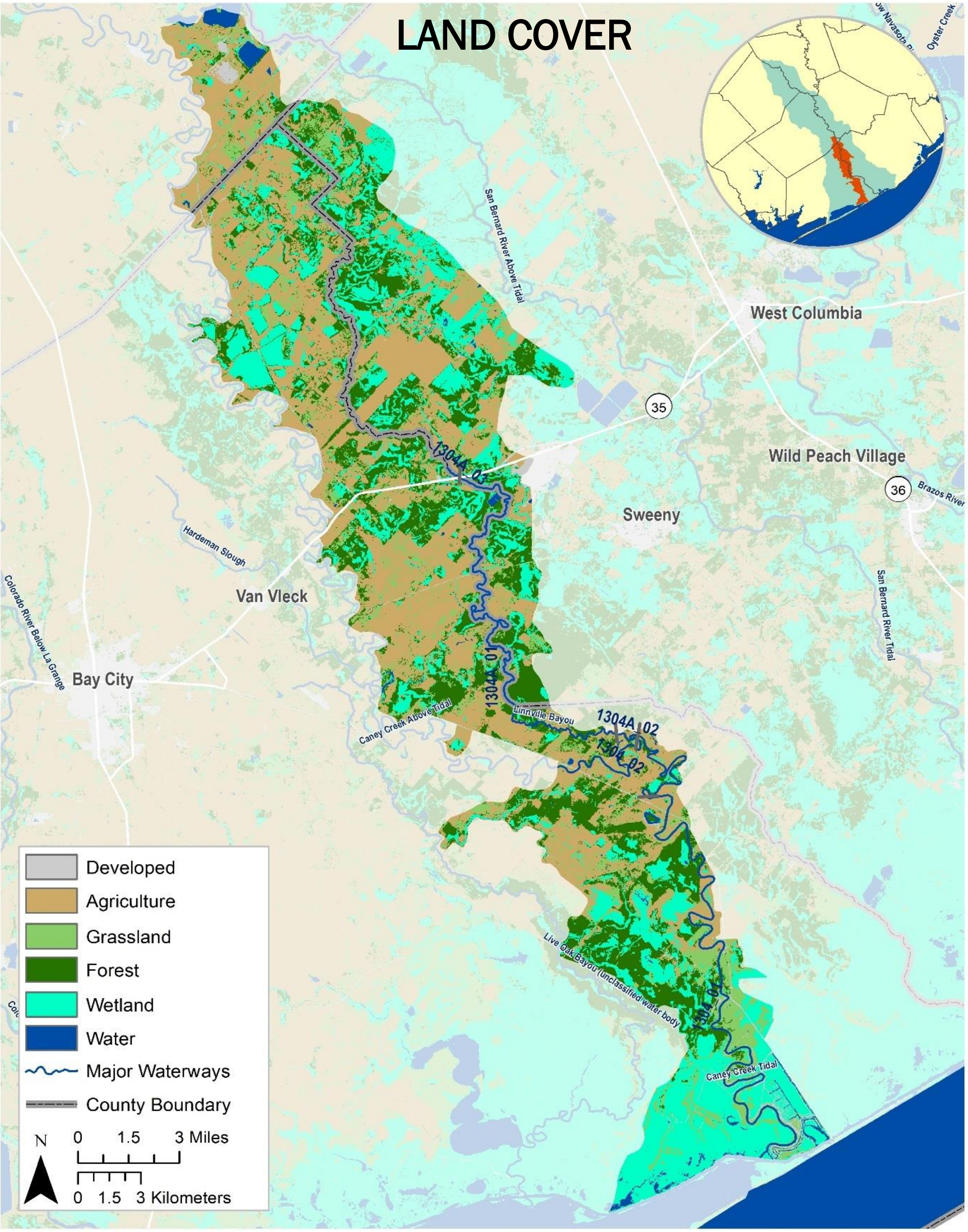
Recommendations
Add sites, at least temporarily, to gather the data necessary to complete the modeling and complete the watershed protection plan
Address concerns found in this segment summary through stakeholder participation and by completing the watershed protection plan.
Continue collecting water quality data to support actions associated with any future watershed protection plan development and possible modeling.
Pursue a new local partner to Clean Rivers Program to collect additional data that would help better isolate problem areas.
Follow up stakeholder interest to add additional TST volunteer monitoring

B3 CANEY CREEK TIDAL - SEGMENT 1304



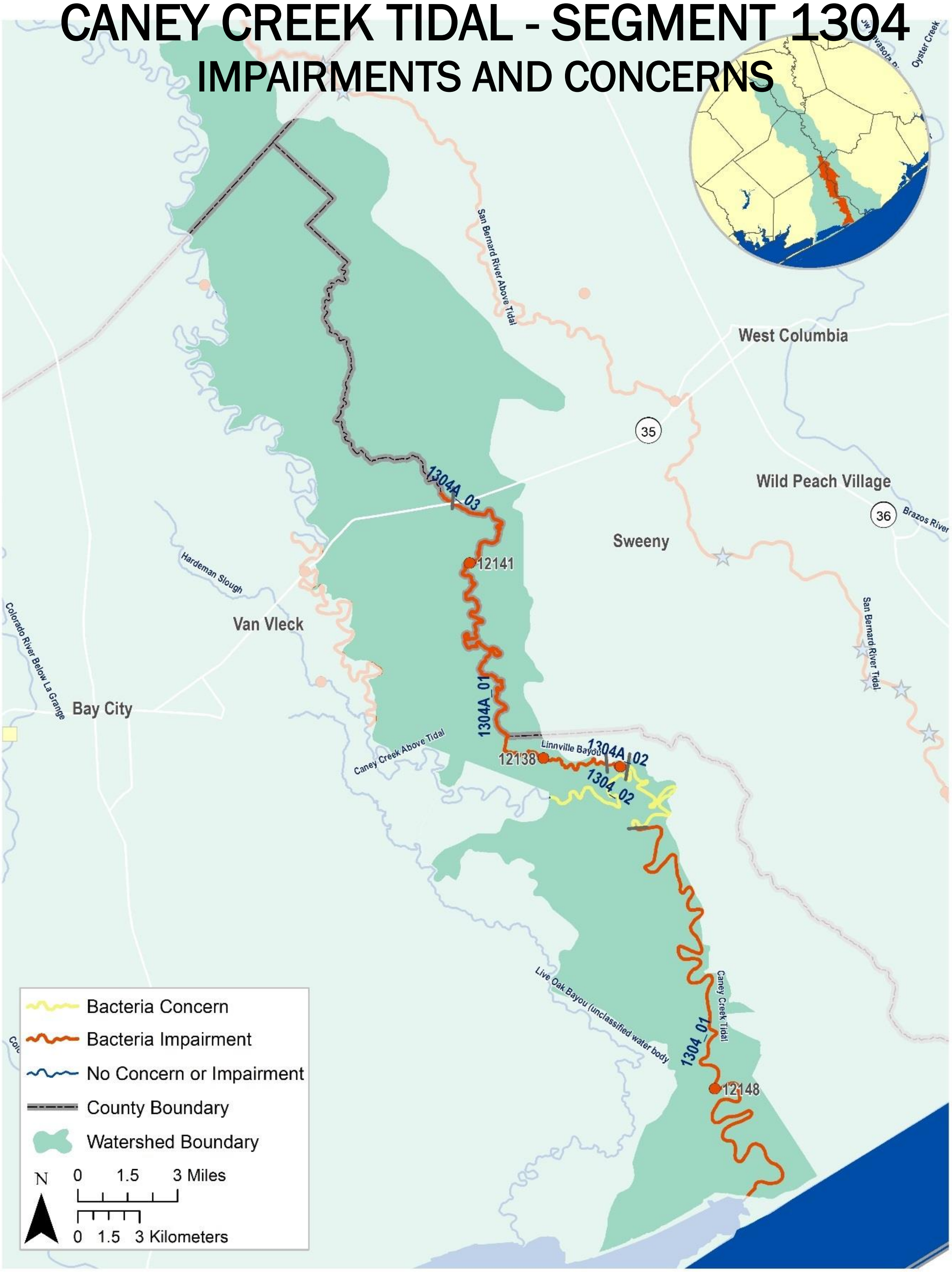
CANEY CREEK TIDAL - SEGMENT 1304

LAND COVER



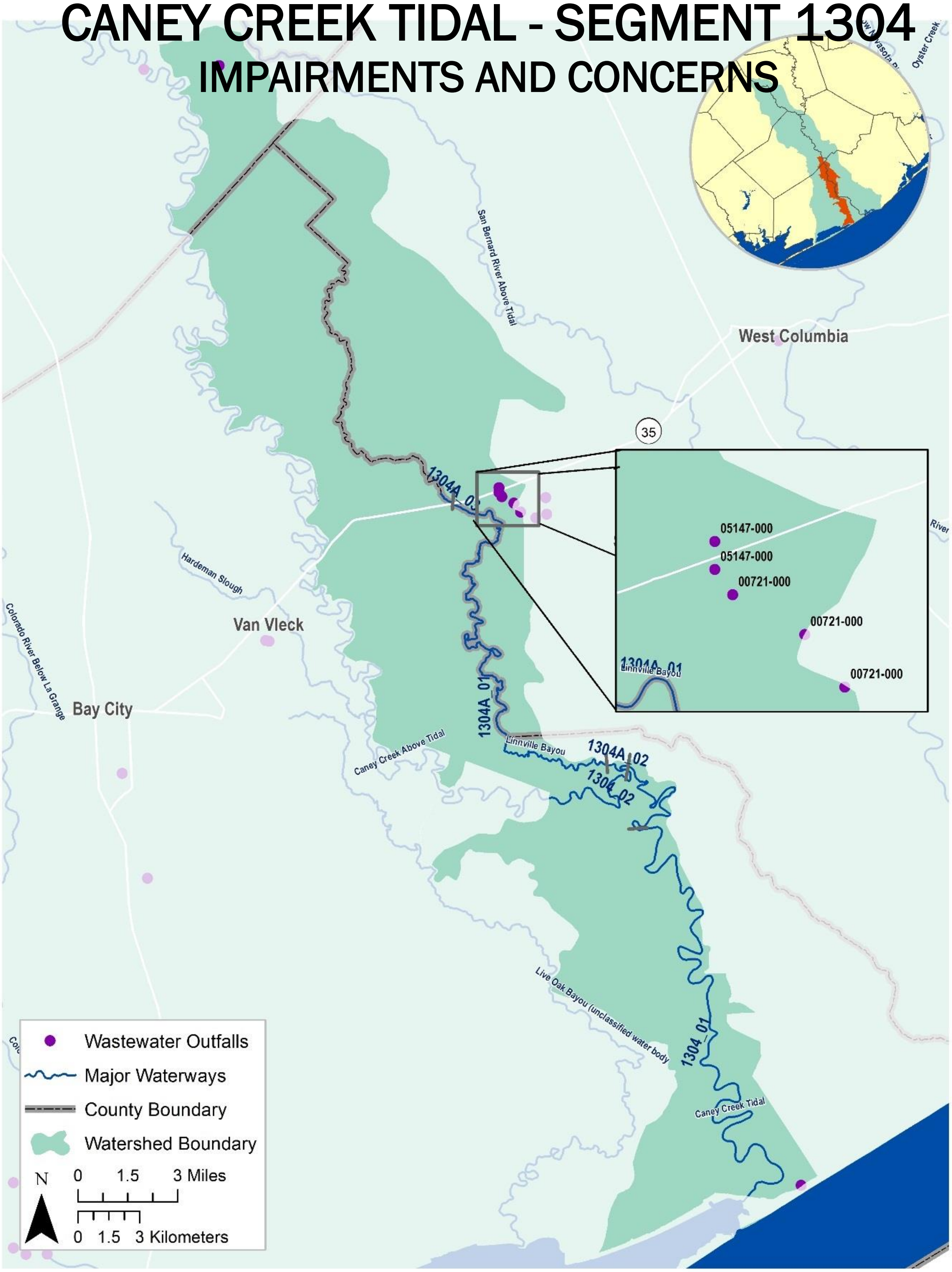
CANEY CREEK TIDAL - SEGMENT 1304

IMPAIRMENTS AND CONCERNS



CANEY CREEK TIDAL - SEGMENT 1304

IMPAIRMENTS AND CONCERNS



Segment Number:	**1304**	**Name:**	**Caney Creek Tidal**		
Length:	36 miles	**Watershed Area:**	142 square miles	**Designated Uses:**	Primary Contact Recreation 1; High Aquatic Life
Number of Active Monitoring Stations:	4	**Texas Stream Team Monitors:**		**Permitted Outfalls:**	6

Description:	Segment 1304 (Tidal Stream w/ high ALU): From the confluence with the Intracoastal Waterway in Matagorda County to a point 1.9 km (1.2) mi) upstream of the confluence of Linville Bayou in Matagorda County Segment 1304A (Intermittent Stream with Pools w/ limited ALU): Linnville Bayou (unclassified water body) – From the confluence with Caney Creek in Matagorda County upstream to a point 0.7 km above FH 35 in Brazoria/Matagorda Counties

Percent of Stream Impaired or of Concern

Segment ID	Bacteria
1304	100
1304A	100

Segment 1304

Standards	Tidal Stream	Perennial Stream	Screening Levels	Tidal Stream	Perennial Stream
Temperature (°C/°F):	35 / 95	35 / 95	Ammonia (mg/L):	0.46	0.33
Dissolved Oxygen *(24-Hr Average)* (mg/L):	4.0	3.0	Nitrate-N (mg/L):	1.10	1.95
Dissolved Oxygen *(Absolute Minima)* (mg/L):	3.0	2.0	Orthophosphate Phosphorus (mg/L):	0.46	0.37
pH (standard units):	6.5-9.0	6.5-9.0	Total Phosphorus (mg/L):	0.66	0.69

Enterococci (MPN/100mL) (grab):	104		Chlorophyll *a* (µg/L):	21	14.1
Enterococci (MPN/100mL) (geometric mean):	35				
E. coli (MPN/100 mL) (grab):		399			
E. coli (MPN/100 mL) (geometric mean):		126			

FY 2016 Active Monitoring Stations

Site ID	Site Description	Frequency	Monitoring Entity	Parameter Groups
12138	Linville Bayou at Simms Rd	Quarterly	EIH	Field, Conventional, Bacteria
12141	Linville Bayou at FM 324	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll *a*
12148	Caney Creek Tidal at Chambless Rd	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll *a*
12151	Caney Creek at concrete bridge and FM 521	Quarterly	EIH	Field, Conventional, Bacteria

Water Quality Issues Summary

Issue	2014 Assessment *I – Impaired* *C – Of Concern*	Possible Causes / Influences / Concerns Voiced by Stakeholders	Possible Solutions / Actions To Be Taken
Elevated Levels of Indicator Bacteria	1304_01 **I** 1304_02 **C**	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal
	1304A_01 **I**	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways

		▪ Improper or no pet waste disposal	▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal

Segment Discussion:

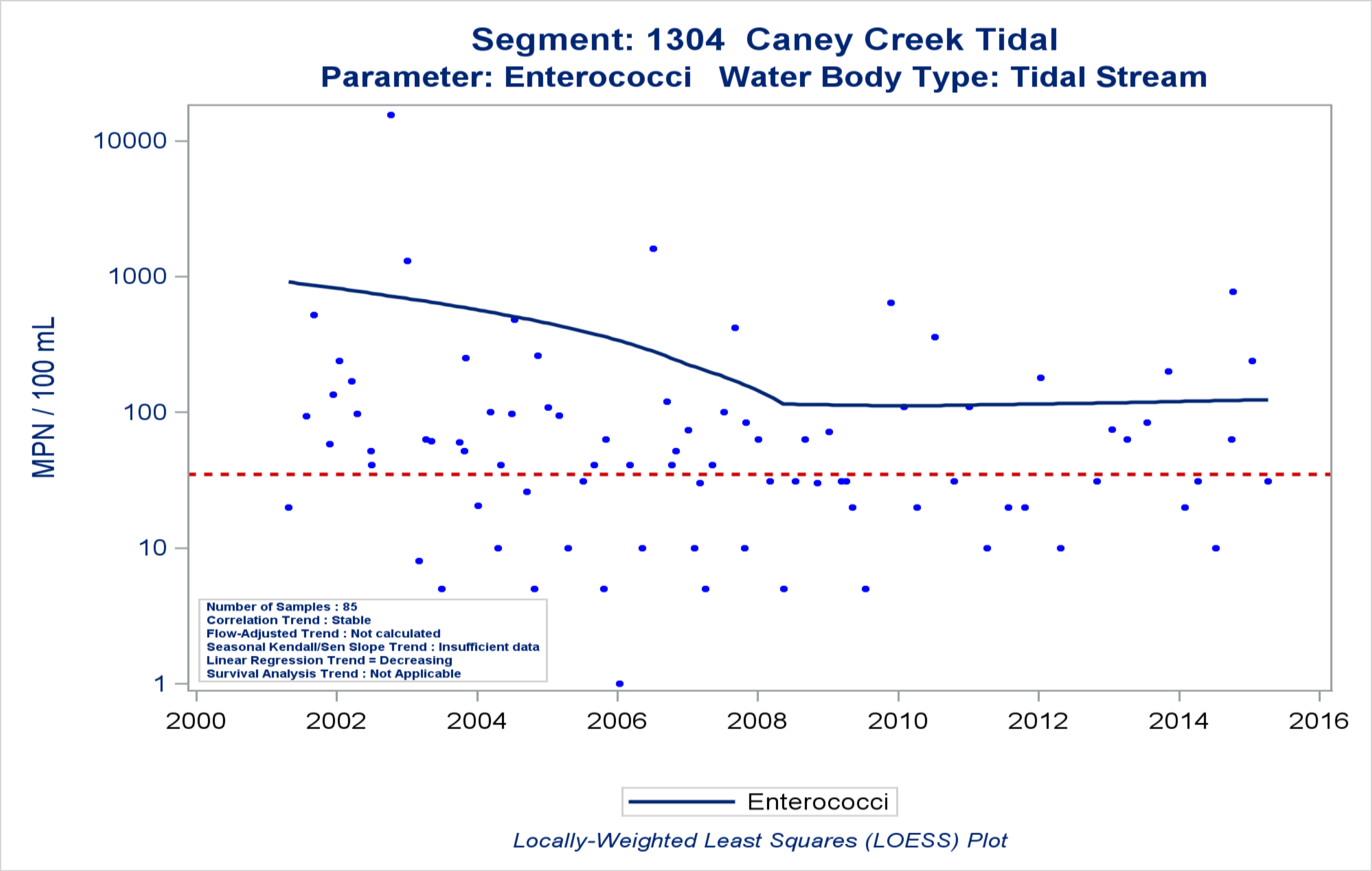
Watershed Characteristics: The watershed is predominantly rural and undeveloped and includes the small communities of Hawkinsville, Sargent, and Bay City. Residential homes with dock access line Caney Creek Tidal in the southern reaches of the watershed, most of which are serviced by onsite sanitary sewer facilities (OSSFs). The dominant land use in the area is agricultural with cattle grazing and horse farms commonly seen throughout. Small, scattered plots of wetland and forested lands are also present, especially in the southern portion of the watershed.

Water Quality Issues: The 2014 Texas Integrated Report (IR) lists the downstream assessment unit of classified water body (segment 1304) and a tributary (1304A_01) as impaired for contact recreational use due to elevated levels of enterococci. The upstream assessment unit of segment 1304 is designated as a concern for near nonattainment. TCEQ assessment data and H-GAC analyses are summarized below:

Assessment Unit	TCEQ Assessment (2005-2012)	HGAC Analysis 2001-2008	HGAC Analysis 2008-2015
	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance
1304_01	49 / NA	51 / 22.2	49 / 25.0
1304_02	47 / NA	43 / 25.0	104 / 33.3
1304A_01	170 / NA	143 / 21.7	165 / 30.8

Special Studies/Projects: In 2017, H-GAC with the approval of TCEQ, coordinated with the Environmental Institute of Houston at the University of Houston at Clear Lake to collect additional bacteria and continuous flow data in Caney Creek Above Tidal. In 2018, H-GAC will work with the TCEQ TMDL Program to address the impairments in Caney Creek Tidal by calculating load allocations using the continuous flow data and facilitating stakeholder discussions on water quality planning efforts.

Trends: Regression analysis of revealed no significant change in bacteria levels over time during the period of record; however, the majority of samples collected exceed the water quality standard for enterococci. Other than a slight dip in 2010, moving seven-year bacteria geometric means remained above the 35 MPN/100 mL standard. Moving bacteria geomeans for Linnville Bayou have also remained above the standard since 2013; however, only seven samples have been collected during the period of record. Additional data is necessary to better evaluate variations in bacteria levels in Linnville Bayou over time.



Segment: 1304 Caney Creek Tidal
Parameter: Enterococci Water Body Type: Tidal Stream

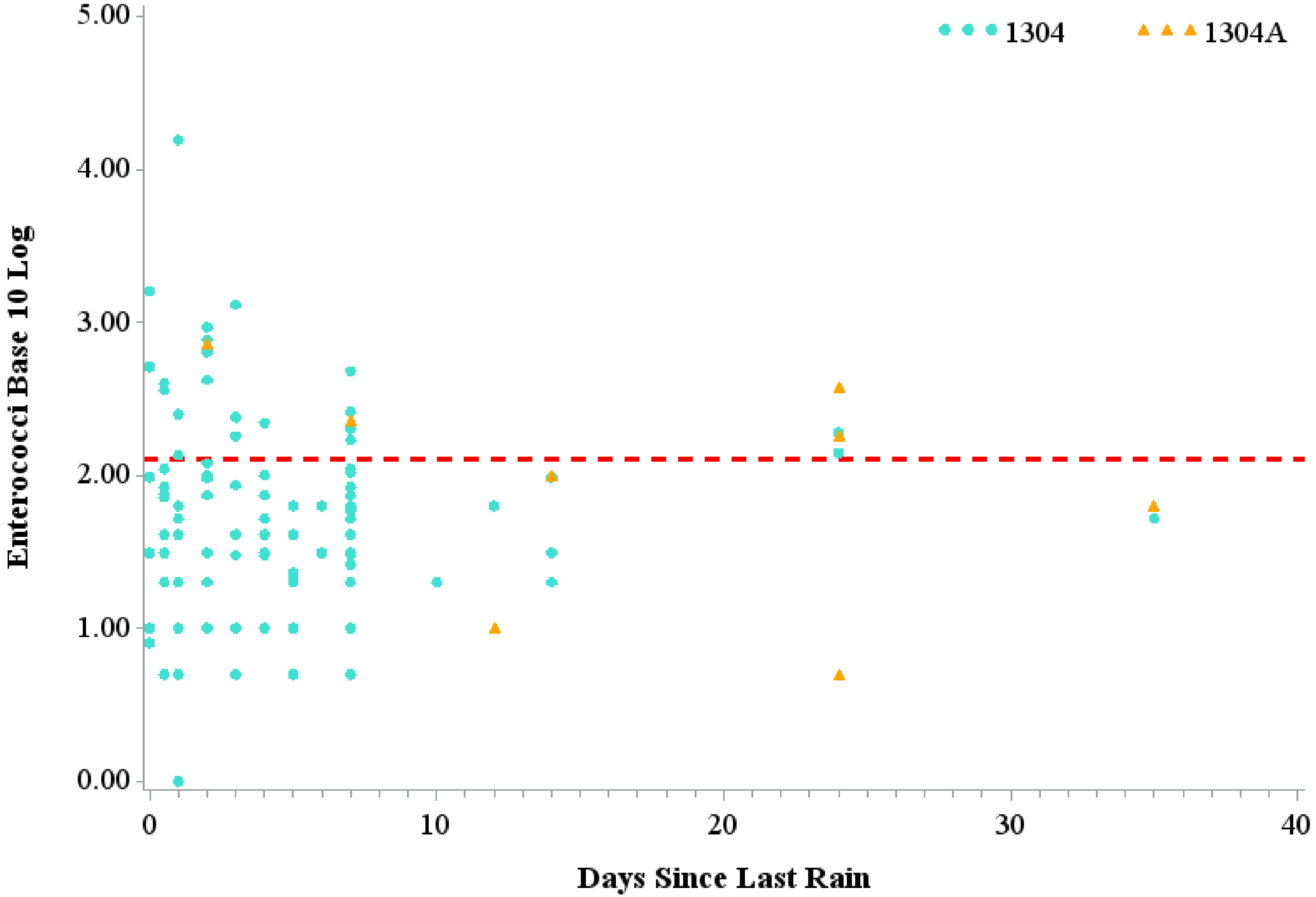
Locally-Weighted Least Squares (LOESS) Plot

Load Duration Curves

While there was sufficient bacteria data to complete a LDC, the tidal influence prohibited development of a simple LDC for this segment. Using the Days Since Last Rain plot as a surrogate until a more complex LDC or development of a model suggest that bacteria declines as bacteria data is collected the greater number of days since last rainfall. Most data after seven days since last rain appear to meet the standard (red dashed line). Days Since Last Rain is problematic as a surrogate as the bacteria data collected cannot be framed within the ambient conditions present as derived by flow conditions (i.e. extreme wet, wet, moderate, dry, extreme dry). A data point could be collected thirty days since the last rain event even while conditions for the watershed are still considered wet. Likewise, a bacteria sample could be collected a day after a rain event while the pervasive conditions are drought for the watershed. As Days Since Last Rain cannot be used to explain the watersheds conditions when the data was collected, it is a far weaker argument compared to the use of LDCs, to say that bacteria loads are less of a problem during dry conditions due to bacteria generated by waste water treatment facilities or failing OSSFs.

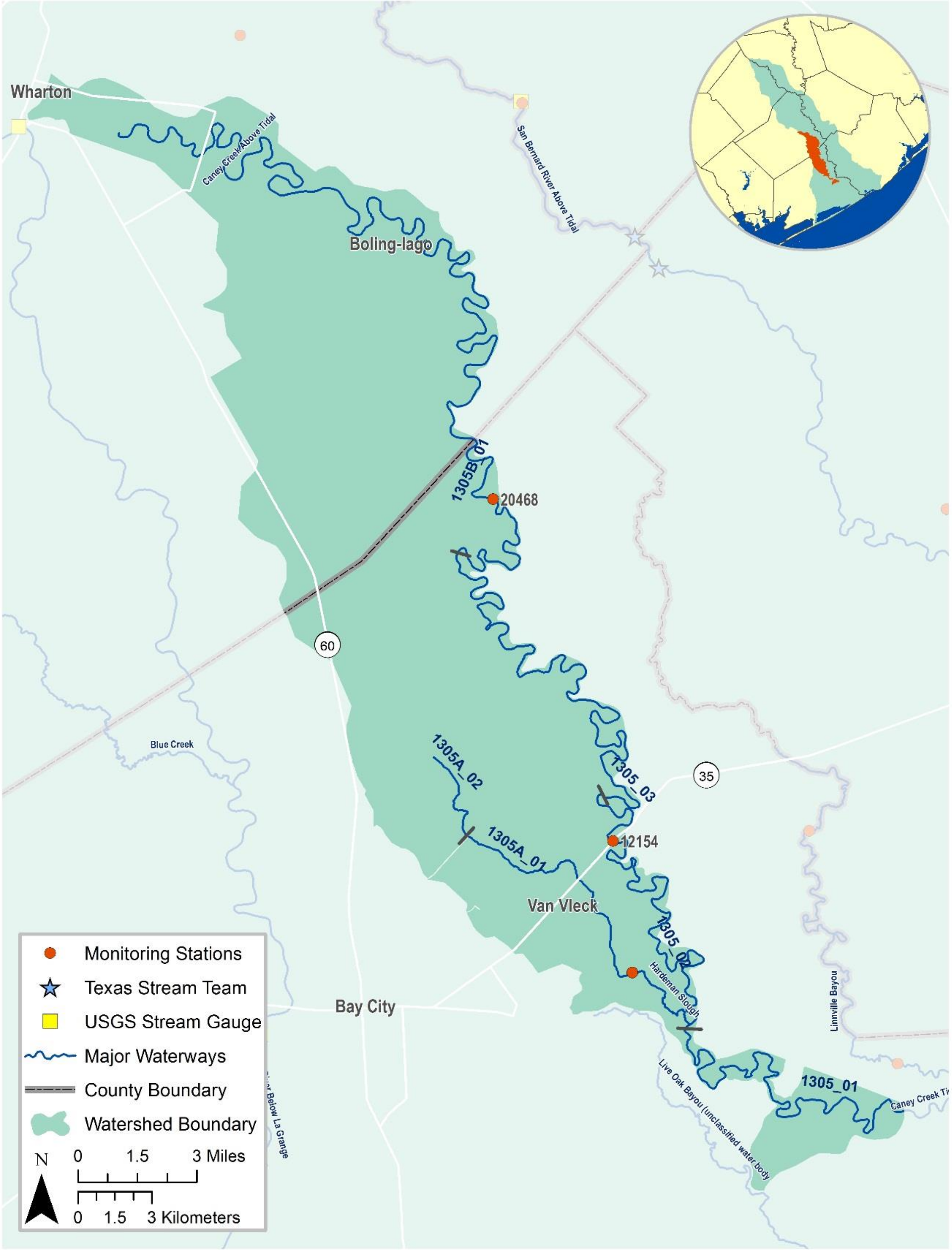
Bacteria vs Days Since Last Rain

Caney Creek Tidal



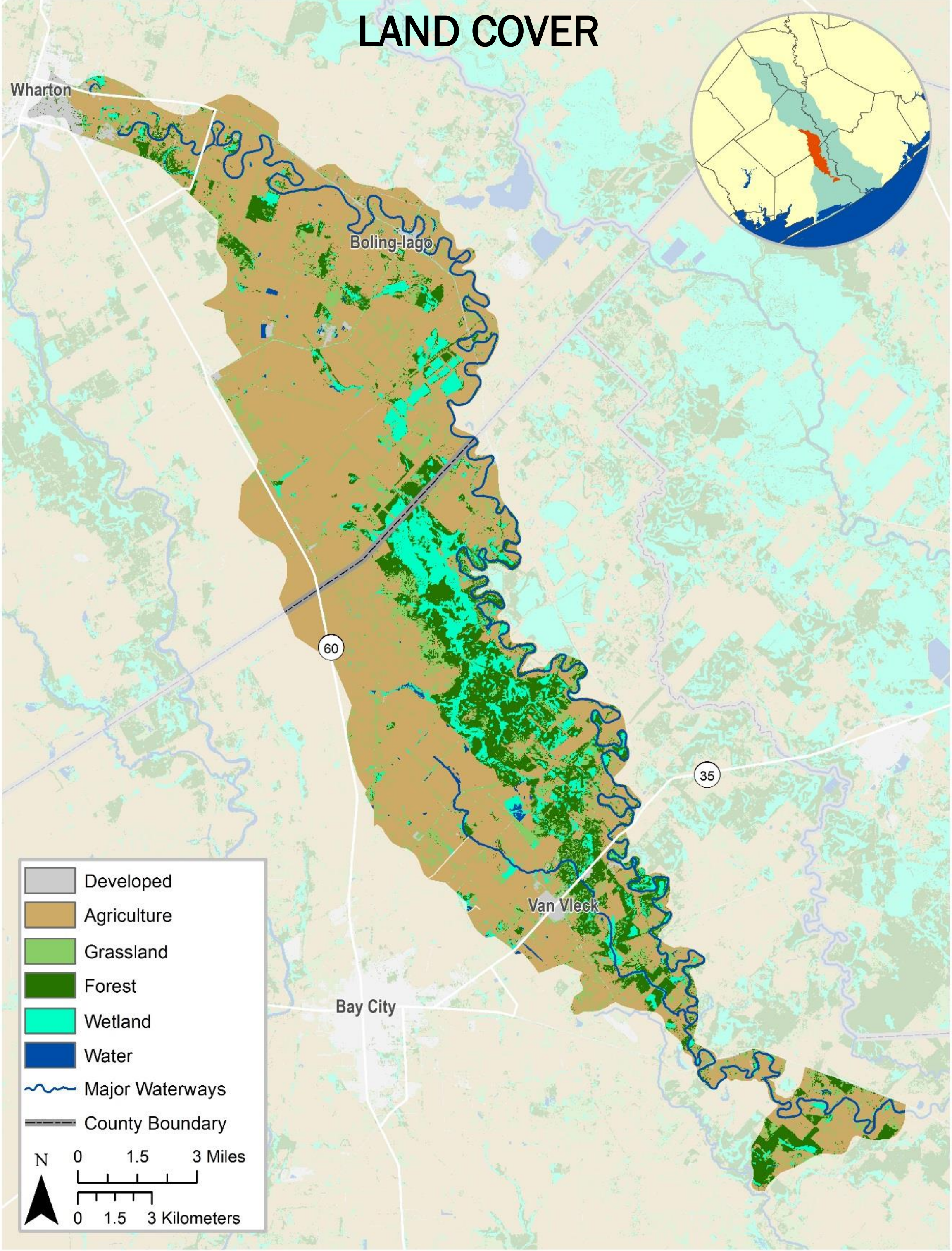
Recommendations
Address concerns found in this segment summary through stakeholder participation.
Continue collecting water quality data and address a lack of flow data on Linville Bayou to support actions associated with any future special projects and modeling efforts.

B4 CANEY CREEK ABOVE TIDAL - SEGMENT 1305



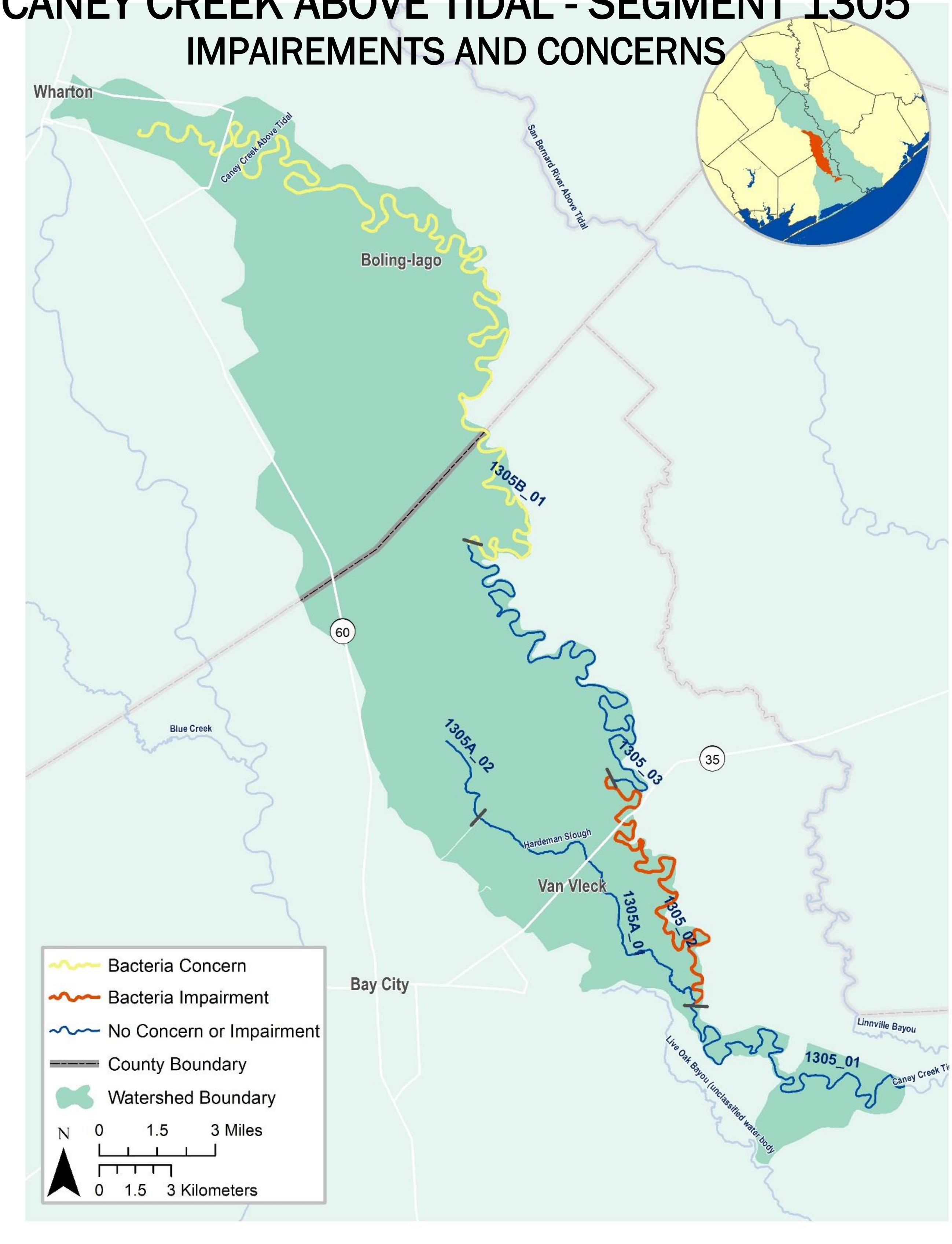
CANEY CREEK ABOVE TIDAL - SEGMENT 1305

LAND COVER



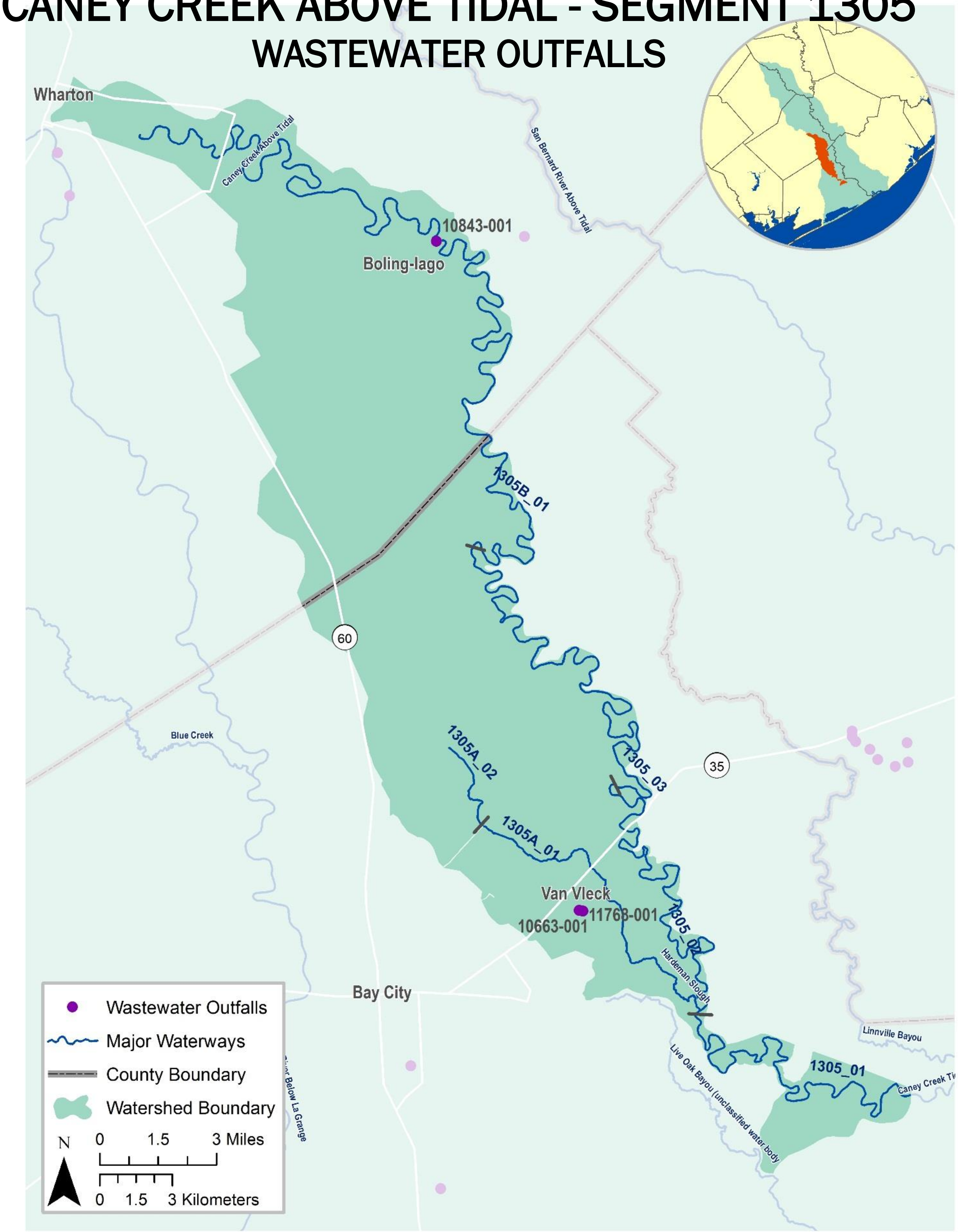
CANEY CREEK ABOVE TIDAL - SEGMENT 1305

IMPAIREMENTS AND CONCERNS



CANEY CREEK ABOVE TIDAL - SEGMENT 1305

WASTEWATER OUTFALLS



Segment Number:	1305	Name:	Caney Creek Above Tidal		
Length:	94 miles	**Watershed Area:**	135 square miles	**Designated Uses:**	Primary Contact Recreation 1; High Aquatic Life
Number of Active Monitoring Stations:	2	**Texas Stream Team Monitors:**	0	**Permitted Outfalls:**	3
Description:	Segment 1305 (Perennial Stream w/ high ALU): From a point 1.9 km (1.2 mi) upstream of the confluence of Linnville Bayou in Matagorda County to the confluence of Water Hole Creek in Matagorda County Segment 1305A (Perennial Stream w/ intermediate ALU): Hardeman Slough (unclassified water body) – From the confluence with Caney Creek to 0.3 km upstream of Matagorda County Rd 110 Segment 1305B (Perennial Stream w/ intermediate ALU): Caney Creek Above Water Hole Creek (unclassified water body) – From the confluence with Water Hole Creek in Matagorda County (at the upper end of Segment 1305) to the headwaters approximately 43 mi at Old Caney Rd in Wharton County				

Percent of Stream Impaired or of Concern	
Segment ID	**Bacteria**
1305	16

Segment 1305

Standards	Perennial Stream	Screening Levels	Perennial Stream
Temperature (°C/°F):	32 / 90	Ammonia (mg/L):	0.33
Dissolved Oxygen *(24-Hr Average)* (mg/L):	5.0 / 4.0	Nitrate-N (mg/L):	1.95
Dissolved Oxygen *(Absolute Minima)* (mg/L):	3.0 / 3.0	Orthophosphate Phosphorus (mg/L):	0.37
pH (standard units):	6.5-9.0	Total Phosphorus (mg/L):	0.69
E. coli (MPN/100 mL) (grab):	399	Chlorophyll *a* (µg/L):	14.1
E. coli (MPN/100 mL) (geometric mean):	126		
Chloride (mg/L as Cl):	200		
Sulfate (mg/L as SO_4):	75		
Total Dissolved Solids (mg/L):	1,000		

FY 2016 Active Monitoring Stations

Site ID	Site Description	Frequency	Monitoring Entity	Parameter Groups
12135	Hardeman Slough downstream of Allenhurst Rd.	Quarterly	EIH	Field, Conventional, Bacteria
12154	Caney Creek at SH 35 NE of Van Vleck	Quarterly	TCEQ	Field, Conventional, Bacteria, Chlorophyll *a*

Water Quality Issues Summary

Issue	2014 Assessment *I – Impaired* *C – Of Concern*	Possible Causes / Influences / Concerns Voiced by Stakeholders	Possible Solutions / Actions To Be Taken
Elevated Levels of Indicator Bacteria	1305_01 1305_02 I 1305_03	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Waste haulers illegal discharges/improper disposal	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Address wildlife, particularly feral hogs.
	1305A_01	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Waste haulers illegal discharges/improper disposal	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways ▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Address wildlife, particularly feral hogs.
	1305B_01	▪ Animal waste from agricultural production, hobby farms, and riding stables ▪ Developments with malfunctioning OSSFs ▪ Improper or no pet waste disposal ▪ Direct and dry weather discharges ▪ Waste haulers illegal discharges/improper disposal	▪ Implement stream fencing or alternative water supplies to keep livestock out of or away from waterways ▪ Create and implement Water Quality Management Plans for individual agricultural properties ▪ Install and/or conserve vegetative buffer areas along all waterways

			▪ More public education regarding OSSF operation and maintenance ▪ Ensure proper siting of new or replacement OSSFs ▪ More public education on pet waste disposal ▪ Address wildlife, particularly feral hogs.

Segment Discussion:

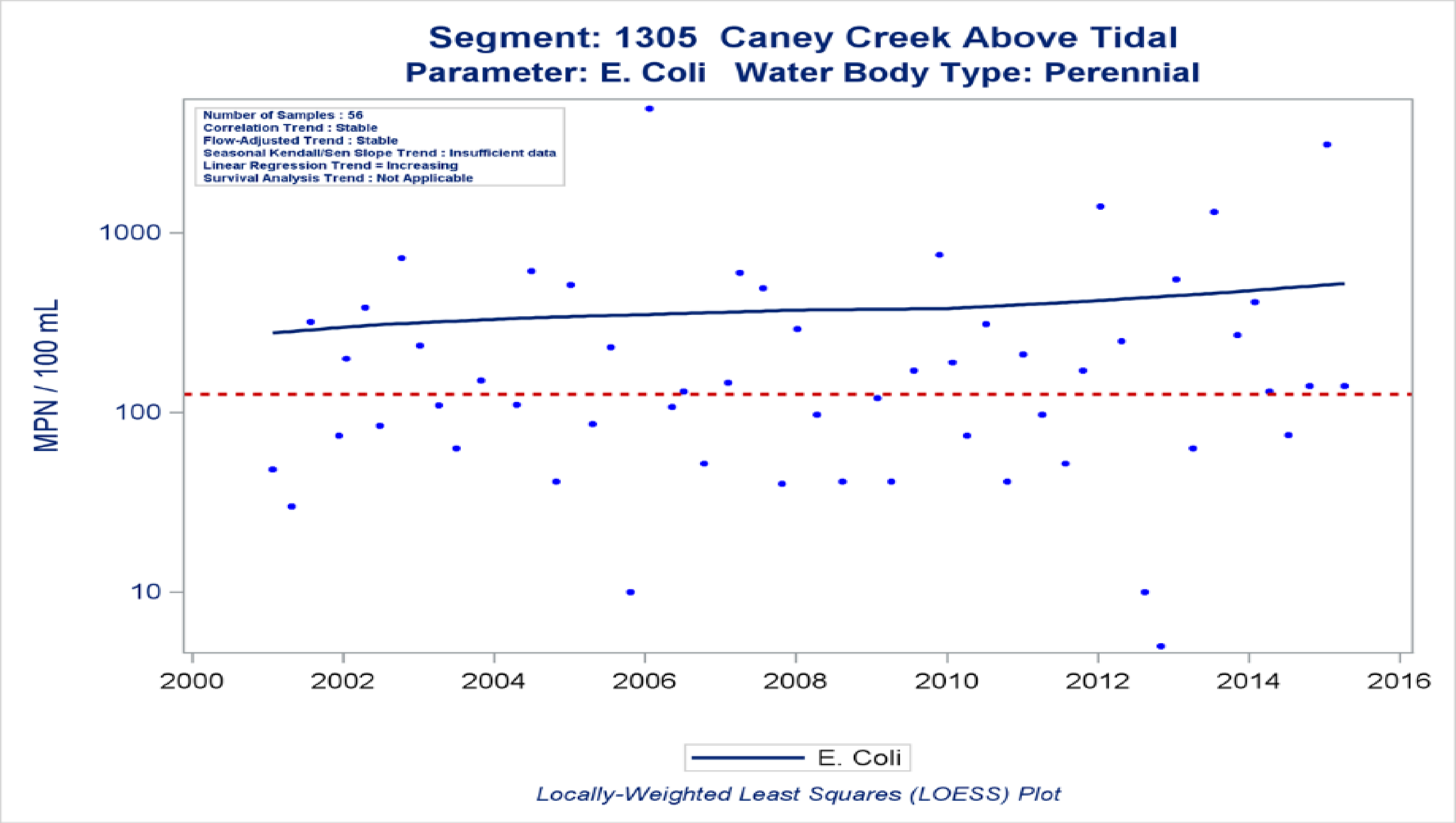
Watershed Characteristics: The watershed is primarily rural with the majority of land used for agricultural purposes. The cities of Wharton, Boling-lago, and Van Vleck represent the only small developed portions of the watershed. A large area of undeveloped forested land and wetland is present in the south-central part of the watershed with other small plots scattered throughout the area.

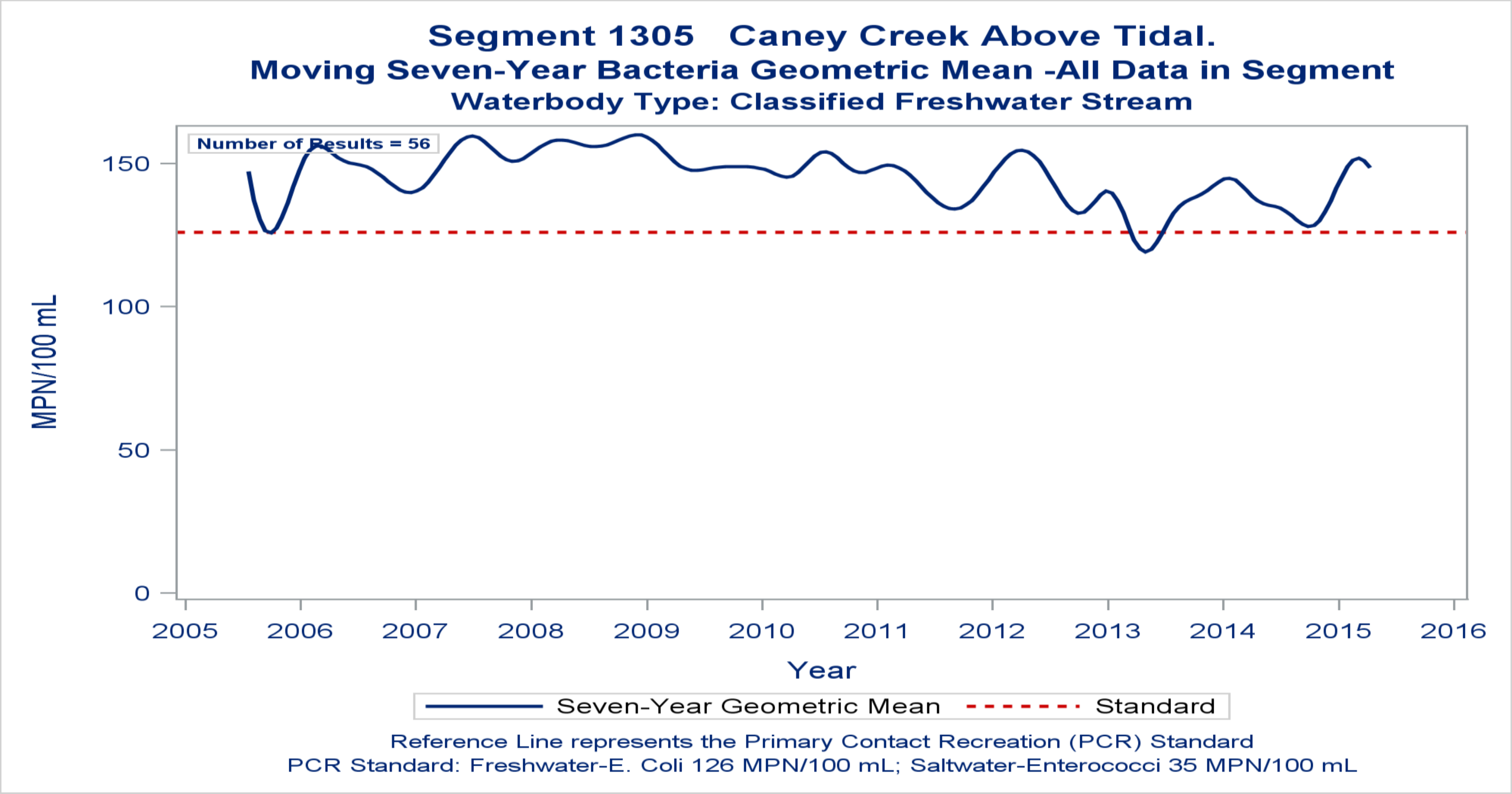
Water Quality Issues: The 2014 Texas Integrated Report lists the classified assessment unit 1305_02 as impaired for contact recreation use due to elevated levels of *E. coli.* Hardeman Slough (1305B_01) was not assessed in 2014. Sampling began in 2013, and the E. coli data collected suggests that this water body is also impaired for recreational use. The TCEQ assessment data and H-GAC analysis are summarized in the below table.

Assessment Unit	TCEQ Assessment (2005-2012)	HGAC Analysis 2001-2008	HGAC Analysis 2008-2015
	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance	Geomean (MPN/100 mL) / % Grab Exceedance
1305_02	137/ NA	168 / 55.6%	148 / 59.3%
1305B_01	1367.4/ NA	Not Assessed	1136 / 100.0%

Special Studies/Projects: An RUAA was completed in September 2010 for this segment. The RUAA is being evaluated by the TCEQ Standards Program and the public comment period on the study has closed. Documents related to the RUAA can be found at: https://www.tceq.texas.gov/waterquality/standards/ruaas/ruaasbrazoscolorado.In 2017, H-GAC with the approval of TCEQ, coordinated with the Environmental Institute of Houston at the University of Houston at Clear Lake to collect additional bacteria and continuous flow data. In 2018, H-GAC will work with the TCEQ TMDL Program to address the impairments in Caney Creek Above Tidal by calculating load allocations and facilitating stakeholder discussions on water quality planning efforts.

Trends: This watershed is currently impaired for bacteria. Regression analysis of *E. coli* data did not reveal a statistically significant trend over time, but the majority of samples collected during the period of record continue to exceed the 126 MPN/100 mL standard. Moving seven-year bacteria geometric mean plots for the main segment show mean *E. coli* concentrations fluctuation near the standard reference line, but has mainly remained above the standard since 2005.

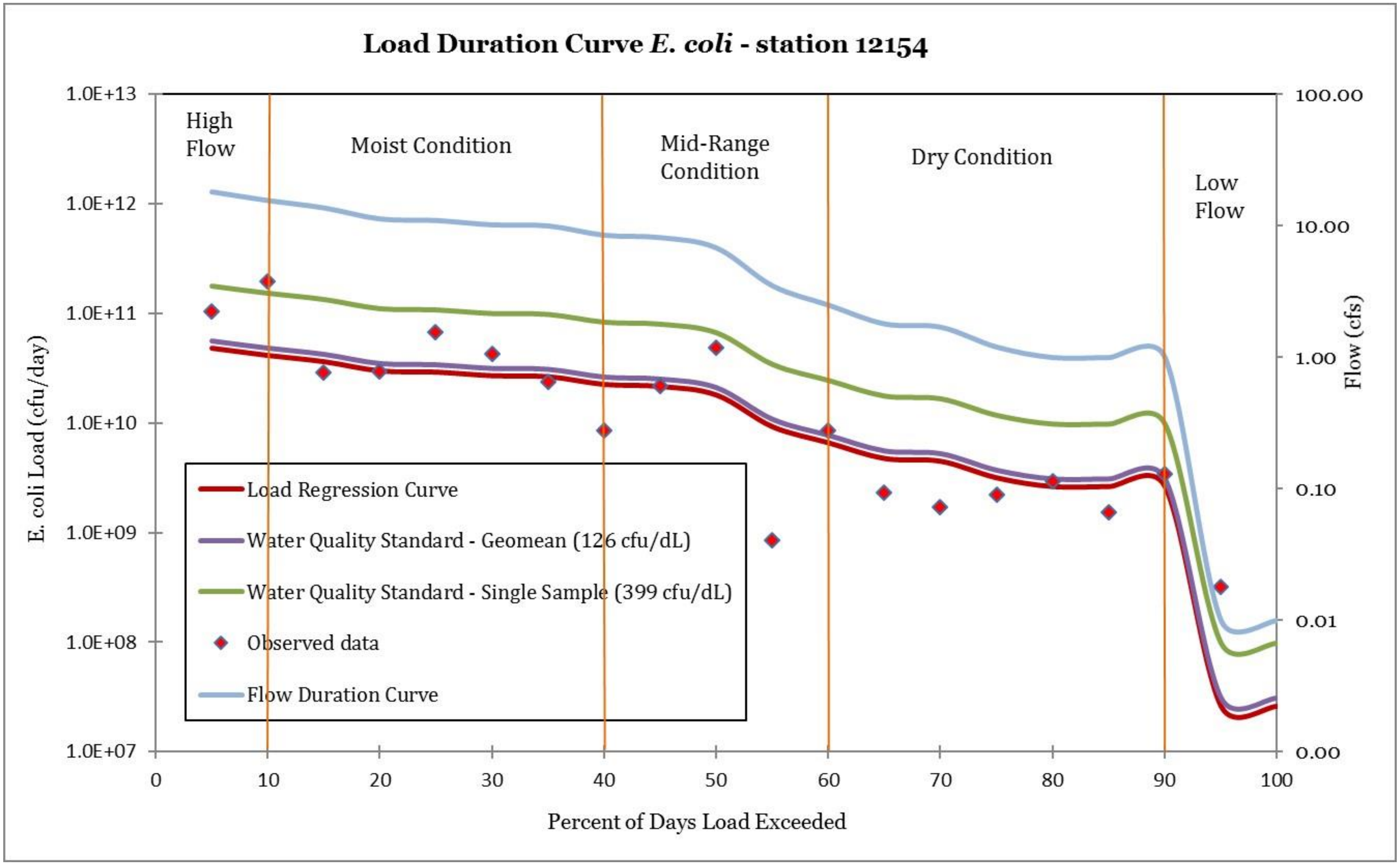


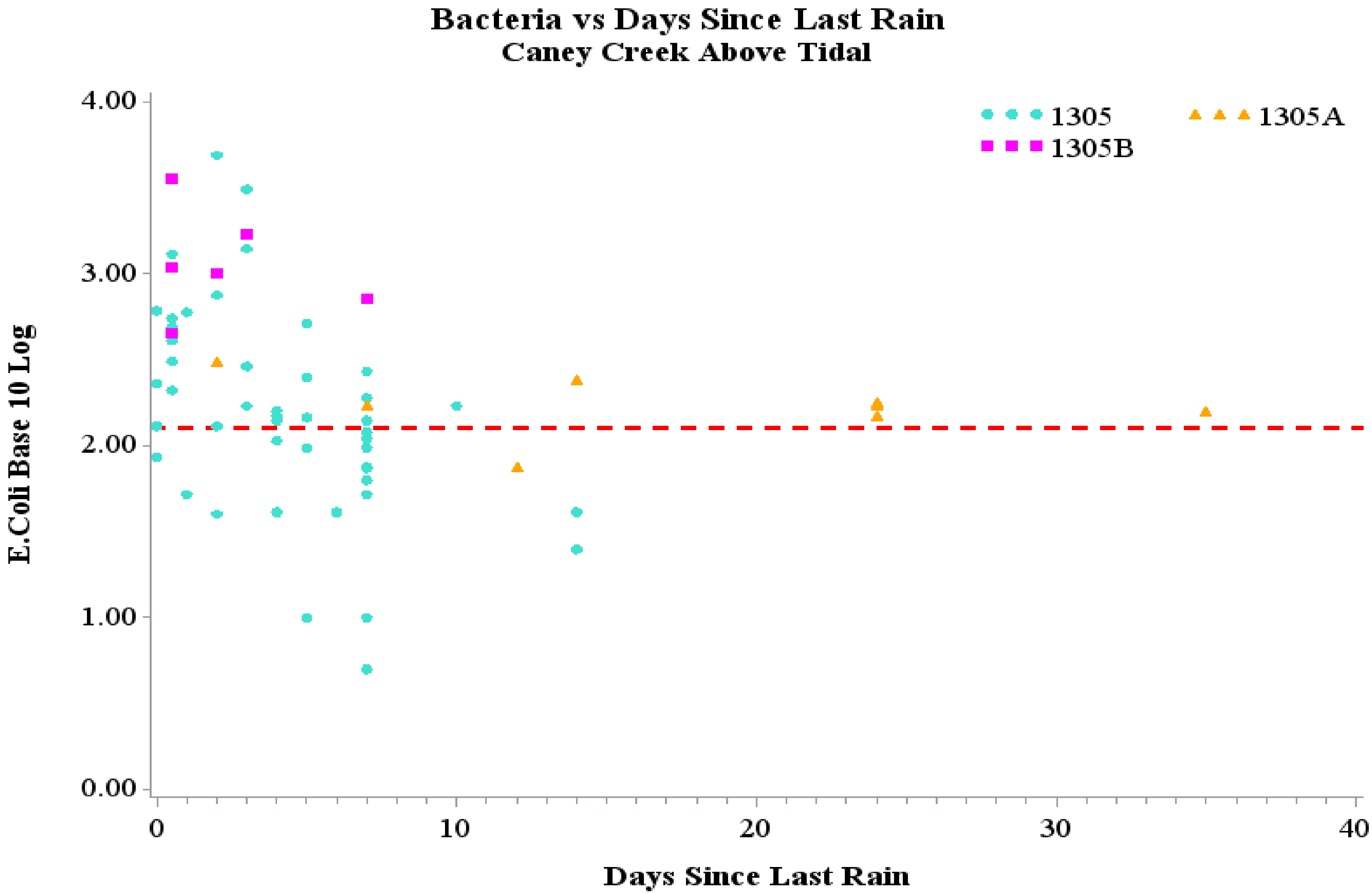


Segment 1305 Caney Creek Above Tidal.
Moving Seven-Year Bacteria Geometric Mean -All Data in Segment
Waterbody Type: Classified Freshwater Stream
Number of Results = 56
MPN/100 mL
150
100
50
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
Seven-Year Geometric Mean
Standard
Reference Line represents the Primary Contact Recreation (PCR) Standard
PCR Standard: Freshwater-E. Coli 126 MPN/100 mL; Saltwater-Enterococci 35 MPN/100 mL

LDC Discussion

Available flow data and bacteria date were sufficient to complete a LDC for the lone station (12154) in this segment. Using the results of the LDC and the Days Since Last Rainfall, factors affecting bacteria levels in this segment do not appear to correlate with waste loads from waste water treatment facilities and on-site sewage facilities (OSSF) during dry periods. Reading the LDC, the Load Regression Curve for bacteria data plotted rarely exceeds the geomean standard and never exceeds the single grab standard throughout the flow regime. If waste water treatment and OSSF were contributing to exceedances, then the expected LDC load regression curve would be found continually above the standard during dry weather conditions. The Days Since Last Rain support this as the observed data at seven days rarely exceeds the standard (red dashed line) while at an average of one day or less, nearly all bacteria data exceed the standard. It is worth noting the few data points for AU 1305B.


Load Duration Curve *E. coli* - station 12154
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
E. coli Load (cfu/day)
100.00
10.00
1.00
0.10
0.01
0.00
Flow (cfs)
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
High Flow
Moist Condition
Mid-Range Condition
Dry Condition
Low Flow
Load Regression Curve
Water Quality Standard - Geomean (126 cfu/dL)
Water Quality Standard - Single Sample (399 cfu/dL)
Observed data
Flow Duration Curve


Bacteria vs Days Since Last Rain
Caney Creek Above Tidal
● ● ● 1305
▲ ▲ ▲ 1305A
■ ■ ■ 1305B
4.00
3.00
2.00
1.00
0.00
E.Coli Base 10 Log
0
10
20
30
40
Days Since Last Rain

Recommendations
Address concerns found in this segment summary through stakeholder participation.
Continue collecting water quality data and address a lack of flow data on Caney Creek to support actions associated with any future special projects and modeling efforts.