Acquired Data Analysis Report for the East Fork San Jacinto River Watershed

June 2022

This document was prepared by the Houston-Galveston Area Council (H-GAC) for the stakeholders of the East Fork San Jacinto River Watershed Partnership. It was prepared in cooperation with the Texas Commission on Environmental Quality (TCEQ) and the United States Environmental Protection Agency (EPA).

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List of Acronyms

AU	Assessment Unit
CBOD5	5-Day Carbonaceous Biological Oxygen Demand
CFS	Cubic Feet Per Second
CFU	Colony Forming Units
CRP	Clean Rivers Program
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
IR	Texas Integrated Report of Surface Water Quality
H-GAC	Houston-Galveston Area Council
MGD	Millions of Gallons Per Day
mg/L	Milligrams Per Liter
mL	Milliliters
SAS	Statistical Analysis Software
SSO	Sanitary Sewer Overflow
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TPDES	Texas Pollutant Discharge Elimination System
TSS	Total Suspended Solids
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility

Section 1: Introduction

The watershed area of the East Fork of the San Jacinto River includes portions of Harris, Montgomery, Liberty, San Jacinto, and Walker counties. Over 410 square miles of land are drained by a network of tributaries into the main stem of the East Fork of the San Jacinto River before ultimately discharging into Lake Houston (**Figure 1**). Land cover in the watershed varies and is characterized by heavily wooded areas, especially in the portions of the watershed spanning Walker and San Jacinto counties, which are part of the Sam Houston National Forest. Pasture and woody wetlands are also common in these areas. The southern part of the watershed is more developed, especially in Liberty and Harris counties. Development is expected to expand as growing populations push north from the Houston area along the US Highway 59 and State Highway 99 (Grand Parkway) transportation corridors. Small cities such as Cleveland, North Cleveland, Plum Grove, and Roman Forest intersect or are completely contained within the watershed area. Large cities intersecting the watershed area include Huntsville and Houston.

To understand the status of surface water quality in the East Fork San Jacinto River watershed, the Houston-Galveston Area Council (H-GAC) has analyzed monitoring and report data from the past decade and summarized the results of these analyses herein. This assessment will serve as a baseline for water quality trends and variability in the watershed which will help to illustrate where improvements can be made to meet surface water quality standards. Such information will be critical for the development of a watershed protection plan (WPP) which will outline the specific goals and action strategies set forth by local stakeholders to achieve water quality improvements.

This document will include:

- A summary of the design and purpose of each analysis.
- A description of the data sources considered for each analysis which include ambient water quality monitoring data, discharge monitoring report (DMR) data from wastewater treatment facilities (WWTFs), and reports of sanitary sewer overflows (SSOs) collected in the past decade.
- An overview of the implications of the results of the analyses.

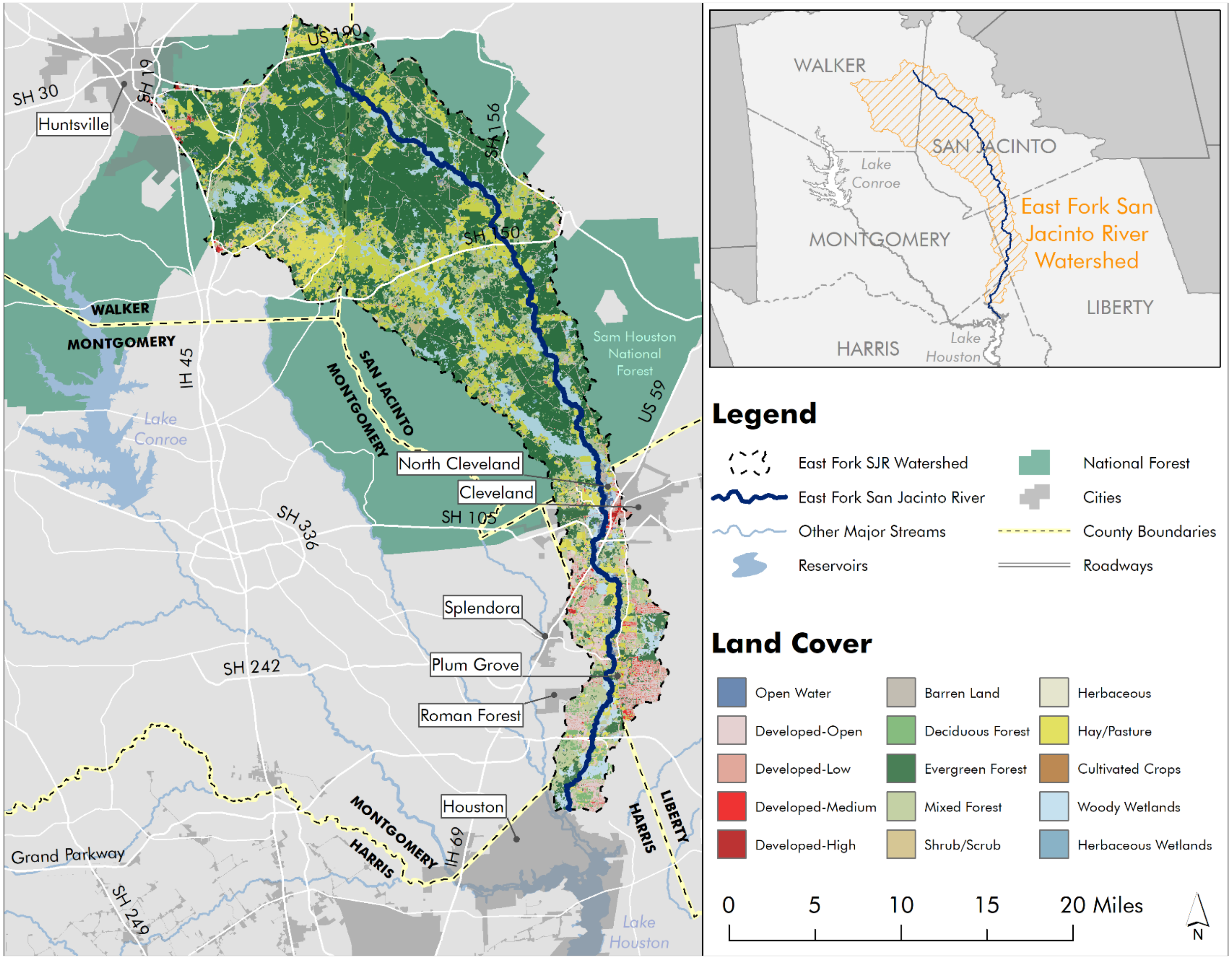

Figure 1 *The East Fork San Jacinto River watershed, land cover, and regional context*

Section 2: Analysis Purpose and Design

2.1 Purpose

Based on findings from the *2022 Texas Integrated Report of Surface Water Quality* (IR)[1] produced by the Texas Commission on Environmental Quality (TCEQ), multiple stream segments throughout the East Fork San Jacinto River watershed are listed as impaired for recreation use. This is due to the frequent exceedance of surface water quality standards for fecal indicator bacteria, *Escherichia coli* (*E. coli*).

2.2 Project Design

To adequately describe the current condition of surface water quality in stream segments throughout the East Fork San Jacinto River watershed, the following analyses were designed to address the needs outlined below.

- General Understanding
  - Determine whether there is sufficient data to describe water quality in the watershed.
  - Describe the extent of the challenges impacting water quality in the watershed.
  - Visualize whether water quality is spatially variable, and if so, identify focus areas.
  - Identify any seasonal variability in the water quality data.
- Source Identification
  - Analyze discharge monitoring report data from Texas Pollutant Discharge Elimination System (TPDES) permitted WWTFs to verify whether discharges comply with permit limits.
  - Quantify the frequency, distribution and causes of SSOs in the watershed.
- Model Development[2]
  - Assess stream flow and water quality data for future use in load duration curve analysis.

To answer these requirements data were acquired and evaluated according to the standards below.

- Data Acquisition
  - Data from stations monitored by partners of the Clean Rivers Program (CRP) throughout the watershed area will be retrieved from TCEQ's Surface Water Quality Monitoring Information System (SWQMIS) database to characterize ambient conditions.
  - At least five years of data from DMRs and SSO reports from within the watershed will be used to characterize wastewater quality.
- Data Evaluation
  - Ambient Surface Water Quality Monitoring (SWQM) Data

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[1] The State of Texas assesses its waterways every two years, based on seven-year sets of SWQM data. These assessments form the basis by which segments (defined portions of waterways) and their tributaries are classified as having impairments (inability to meet a surface water quality standard for which a numerical or other specific limit exists) or concerns (levels of constituents which exceed screening levels or other criteria, but for which numerical or specific limits do not exist). The existence of an impairment is usually the primary driver for developing watershed-based plans for affected segments.

[2] The data evaluated in this report will be used to develop models to estimate potential pollutant source loads contributing to impairments in the watershed. These models and their implications will be discussed further in a summary report to be developed later in 2022. Additional information about the data quality objectives, concerns, and methodologies used in these analyses can be found in the *East Fork San Jacinto River Watershed Protection Plan Modeling Quality Assurance Project Plan* available for review at www.eastforkpartnership.com.

- Determine if sufficient data exists for each station.
- Identify the historical trends for constituents of concern, by each station.
- Identify any seasonal trends, by constituent.
- Evaluate the relative character of water quality between stations.
- Update evaluations prior to the development of the WPP.

o DMR Data
  - Evaluate the constituents of concern for compliance with WWTF permit limits and the general level of compliance for WWTFs.
  - Evaluate whether there is any seasonal variance of exceedances.
  - Evaluate any relationship between plant size and exceedance.
  - Update evaluations prior to the development of the WPP.

o SSO Report Data
  - Evaluate the frequency, volume and causes of SSOs by stream segment.
  - Update evaluations prior to the development of the WPP.

Table 1 *Data sources for constituents of concern*

Constituent of Concern	SWQM Data	DMR Data	SSO Data
Temperature	X		
Dissolved Oxygen (DO)	X	X	
pH	X		
Instantaneous Flow	X		
Total Phosphorous	X		
Nitrate	X		
Nitrite	X		
Nitrate-Nitrite	X		
Ammonia Nitrogen	X	X	
Total Suspended Solids (TSS)	X	X	
E. coli	X	X	
Biological Oxygen Demand		X	
SSO Cause			X
SSO Frequency/Volume			X

Section 3: Evaluations

3.1 Overview

Analyses conducted for this report began in the spring of 2022 using the latest available data from the SWQMIS, DMR, and SSO databases. Statistical Analysis Software (SAS) was used to generate statistical results and the spatial analysis platform ArcGIS v10.6 was used to evaluate geographical trends and variations in the data. The results of all analyses conducted for this report were reviewed by project staff, and outcomes pertinent to the development of a WPP were selected for the focus of discussion in this document. The full data and evaluation worksheets for these efforts are available on request but are not included in this report for sake of brevity.

3.2 Ambient Data

Ambient water quality data are collected at over 400 sites in the 13-county Houston-Galveston region by H-GAC, local partners, and TCEQ as part of the CRP. In general, most monitoring stations are sampled by CRP partners on a quarterly frequency for a suite of field, bacteriological, and conventional parameters. Waterways are inherently dynamic systems, and water quality can vary greatly dependent on conditions at the time. However, a history of samples provides a more representative view of the range of conditions that may be present in that waterway. Ambient data are important for characterizing waterways because they represent a range of conditions and have an historical aspect that allows for the identification of trends over time. The final determination of the regulatory status of each segment is based primarily on these ambient data. The goals and decisions for the WPP are established in part due to the regulatory status, and therefore ambient data are an important source of information for informing stakeholder decisions. There are currently 14 water quality monitoring stations in the East Fork San Jacinto River watershed (**Figure 2** and **Table 2**).

Data collected by CRP partners and incorporated into the SWQMIS database include a number of parameters characterizing conventional, bacteriological and other field conditions of surface water at each site. For the purposes of this report, specifically pertaining to the informed development of a WPP for the East Fork San Jacinto River Watershed, a subset of the SWQM dataset for stations throughout the watershed area was selected. The parameters focused on in this analysis include:

- Temperature – an indicator of a waterway's ability to hold oxygen, and a means for correlating other indicators to conditions in the waterways.
- DO grab measurements – an indicator of the ability of the waterway to support aquatic life.
- pH – an indicator of the acidity or basicness of water, which may affect aquatic life and other uses.
- Instantaneous Flow – a measure of water volume over time.
- Total Phosphorus – an indicator of nutrient levels, especially in relation to potential for algal blooms and depressed DO in elevated levels.
- Nitrate and Nitrite – a measure of nitrogenous compounds and indicator of nutrient levels (and thus potential DO impacts).
- Ammonia Nitrogen – a measure of specific nitrogenous compound that can impact aquatic life and is an indicator of nutrient levels and potentially of improperly treated sewage effluent.
- TSS – a measure of the number of suspended particles in water that indicates the potential of light infiltration in the water column and the presence of particulate matter on which bacteria may seek shelter.
- *E. coli* – bacteria common in the intestines of all warm-blooded animals used as an indicator of the presence of fecal waste. Due to this relationship, it may also be used as a proxy indicator of the safety of waterways for human recreation as fecal waste can be a vector for human pathogens. The surface water quality geomean standard for *E. coli* concentrations is 126 colony forming units per 100 milliliters (cfu/100 mL) and the single sample standard is 399 cfu/100 mL.

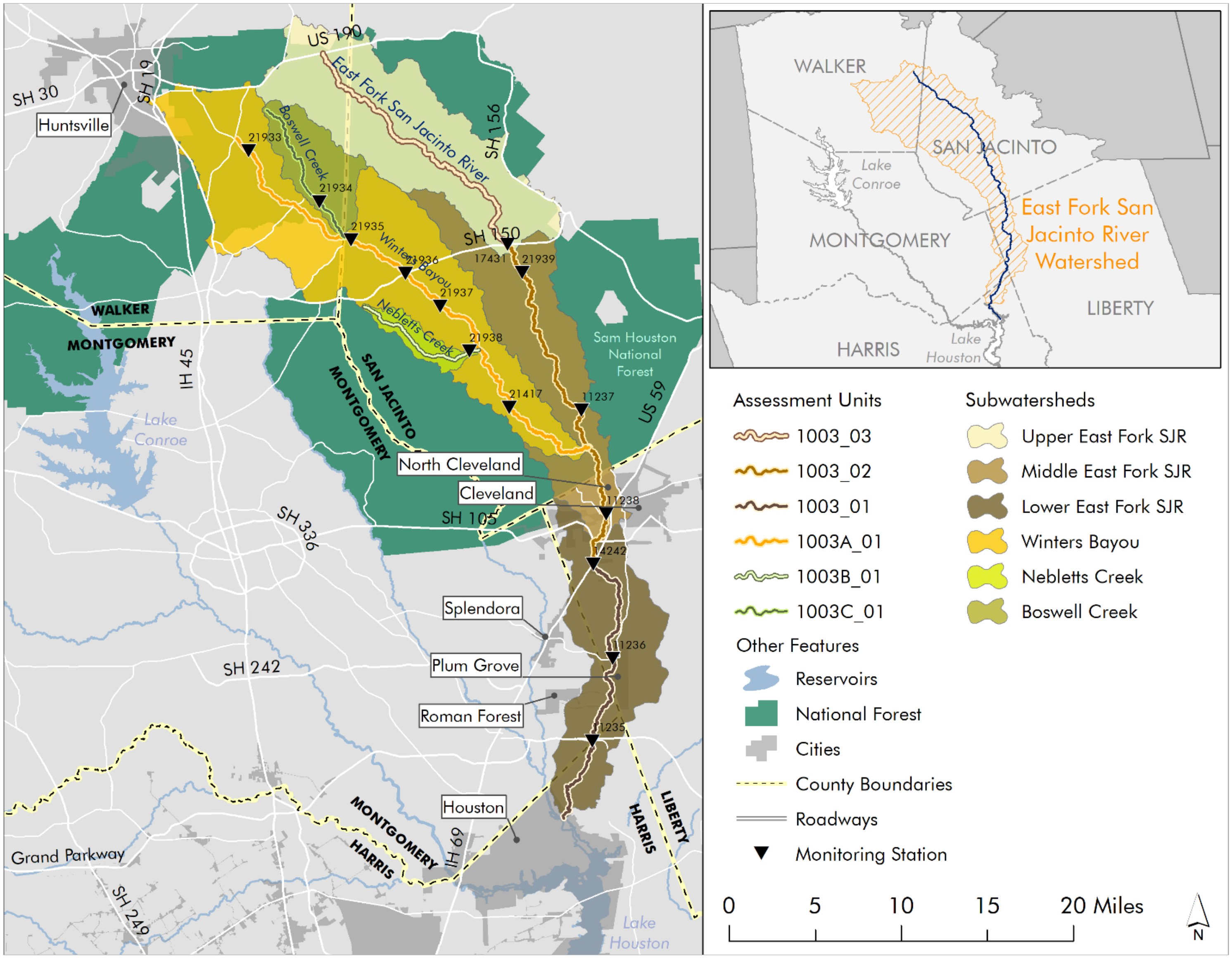


***Figure 2** Monitoring sites and assessment units in the East Fork San Jacinto River watershed*

Table 2 Water quality monitoring stations, locations, sampling frequency, and period of record

Station Number	Stream Segment	Assessment Unit	Sampling Events	Earliest Event	Latest Event
11235	East Fork San Jacinto River	1003_01	59	5/25/2011	3/17/2021
11236	East Fork San Jacinto River	1003_01	17	12/20/2016	4/8/2021
11237	East Fork San Jacinto River	1003_02	22	4/14/2011	4/8/2021
11238	East Fork San Jacinto River	1003_02	58	5/25/2011	3/17/2021
14242	East Fork San Jacinto River	1003_02	16	12/20/2016	4/8/2021
17431	East Fork San Jacinto River	1003_03	34	4/14/2011	4/21/2021
21939	East Fork San Jacinto River	1003_02	17	12/21/2016	4/7/2021
21417	Winters Bayou	1003A_01	31	12/3/2013	4/21/2021
21933	Winters Bayou	1003A_01	17	12/21/2016	4/6/2021
21935	Winters Bayou	1003A_01	16	12/21/2016	4/6/2021
21936	Winters Bayou	1003A_01	17	12/20/2016	4/7/2021
21937	Winters Bayou	1003A_01	17	12/21/2016	4/7/2021
21938	Nebletts Creek	1003B_01	17	12/20/2016	4/7/2021
21934	Boswell Creek	1003C_01	15	12/21/2016	4/6/2021

Monitoring in the East Fork of the San Jacinto River

Between 2011 and 2021, 353 samples were collected from 14 water quality monitoring stations within the East Fork San Jacinto watershed (**Table 2**). The main segment, East Fork San Jacinto River (1003), is represented by seven of 14 total sites throughout the watershed. This dataset captures historic trends in the most recent decade and will be updated in advance of the completion of the WPP to reflect data collected during the project term. A full analysis of each constituent for stations with sufficient data will be represented as a series of graphs in **Appendix A: Water Quality Monitoring** Site Data[3].

Sub-sections of each stream segment classified as assessment units (AUs) are the basic unit of analysis for the IRs produced by TCEQ. The *2022 IR* deemed several AUs in the East Fork San Jacinto River watershed impaired or a concern for recreation use due to high levels of fecal indicator bacteria (*E. coli;* **Table 3** and **Table 4**).

Table 3 2022 IR impairments in the East Fork San Jacinto River watershed

Segment	AU(s)	Parameter	Use	Category
East Fork San Jacinto River, 1003	01, 02, 03	*E. coli*	Recreation	4a (all)
Winters Bayou, 1003A	01	*E. coli*	Recreation	5c

Table 4 2022 IR concerns in the East Fork San Jacinto River watershed

Segment	AU(s)	Parameter	Use	Level of Concern
Boswell Creek, 1003C	01	*E. coli*	Recreation	CN

[3] Throughout this ambient water evaluation, statistical significance is defined as a p-value of 0.0545 or less. Any significance not based on this statistical review (e.g., seasonal trends, qualitative comments) will be specifically described as not being related to this significance threshold. The quantitative analysis for the ambient conditions was conducted using SAS. Statistical analyses in the graphs of Appendix A are based on a LOESS curve rather than a straight regression curve to better indicate change in trend over time for disparate stations.

Sufficiency of Data

The East Fork of the San Jacinto River (Segment 1003) is best represented by water quality monitoring stations 11235 and 11238, with averages of 5.9 and 5.8 sampling events per year of study, respectively. Station 11237 had the lowest sampling density at 2.2 events per year of study. The remaining stations on segment 1003 averaged between 3.2 and 3.4 sampling events per year.

Regular sampling on the tributaries to the East Fork of the San Jacinto River is a more recent undertaking with many of the earliest time points starting in the year 2016. Winters Bayou (Segment 1003A) is represented by five stations. Of these, the minimum average number of sampling events per year of study is equal to 3.2. Nebletts Creek (1003B) and Boswell Creek (1003C) are each represented by only one station and averaged 3.4 and 3.0 sampling events per year of study, respectively.

In the second year of this project, updated data will be analyzed in a subsequent report to reflect more current conditions.

Monitoring Results

A summary of ambient data represented as the geometric mean of each parameter for its period of record (**Table 5**) are comparable to that of the *2022 IR*, though not identical due to the use of overlapping datasets. Where the *2022 IR* examined surface water data collected from 2013 to 2020, this analysis extends the dataset to cover 2011 to 2021 where possible.

Table 5 *Water quality monitoring geometric mean results by segment, 2011-2021*

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

Note: Results shaded in dark gray indicate geomeans that exceed criteria or screening levels, while those shaded in light gray represent results that comply with criteria or screening levels. Italicized values indicate the data is not being compared to criteria or screening levels.

Trends

By examining parameters collected from surface water samples in the East Fork San Jacinto River watershed and how measurements for those parameters have changed over time, trends in the data were determined. Each segment was assessed for increasing, decreasing, or stable trends of statistical significance ($p < 0.0545$) for each parameter. Trends indicating improvements in water quality could be either decreasing or increasing such as decreasing fecal indicator bacteria levels and increasing dissolved oxygen. Conversely, degrading water quality can also be indicated by either decreasing or increasing trends such as increasing nutrient levels and decreasing dissolved oxygen. Stable parameter trends do not necessarily indicate good conditions for water quality. For example, fecal indicator bacteria measurements that exceed water quality standards but remain consistently high throughout the study period will result in a stable trend. Graphs depicting the results of all parameter assessments can be found in **Appendix A: Water Quality Monitoring** Site Data.

Ambient Analysis Summary

Of the ambient water quality parameters observed, geometric mean values for fecal indicator bacteria levels measured between 2011 and 2021 exceeded surface water quality standards in segments 1003, 1003A, and 1003C. No significant trends in *E. coli* over time were observed in any of the segments.

Geometric means for nutrients such as total phosphorous, nitrate, nitrite, and ammonia nitrogen met the criteria in all segments. Though the trend analyses for nutrients generally did not yield significant results, nitrate measurements on segment 1003 and 1003A were observed to decrease significantly over time (**Table 6**).

Results of analyses for ambient water quality data related to *E. coli* confirmed observations in the *2022 IR*. However, the ten-year geometric means for this parameter observed in 1003, 1003A, and 1003C only exceeded the criteria by a maximum of 58%. Targeted assessment and application of best management practices could help to reduce or remove impairments and concerns related to fecal indicator bacteria in the waterways.

Table 6 *Summary of significant ($p < 0.0545$) water quality trends*

Segment	Parameter	Trend	N
East Fork San Jacinto River, 1003	Nitrite	Decreasing	84
Winters Bayou, 1003A	Nitrite	Decreasing	90

3.3 Discharge Monitoring Report Data

Discharges from WWTFs are regulated by water quality permits from TCEQ which require stringent limits for effluent quality. Generally, WWTFs in the Houston region are able to meet their permits. However, because human waste has an appreciable pathogenic potential, identifying trends in permit exceedances for indicator bacteria by WWTFs is important in understanding overall impacts to waterways. Additionally, effluent (especially if improperly treated) can be a source of nutrient precursors to depressed DO. Discharges from WWTFs are monitored on a regular basis (with a frequency dependent on plant size and other factors). The data from these required sampling events are submitted to (and compiled by) TCEQ as DMRs. As with any self-reported data, there is an expectation that some degree of uncertainty or variation from conditions may occur, but these DMRs are the most comprehensive data available for evaluating WWTFs in the watershed.

For this project, staff evaluated five parameters common to most WWTF permits, as reported in the most recent five years (2017 to 2021) of DMRs available from TCEQ. Some parameters are themselves constituents of concern, while the others are indicators of the presence or potential presence of untreated or improperly treated waste:

- Indicator bacteria (*E. coli*) – bacteria common in the intestines of all warm-blooded animals used as an indicator of the presence of fecal wastes. Due to this relationship, it may also be used as a proxy indicator of the safety of waterways for human recreation as fecal waste can be a vector for human pathogens.

- TSS – this measure of the number of suspended particles in water indicates the efficiency of the WWTF process, and the potential of effluent to impact sedimentation and light transmission in the waterway. Excessive particles in the water quality can foster bacteria survival, among other impacts.
- Ammonia Nitrogen – this nitrogenous compound is specifically harmful to aquatic systems, can impact human health in high concentrations, contributes to algal blooms and low DO, and can indicate the efficiency of wastewater treatment processes.
- DO, grab samples – this indicator directly characterizes the ability of the effluent to support aquatic life, and indicates the potential presence of nutrients and other oxygen-demanding substances (and thus the efficiency of treatment processes).
- 5-Day Carbonaceous Biological Oxygen Demand (CBOD5) – This indicator, which measures the depletion of oxygen over time by biological processes, indicates the efficiency of treatment.

The parameter evaluations were based on the regulatory permit limits specific to each plant, and consider the number of exceedances by each plant, in each year, in each segment, and as a percentage of the total samples.

Indicator Bacteria

As with surface water sampled throughout the watershed to gage ambient conditions, discharge from WWTFs is assessed for compliance with surface water quality standards. In the case of *E. coli*, the permitted geomean standard for bacteria concentrations is 126 CFU/100 mL whereas the grab sample standard is 399 CFU/100 mL. For this analysis, compliance with permit limits for bacteria were compared across segments, plant types, years, and seasons. Data from eight of the 10 plants represented by DMRs in the East Fork San Jacinto River watershed are summarized below.

Of the plants reporting violations of bacteria criteria, the majority experience exceedances less 1% of the time (**Table 7**). Following these, plants reporting samples exceeding the criteria between 1% and 5% of the time comprise the remainder. No WWTFs reported values exceeding the standard greater than 5% of the time.

With only one exceedance of the geometric mean and a single grab sample, respectively observed in a total of 217 records, it is difficult to make assumptions about these data being representative of a trend. No pattern was observed in either geomean or single grab criteria exceedance, or in the total number of *E. coli* exceedances observed annually and seasonally (**Table 8** and **Table 9**).

Table 7 E. coli *exceedance statistics, 2017-2021*

Parameter	Number of Plants	Percent of Plants	Percent of Reports
Plants in DMR	10		
Plants Reporting Bacteria	8		
Total Records	217		
Less than 1% Violations[4]	6	75.0%	
1% to 5% Violations	2	25.0%	
5% to 10% Violations	0	0.0%	
10% to 25% Violations	0	0.0%	
Greater than 25% Violations	0	0.0%	
Exceedances of Geomean	1		0.4%
Exceedances of Single Grab	1		0.4%
Total Exceedances	2		0.9%

Table 8 E. coli *exceedances by year*

	2017	2018	2019	2020	2021	Total
By Geomean	1	0	0	0	0	1
By Grab	0	0	0	0	1	1
Total Exceedances	1	0	0	0	1	2

Table 9 E. coli *exceedances by season*

	Spring (Months 3-5)	Summer (Months 6-8)	Fall (Months 9-11)	Winter (Months 12-2)	Total
By Geomean	0	0	0	1	1
By Grab	0	0	1	0	1
Total Exceedances	0	0	1	1	2

[4] Several plants in the watershed have more stringent limits (e.g., 63 CFU/100mL) depending on site-specific conditions, or participation in TMDL projects like the Houston-area Bacteria Implementation Group. For all analyses, the actual limit for each plant was used in comparison with its plant-specific results. The range of limits applied to the average and maximum conditions ranges from 63 to 399 CFU/100ml.

A relationship between plants evaluated for bacteria criteria exceedance compared to age of initial permit issuance is not clear (**Table 10**). Further, it should be noted that this analysis does not reflect any improvements made to older plants between their initial permit date and the present day that may have led to better management of effluent water quality.

Table 10 E. coli *exceedances by plant age*

	Before 1980	**1980 to 2000**	**2000 to 2020**
Number of Plants	0	1	7
Percent of All Plants	0.0%	12.5%	87.5%
Geomean Exceedances	0	1	0
Single Grab Exceedances	0	0	1
Total Exceedances	0	1	1

WWTFs are sized according to permitted output in millions of gallons per day (MGD). Plants of different sizes were analyzed for *E. coli* criteria exceedance, and according to the results, both of the exceedances occurred in plants of less than 0.1 MGD in size (**Table 11**). However, as this category makes up most plants in the watershed, this is not surprising. As mentioned previously, the low number of exceedances compared to the total recorded observations discourages any assumptions about data trends.

Table 11 E. coli *exceedances by plant size*

	Variable/Intermittent Discharge	**< 0.1 MGD**	**0.1 to 0.5 MGD**	**0.5 to 1 MGD**
Number of Plants	2	3	1	2
Percent of All Plants	25.0%	37.5%	12.5%	25.0%
Geomean Exceedances	0	1	0	0
Single Grab Exceedances	0	1	0	0
Total Exceedances	0	2	0	0

Overall, the results of the analyses of DMR *E. coli* data indicated that the total number of exceedances reported was small relative to the total number of DMR reports submitted for the period of 2017-2022 (2 out of 217 records). Seasonality was not observed to be significant in shaping trends in bacteria concentrations. Plant age and size are also not believed to correlate in any way with the observed exceedances. While WWTFs may be appreciable contributions under certain conditions, in localized areas, the DMR analysis indicates that they are not likely a significant driver of bacteria impairments in waterways due to the comparatively few exceedances. However, due to high risk of pathogen transmission via human waste relative to other bacteria sources, and proximity to developed areas, WWTF exceedances are likely still a point of concern for stakeholders.

Dissolved Oxygen

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

Only one exceedance of the minimum standard was observed in the winter of 2021 (**Table 12**). As with bacteria, the low occurrence of violations relative to the sample size cautions against determining trends for this analysis.

Table 12 *Dissolved Oxygen exceedance statistics, 2017-2021*

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

Due to the findings of this analysis, it is unlikely that DO levels in the waterways of the East Fork San Jacinto River watershed are being affected by WWTF effluent. As with the results of the bacteria analysis, it is important to note that periodic impacts to DO levels may occur on a localized level but may not be well represented in this broad analysis. While the impacts of WWTFs on DO levels may not be a chronic or widespread issue in the watershed, an analysis of DO values reported in DMRs is still a critical component of this project especially as it pertains to identifying localized impacts.

TSS

To determine the efficiency of wastewater treatment in removing solids, TSS was evaluated. Bacteria use suspended particles as a protected growth medium and can therefore occur in greater concentrations when TSS is high. Additionally, TSS can be useful as an indicator that inefficient treatment may have led to other waste products (nutrients, etc.) being elevated in effluent.

Permit limits for TSS include a concentration based (average) limit in mg/L and a total weight-based limit in weight per day. Both average and maximum monitored results exist for most plants. Evaluations for compliance with concentration and total weight permit limits were made for the overall dataset and for annual and seasonal data.

Exceedances of the concentration standard were far greater than exceedances of the weight standard. However, the total number of exceedances constituted less than 7% of the observed data (**Table 13**).

Table 13 *Total Suspended Solids exceedance statistics, 2017-2021*

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

The year with the most violations of both concentration and weight was 2019 (**Table 14**). These occurrences were observed after a year of no reported violations. In the following years (2020 and 2021), exceedances decreased back to the low levels observed in 2017.

Table 14 Total Suspended Solids exceedance by year

	2017	2018	2019	2020	2021	Total
Concentration	3	0	10	7	3	23
Weight	0	0	2	0	0	2
Total	3	0	12	7	3	25

Of the four seasons, samples exceeding the concentration standard seem to be most prevalent during the summer and winter months (**Table 15**). Exceedances of the weight standard were only observed during the spring.

Table 15 Total Suspended Solids exceedance by season

	Spring (Months 3-5)	Summer (Months 6-8)	Fall (Months 9-11)	Winter (Months 12-2)	Total
Concentration	4	8	4	7	23
Weight	2	0	0	0	2
Total	6	8	4	7	25

Though periodic, local impacts may not be captured by these results, water quality throughout the East Fork San Jacinto River watershed is unlikely to be impacted by TSS from WWTFs at the watershed level. A seasonal analysis showed that samples exceeding the concentration standard occurred with the highest frequency in winter and summer months, but the overall percentage of samples exceeding the standards compared to the total number of reports was negligibly small. Despite this, observing TSS in WWTF effluent is still worth considering when moving forward with best management practices for water quality. As mentioned previously, TSS is often correlated with nutrient and bacteria levels, and can be tracked as a measure of WWTF improvement.

Ammonia Nitrogen

Ammonia nitrogen is a component that indicates negative impacts to water quality due to nutrient loading. Further, it can be toxic to humans and wildlife. Deficiencies in wastewater treatment that lead to improperly treated sewage entering waterways can be indicated by elevated levels of ammonia nitrogen.

Similar to TSS, concentration and weight measurements are used to assess compliance of ammonia nitrogen levels with permit limits. Results of samples reported between 2017 and 2021 to be in exceedance of the standards indicate that ammonia nitrogen violations were infrequent and occurred in less than 9% of the observed records (**Table 16**).

Table 16 Ammonia nitrogen exceedance statistics, 2017-2021

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

As seen with TSS, the most exceedances observed in one year occurred in 2019 after relatively low occurrences of exceedances in preceding years (**Table 17**).

Table 17 *Ammonia nitrogen exceedance by year*

	2017	**2018**	**2019**	**2020**	**2021**	**Total**
Concentration	1	1	10	6	7	25
Weight	0	1	1	2	1	5
Total	1	2	11	8	8	30

When observed seasonally, exceedances of concentration and weight standards for ammonia nitrogen do seem to occur more frequently in the summer months (**Table 18**).

Table 18 *Ammonia nitrogen exceedance by season*

	Spring (Months 3-5)	**Summer (Months 6-8)**	**Fall (Months 9-11)**	**Winter (Months 12-2)**	**Total**
Concentration	5	9	3	8	25
Weight	1	3	0	1	5
Total	6	12	3	9	30

The results of the analyses of ammonia nitrogen reported by WWTFs in the East Fork San Jacinto River watershed show that exceedances were most frequent in 2019 and are more common in summer months. However, the total number of exceedances reported for ammonia nitrogen comprise less than 9% of the total reported values. This indicates that WWTFs are generally operating within permit limits and that ammonia inputs from WWTFs are not likely a chronic issue of importance for East Fork San Jacinto River waterways. Periodic, localized impacts may not be as apparent when using a broad scope analysis. Ammonia nitrogen may still have use as an indicator of WWTF efficiency much in the same way as TSS and will therefore continue to be considered for best management practices in the watershed.

Biological Oxygen Demand

CBOD5 measures the depletion of oxygen over time by biological processes and indicates the efficiency of treatment. It is not a pollutant itself but is informative of the water quality of effluent from WWTFs. Exceedances of the concentration standard make up less than 2% of the dataset (**Table 19**). No exceedances of the weight standard were observed.

Table 19 *CBOD5 exceedance statistics, 2017-2021*

Category	**Number**	**Percent of Records**
Plants in DMR Dataset	10	
Plants Reporting Ammonia Nitrogen	9	
Total Records	367	
Exceedances of Concentration	6	1.64%
Exceedances of Weight	0	0.0%
Total Exceedances	6	1.64%

Annual exceedances were only observed in 2019 and 2020 (**Table 20**), but as with bacteria and DO, it should be noted that determining a trend from exceedance values occurring at such low frequencies might be misrepresentative of the overall dataset.

Table 20 CBOD5 exceedance by year

	2017	2018	2019	2020	2021	Total
Concentration	0	0	2	4	0	6
Weight	0	0	0	0	0	0
Total	0	0	2	4	0	6

From the seasonal observations of CBOD5 exceedance frequency (**Table 21**), there does seem to be a higher occurrence of exceedance in cooler spring and winter months. However, it bears repeating that as a subset of 367 total report values, the 5 exceedances of CBOD5 observed in spring and winter months may not constitute a representative trend.

Table 21 CBOD5 exceedance by season

	Spring (Months 3-5)	Summer (Months 6-8)	Fall (Months 9-11)	Winter (Months 12-2)	Total
Concentration	2	1	0	3	6
Weight	0	0	0	0	0
Total	2	1	0	3	6

CBOD5 exceedances did not occur frequently in this DMR dataset, and no strong annual or seasonal patterns were observed as the small number of exceedances limits the applicability of any trends. From this analysis, it can be assumed that WWTFs are not likely a chronic source of poor CBOD5 values in the East Fork San Jacinto River watershed. As with previous analyses however, it should be noted that determining periodic and localized impacts may require further investigation.

Overview of Results

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

WWTFs may not be a significant source of bacteria leading to impairments and concerns in the East Fork San Jacinto River waterways, but effluent from these facilities has an inherently higher pathogenic potential than other sources due to the treatment of human waste. Additionally, unlike other sources of natural and diffuse fecal waste in the watersheds, WWTF effluent has both regulatory controls and voluntary measures by which improperly treated wastewater may be addressed. Given the nature of WWTF effluent as a human pollutant, and our direct ability to influence its character, WWTF bacteria should be considered as a potential focus for some best management practices. While other constituents (e.g., nutrients) are not necessarily any more harmful than other sources in the watershed, the principle of direct control of effluent applies to their consideration as well. This is exacerbated for nutrients given the lack of permit limits for some nutrient parameters, and the likelihood that WWTFs may be appreciable nutrient loading sources in effluent dominated streams.

3.4 Sanitary Sewer Overflow Data

Though SSOs occur episodically, they represent a high-risk vector for bacteria contamination because they can have concentrations of bacteria several orders of magnitude higher than treated effluent. Untreated sewage can contain large volumes of raw fecal matter, making it a significant health risk where SSOs are sizeable and/or chronic issues. The causes of SSOs vary from human error to infiltration of rainwater into sewer pipes. Data used for these analyses are self-reported and may vary in quality. Even in the best of circumstances, the ability to accurately gauge SSO volumes or even occurrences in the field is limited by several factors. Actual SSO volumes and incidences are generally expected to be greater than reported due to these fundamental challenges. To reflect the breakdown in the TCEQ SSO database, known causes of SSOs were broken into four broad categories (weather, malfunctions, blockages, and unknown) with several subcategories each (**Table 22**). It should be noted, however, that this categorization depends on the accuracy of the data reported by the utilities. Additionally, while a single cause is typically listed on the SSO report, many SSOs are caused by a combination of factors.

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

The highest number of SSOs observed in one year occurred in 2019 (**Table 22** and **Figure 3**). In terms of cause by number, the general category of weather-related issues accounted for 50.0% of the overall total, malfunctions and operational issues accounted for 40.9%, and 9.1% were listed as blockages.

***Table 22** Number of annual Sanitary Sewer Overflow events*

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

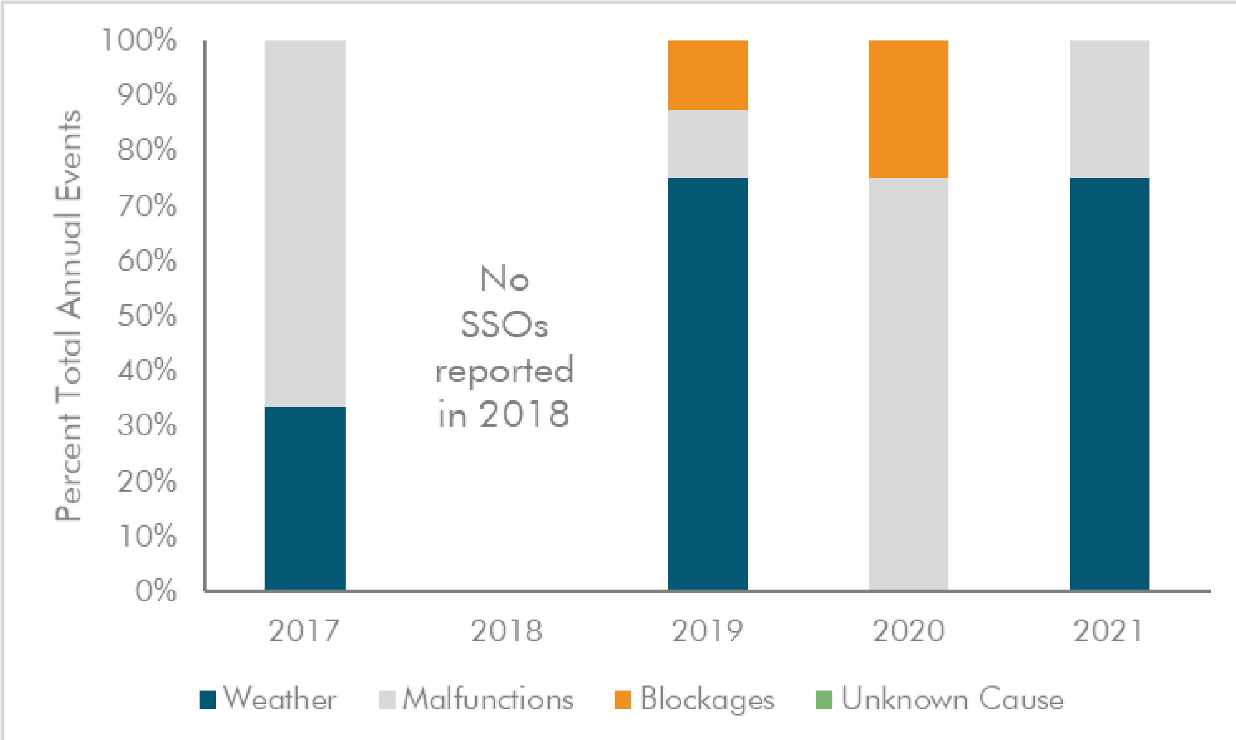


Figure 3 Percent total annual Sanitary Sewer Overflow events separated by cause

While numbering SSO events informs how frequently these overflows impact the watershed, volume of overflow is an indicator of the magnitude of impact. As with number of events, the highest annual volume of SSOs occurred in 2019 (**Table 23** and **Figure 4**). Of note though, 2017 had only the second highest total overflow volume reported over the five years of study, over 73% of the overflow volume was associated with a hurricane event (Hurricane Harvey). High flows associated with Tropical Storm Imelda in 2019 yielded over 84% of the annual SSO volume.

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

Table 23 Annual Sanitary Sewer Overflow events by volume (in gallons)

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

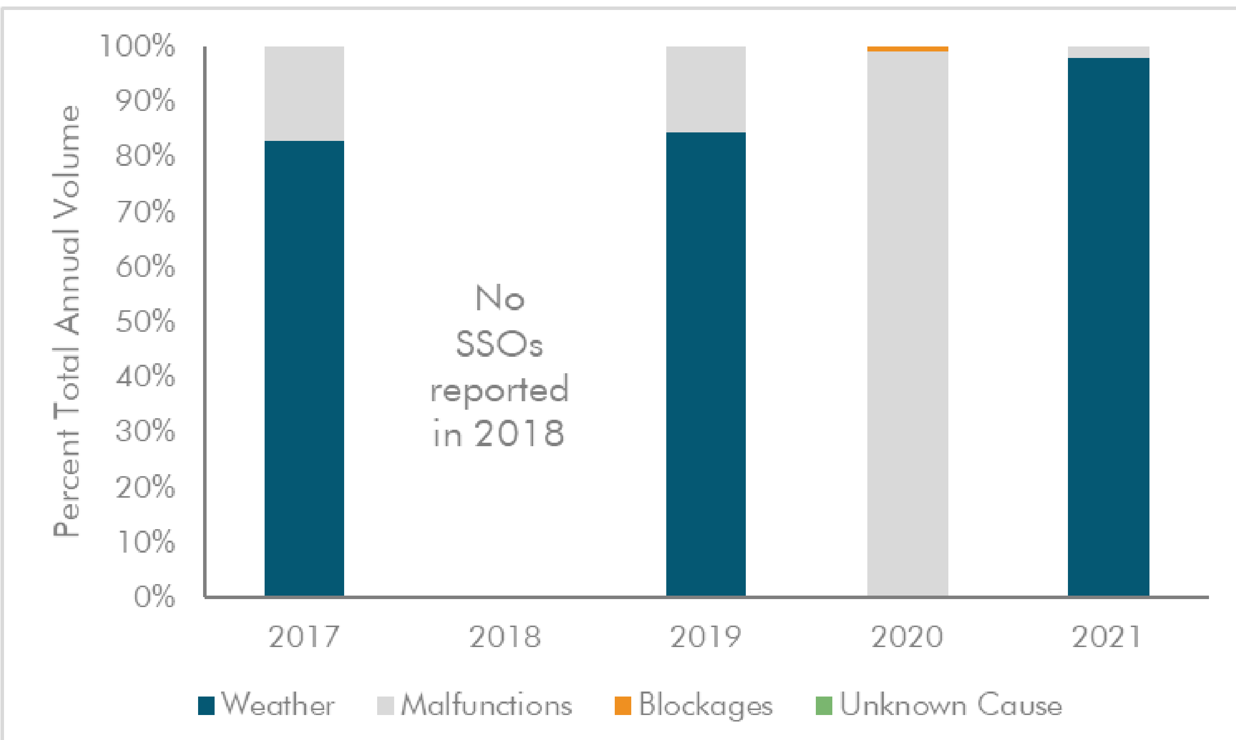


***Figure 4** Percent total annual Sanitary Sewer Overflow volume separated by cause*

One further consideration to make from the SSO report data is whether the frequency or volume of events showed any seasonal trend. The data do not support any clear seasonal pattern in the data aside from a lower frequencies and volumes observed in the winter months relative to the other seasons (**Table 24**).

Table 24 *Seasonal Sanitary Sewer Overflow frequency and volume (in gallons)*

Season	Number	Volume
Winter (Months 12-2)	4	11,600
Spring (Months 3-5)	7	153,500
Summer (Months 6-8)	5	151,800
Fall (Months 9-11)	6	148,350
Total	**22**	**465,250**

SSO Summary

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

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

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

SECTION 4: OUTCOMES AND IMPLICATIONS

This initial analysis of ambient water quality, DMR, and SSO report data is foundational for understanding and characterizing water quality concerns in the East Fork San Jacinto River watershed. Findings from this report can be used to inform stakeholders as they work toward the development of a WPP.

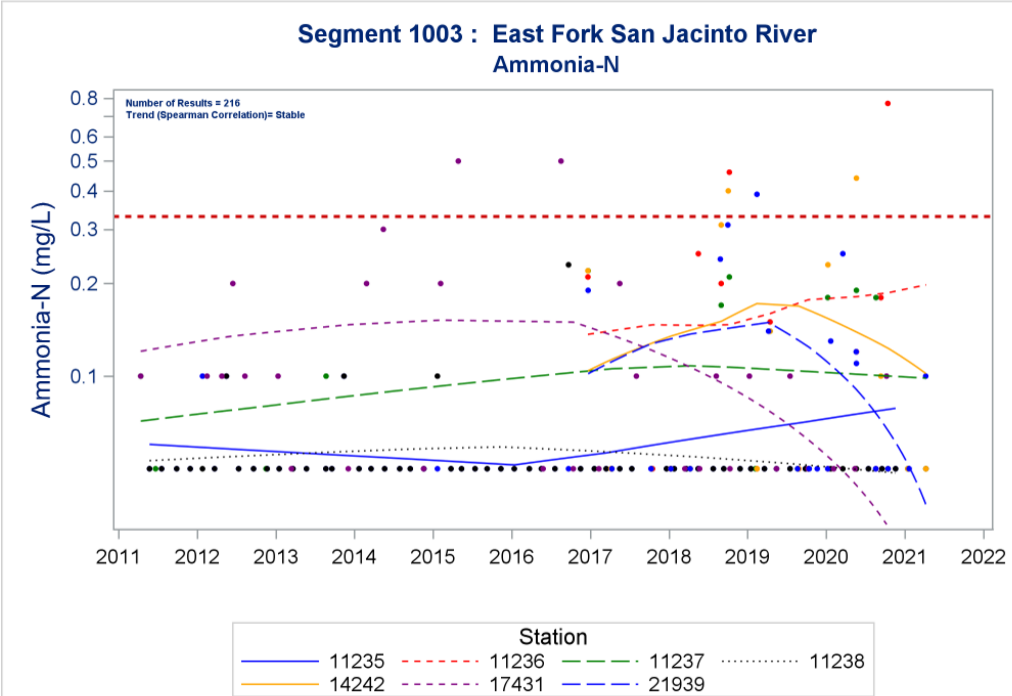
Data meeting the criteria for sufficiency were used to determine what constituents of water quality are of greatest concern and the extent to which their impacts have been observed throughout the area waterways. As indicated in the *2022 IR* results for this watershed, an analysis of the SWQM dataset identified high levels of the fecal indicator bacteria *E. coli* as the most pervasive impact to water quality. This was confirmed by the analysis of ambient water quality collected between 2011 and 2021, however, relatively low exceedances of the standard in the impaired segments (1003, 1003A) and segments with bacteria concerns (1003C) are likely to be reduced with water quality improvement strategies to be included in a future WPP.

Permitted wastewater effluent was unlikely to be a widespread or chronic water quality issue but requires further investigation on limited spatial scales and timeframes. However, understanding these discharges is still critical to the development of this project. Further, as treatment facilities for human waste, improper treatment indicators identified in DMR analyses can have greater implications for risk to human health.

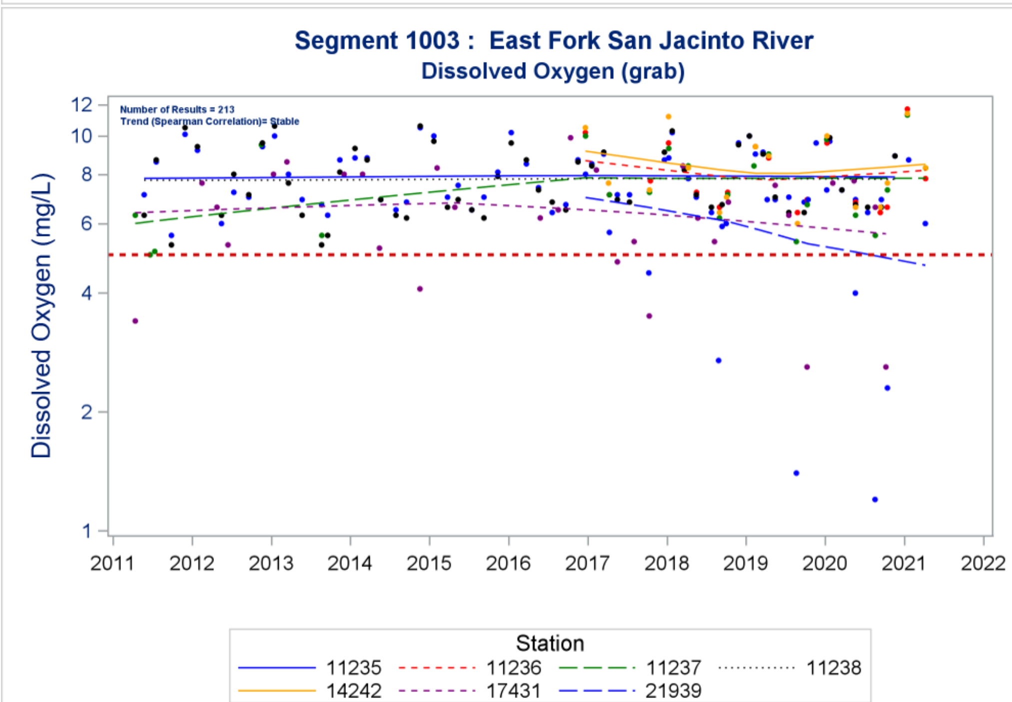
An analysis of SSO reports from the East Fork San Jacinto River watershed indicated that 28.6% of reporting plants experienced five or more SSO events between 2017 and 2021. Patterns in number of events were representative of patterns observed in magnitude of overflow volume. For both number of SSO events and volume of overflow, weather was the most common for the general cause categories. However, it is important to note that while only one cause is usually listed on the report, multiple compounding factors can lead to SSOs. Ultimately, causes listed in SSO reports are prone to a degree of subjectivity as opposed to more quantitative measurements. While the episodic overflow volumes reported during these events are relatively small compared to the scale of effluent produced by WWTFs, SSO inputs are of particular concern due to the untreated nature of the sewage associated with them and the subsequent risk to human health. As future growth projections indicate that increased development in the watershed is likely, the balance of pollutant sources and current hydrologic processes could be altered significantly in the coming years. These changes could result in further water quality impacts without intervention. Subsequent efforts should be made to identify causes and sources of the primary constituent of concern (indicator bacteria) to identify areas within the project watersheds most vulnerable to pollutant loadings and/or best suited for the implementation of management strategies.

APPENDIX A: WATER QUALITY MONITORING SITE DATA

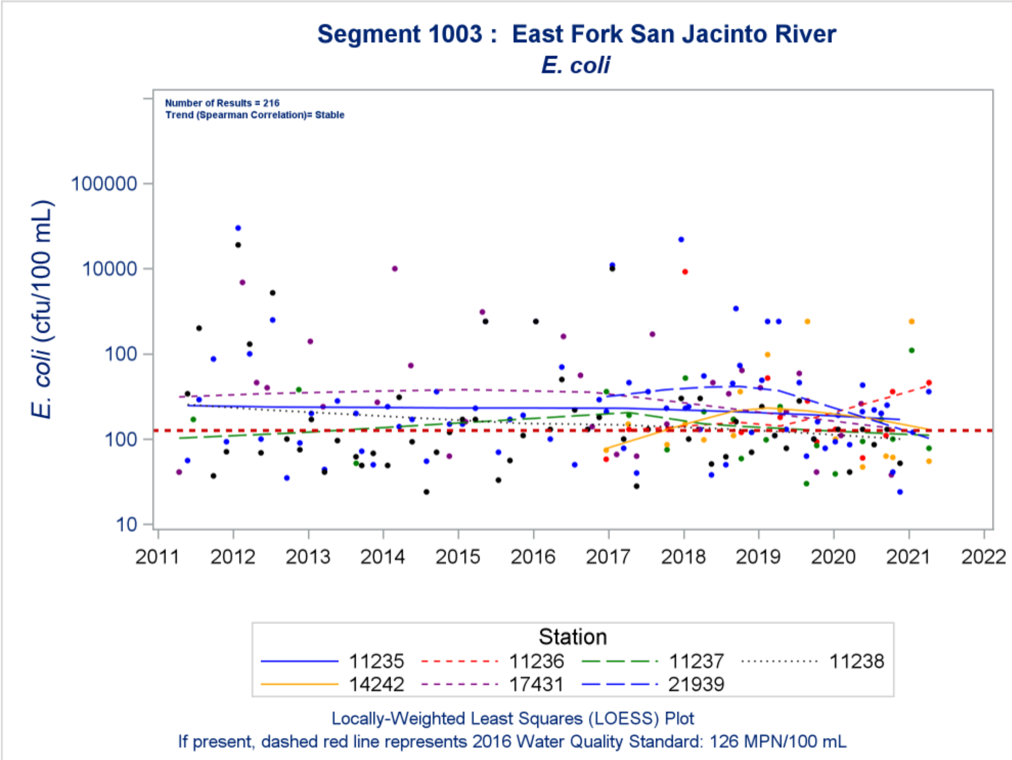
The following figures represent the results, by segment and station, for all constituents evaluated. The period of observation is 2011 to 2021, although data for each station may vary as indicated in the charts. The quantitative analysis for the ambient conditions was conducted using SAS. Statistical analyses are based on a LOESS curve rather than a straight regression curve to better indicate change in trend over time for disparate stations.

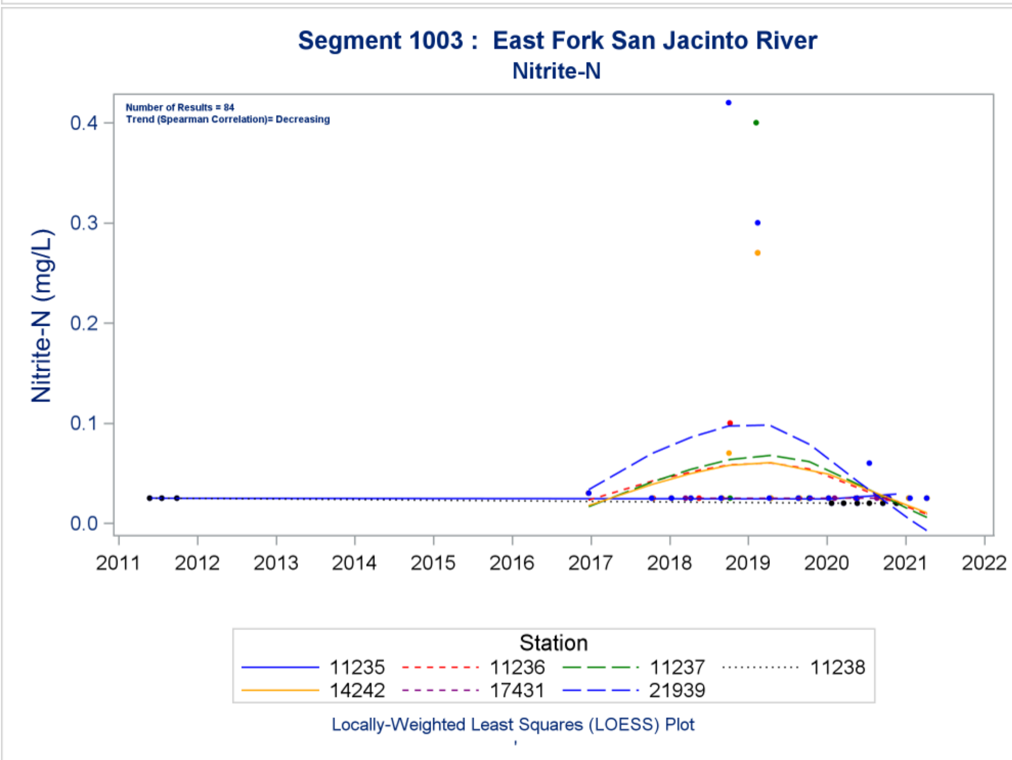


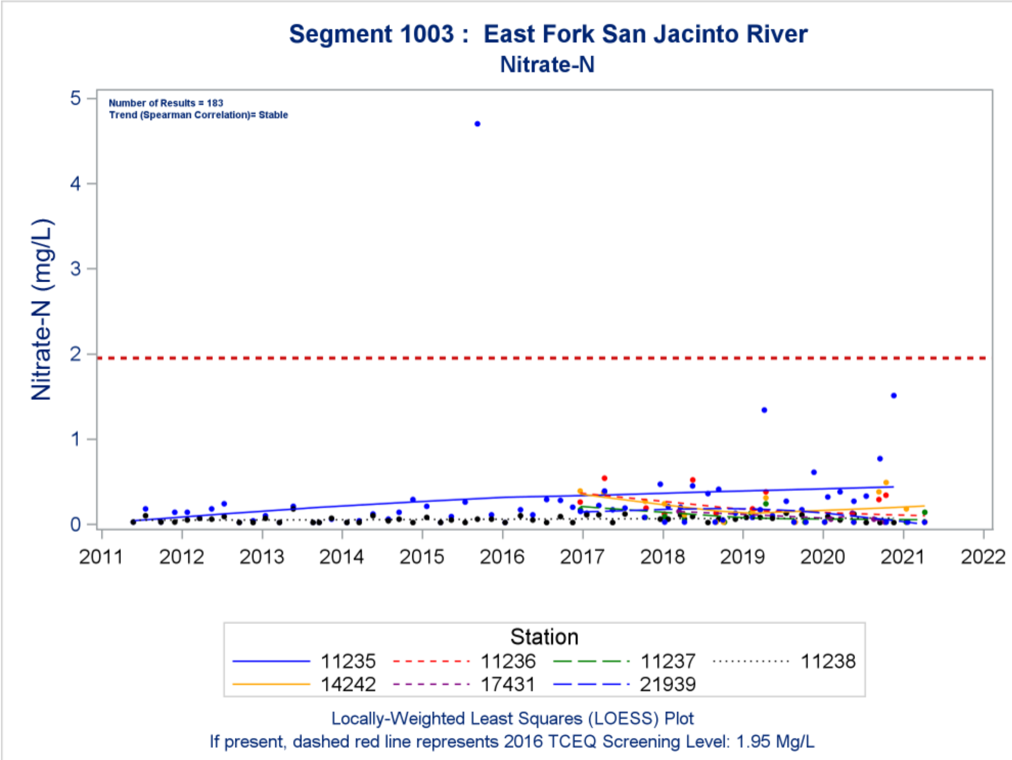
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 0.33 mg/L

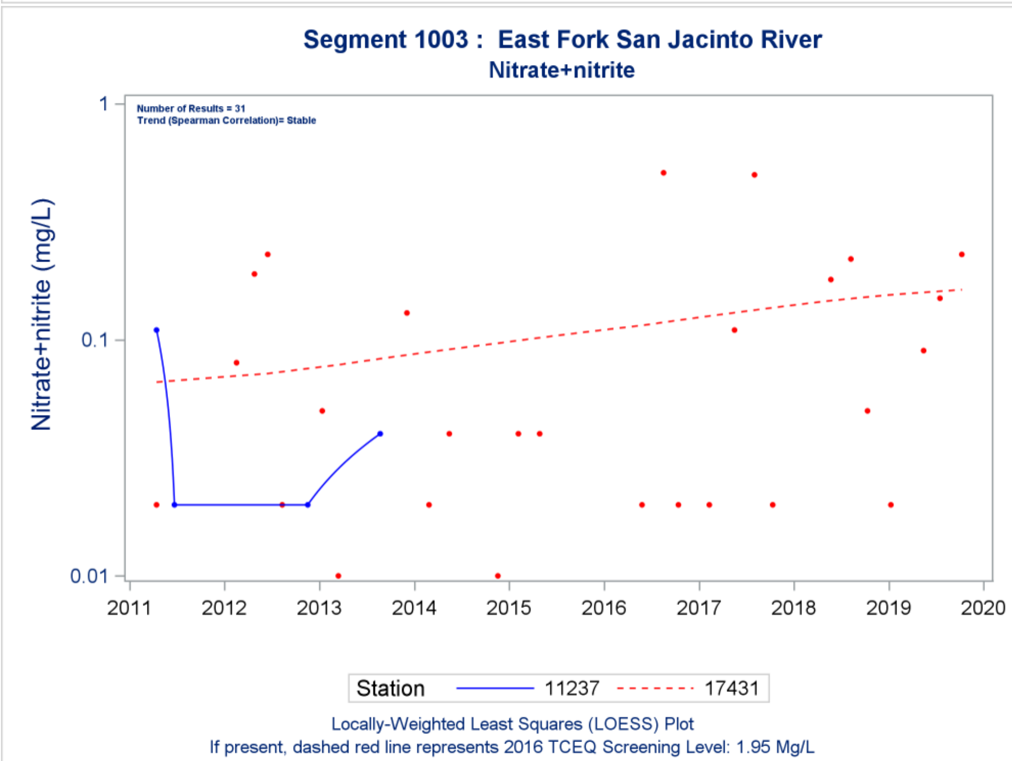


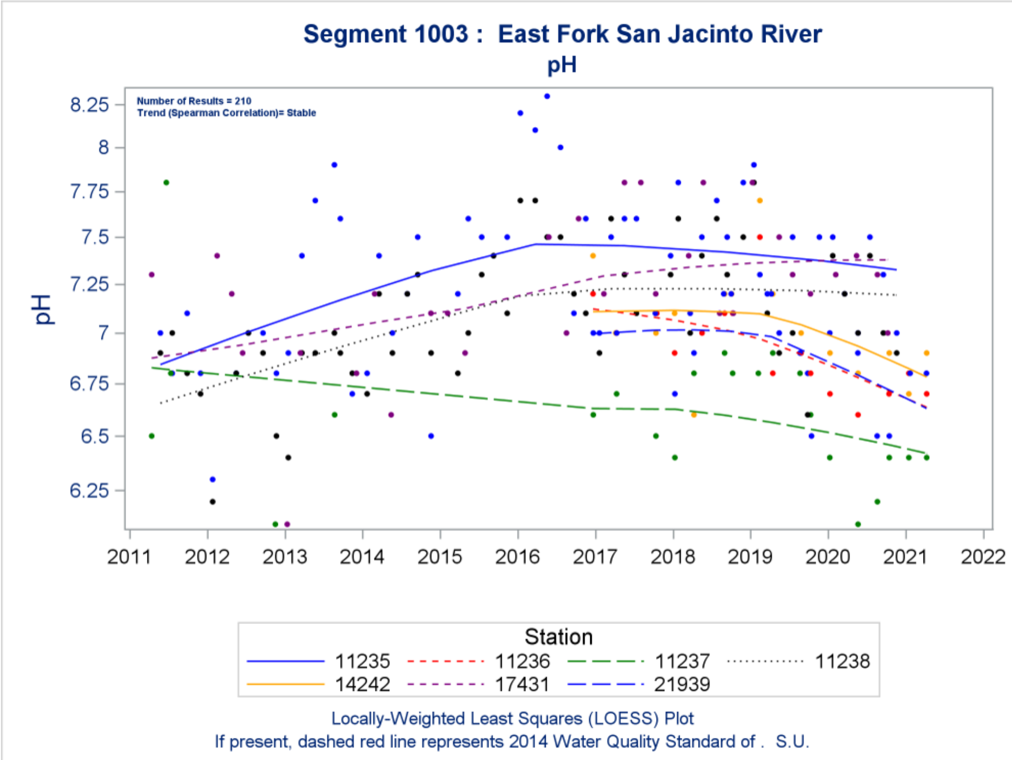
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 Water Quality Standard: 5.0 mg/L

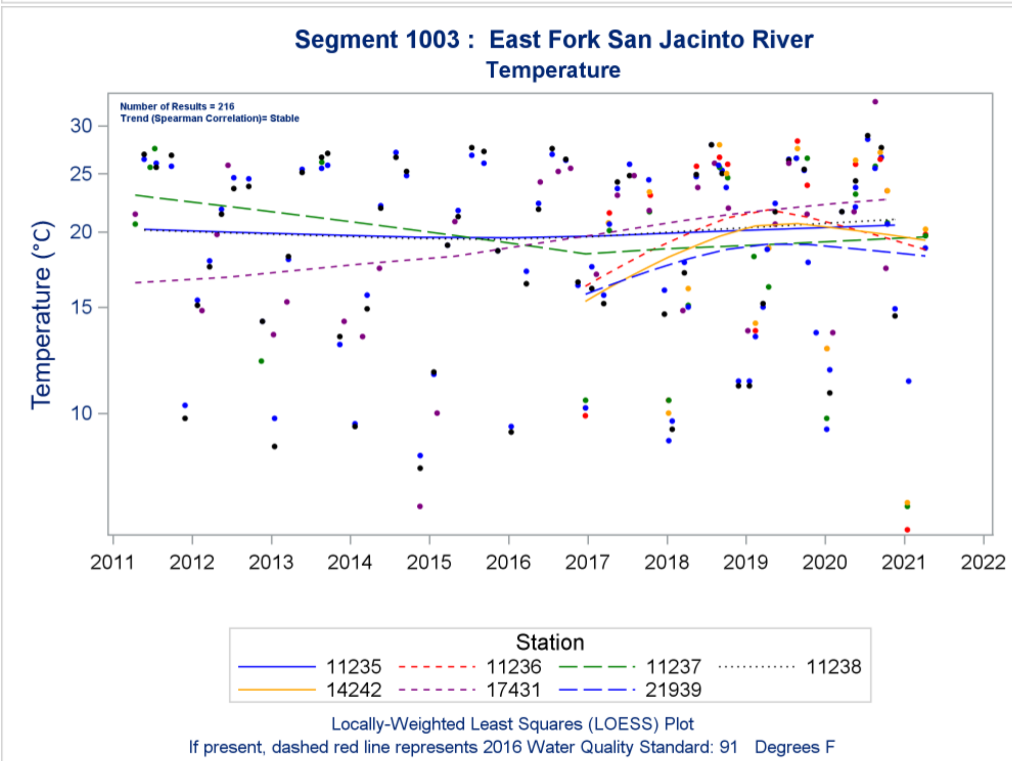

Segment 1003 : East Fork San Jacinto River
E. coli
Number of Results = 216
Trend (Spearman Correlation)= Stable
E. coli (cfu/100 mL)
100000
10000
100
100
10
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 Water Quality Standard: 126 MPN/100 mL

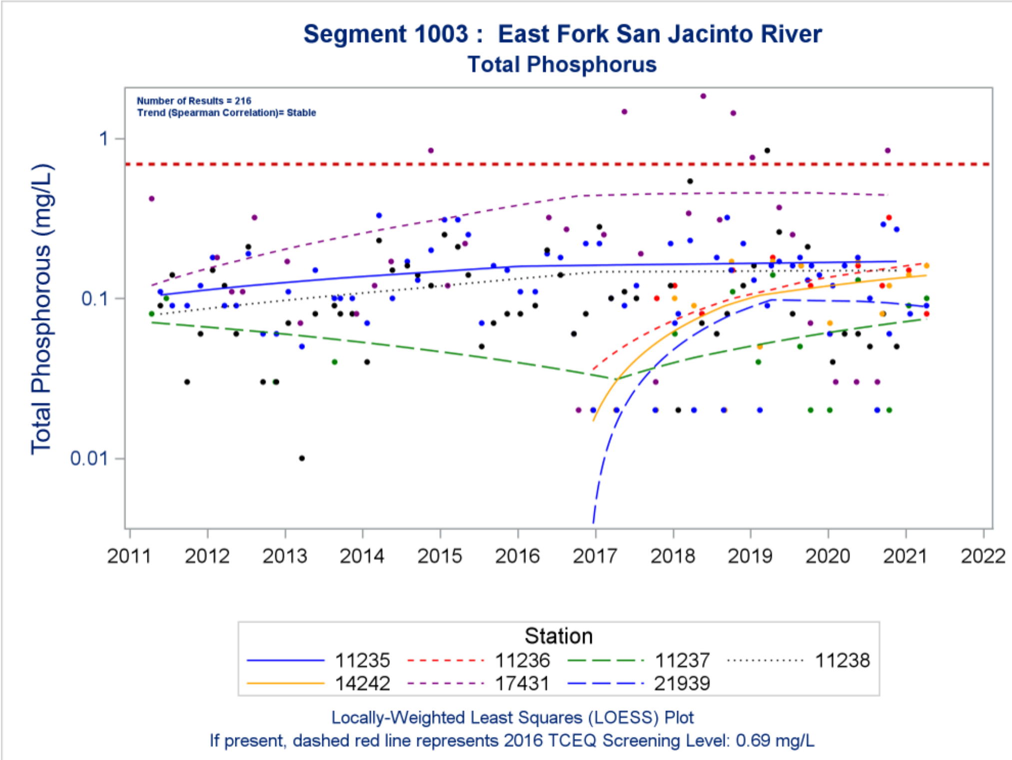

Segment 1003 : East Fork San Jacinto River
Nitrite-N
Number of Results = 84
Trend (Spearman Correlation)= Decreasing
Nitrite-N (mg/L)
0.4
0.3
0.2
0.1
0.0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot


Segment 1003 : East Fork San Jacinto River
Nitrate-N
Number of Results = 183
Trend (Spearman Correlation)= Stable
Nitrate-N (mg/L)
0
1
2
3
4
5
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 1.95 Mg/L

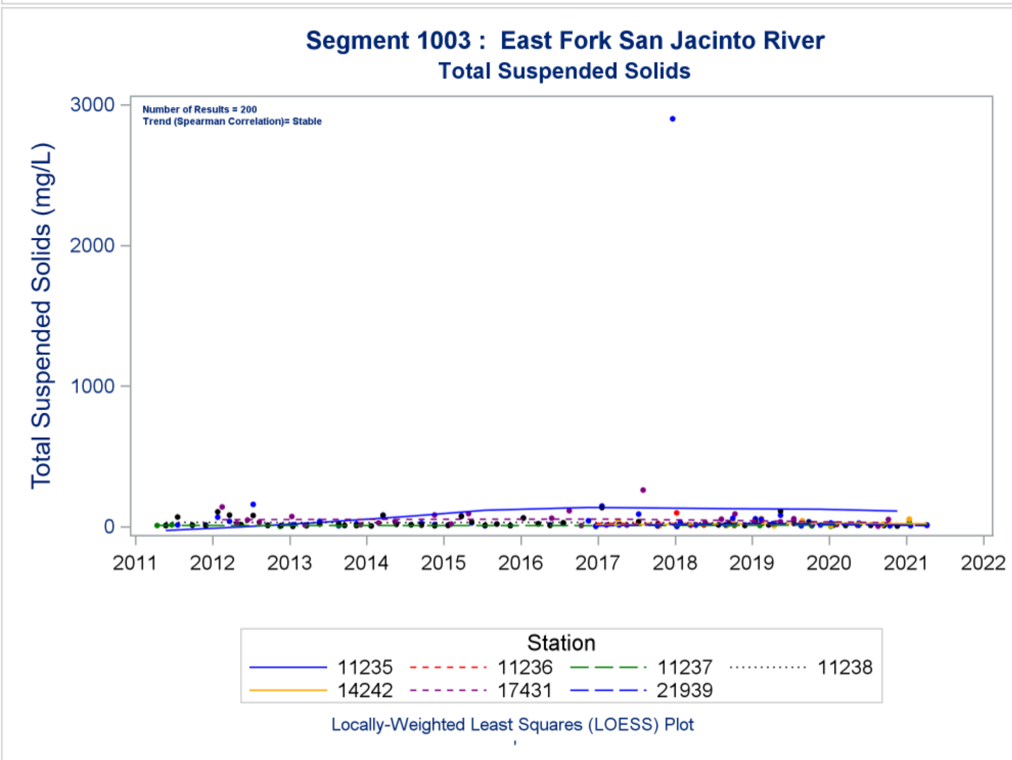

Segment 1003 : East Fork San Jacinto River
Nitrate+nitrite
Number of Results = 31
Trend (Spearman Correlation)= Stable
Nitrate+nitrite (mg/L)
0.01
0.1
1
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Station
11237
17431
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 1.95 Mg/L


Segment 1003 : East Fork San Jacinto River
pH
Number of Results = 210
Trend (Spearman Correlation)= Stable
pH
8.25
8
7.75
7.5
7.25
7
6.75
6.5
6.25
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2014 Water Quality Standard of . S.U.

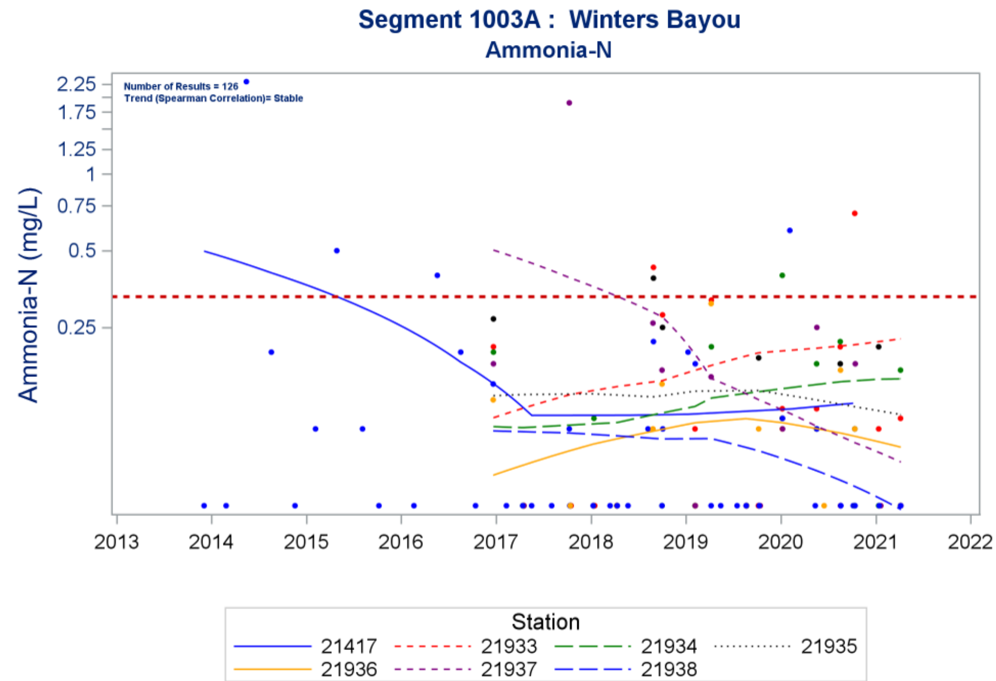

Segment 1003 : East Fork San Jacinto River
Temperature
Number of Results = 216
Trend (Spearman Correlation)= Stable
Temperature (°C)
30
25
20
15
10
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 Water Quality Standard: 91 Degrees F



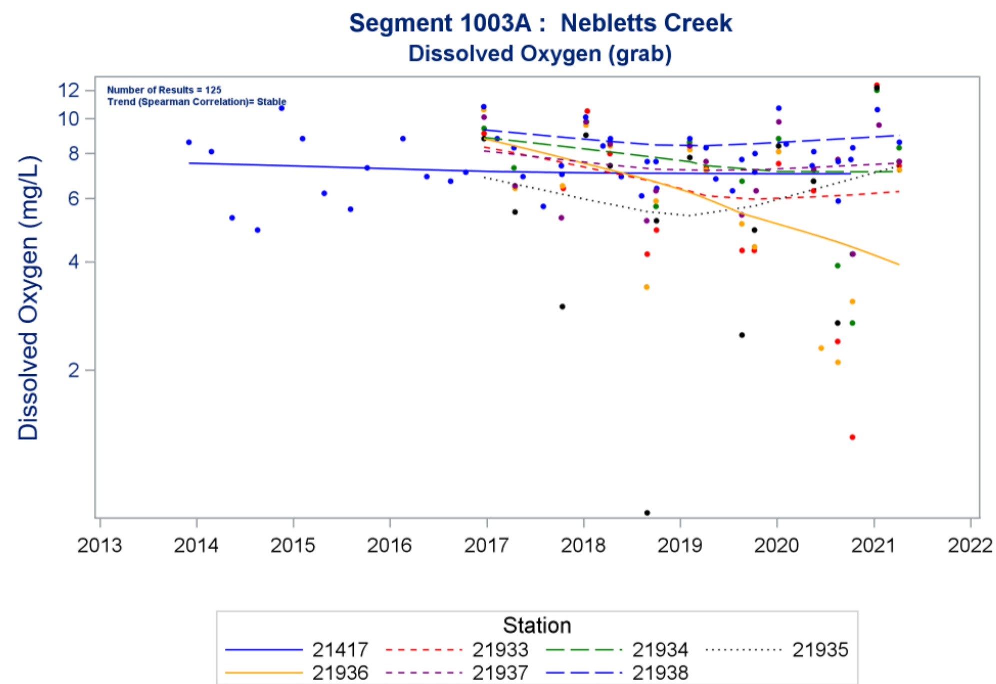
Segment 1003 : East Fork San Jacinto River
Total Phosphorus
Number of Results = 216
Trend (Spearman Correlation)= Stable
Total Phosphorous (mg/L)
1
0.1
0.01
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 0.69 mg/L



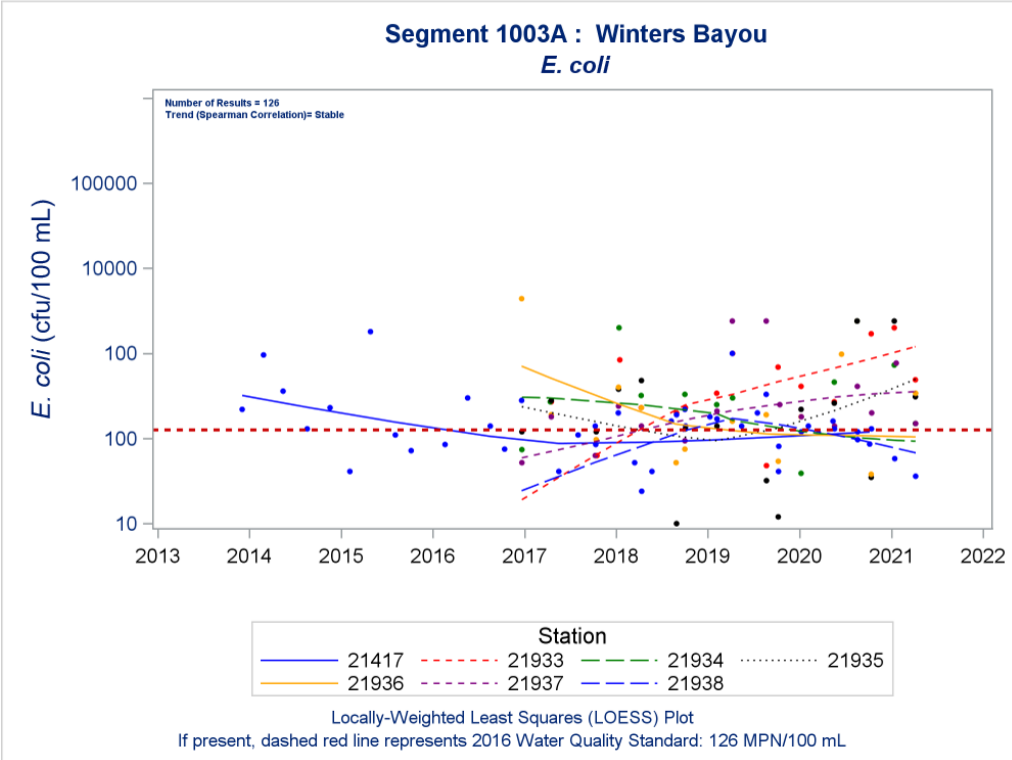
Segment 1003 : East Fork San Jacinto River
Total Suspended Solids
Number of Results = 200
Trend (Spearman Correlation)= Stable
Total Suspended Solids (mg/L)
3000
2000
1000
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
11235
11236
11237
11238
14242
17431
21939
Locally-Weighted Least Squares (LOESS) Plot

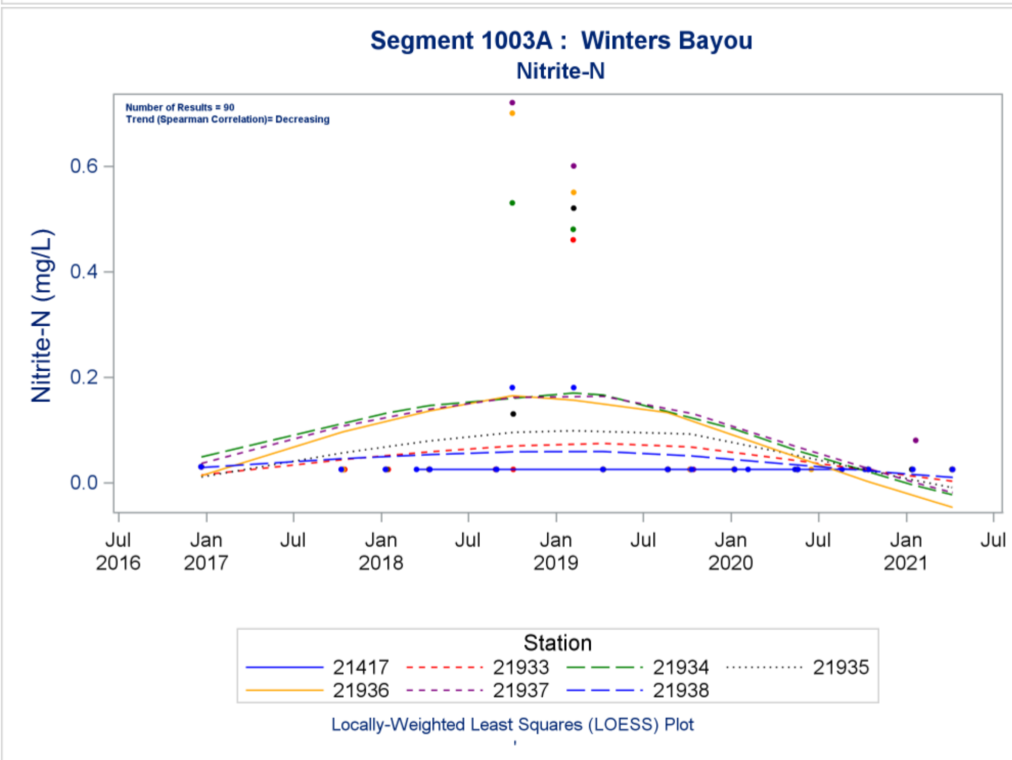


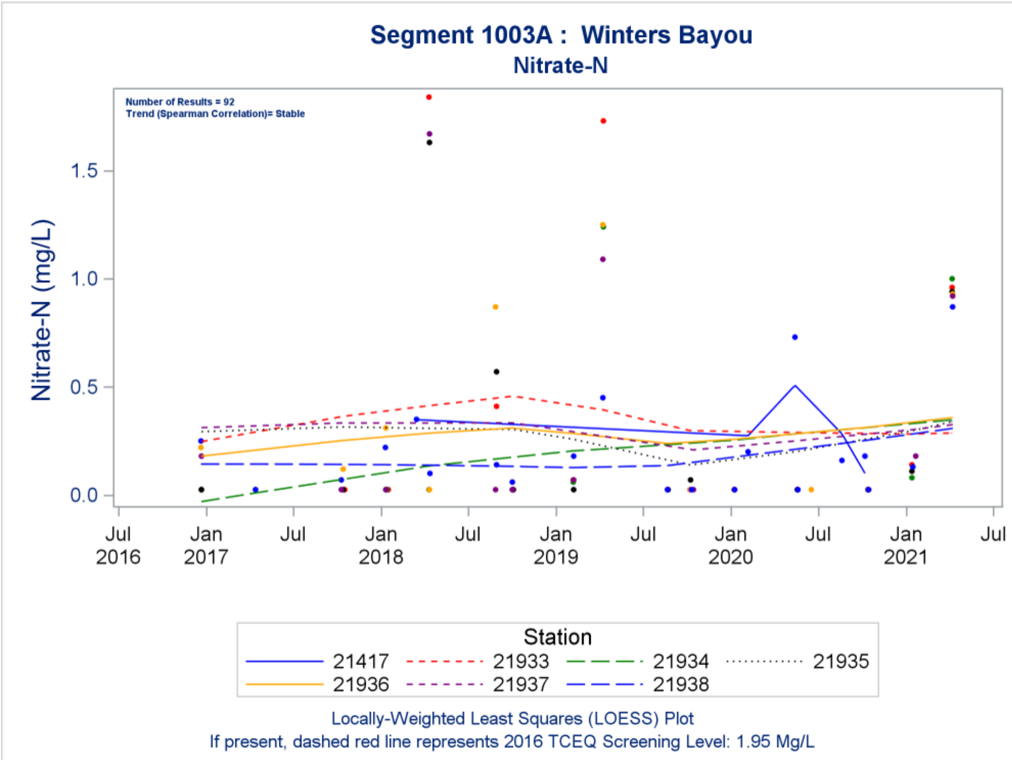
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 0.33 mg/L

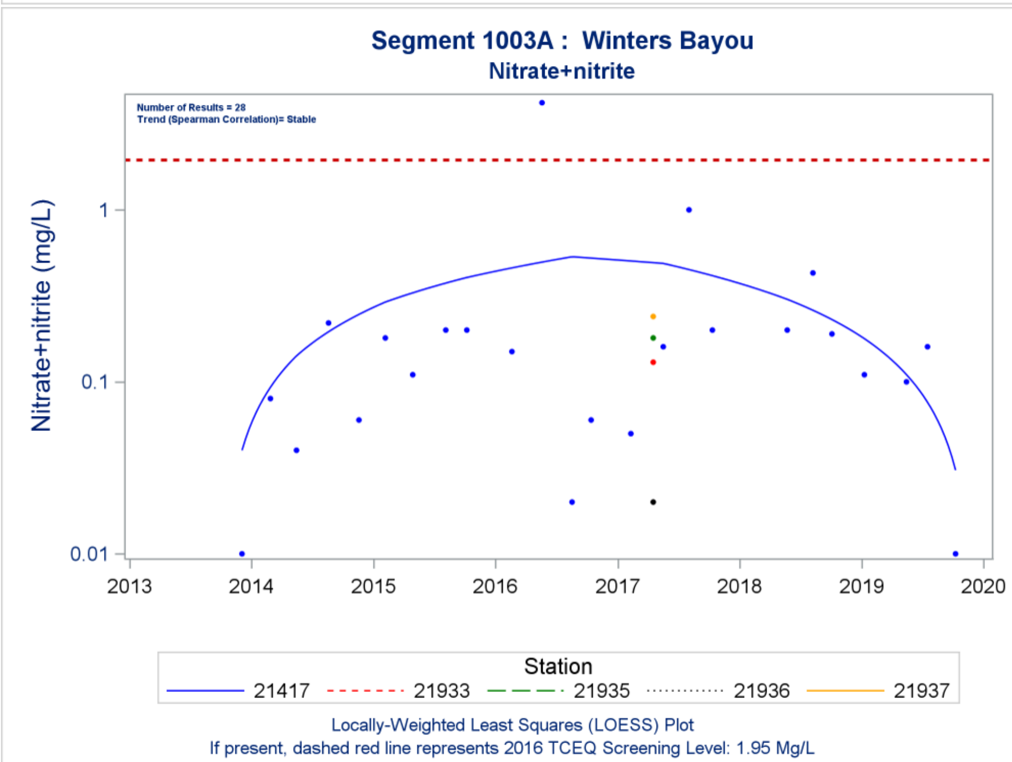


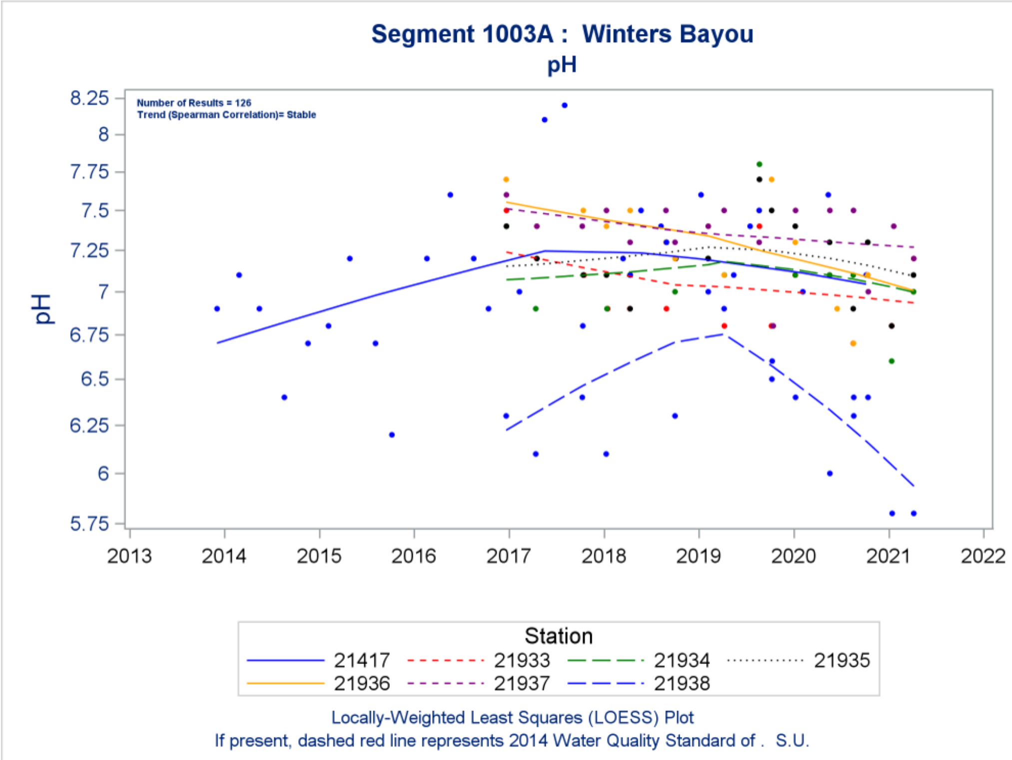
Locally-Weighted Least Squares (LOESS) Plot

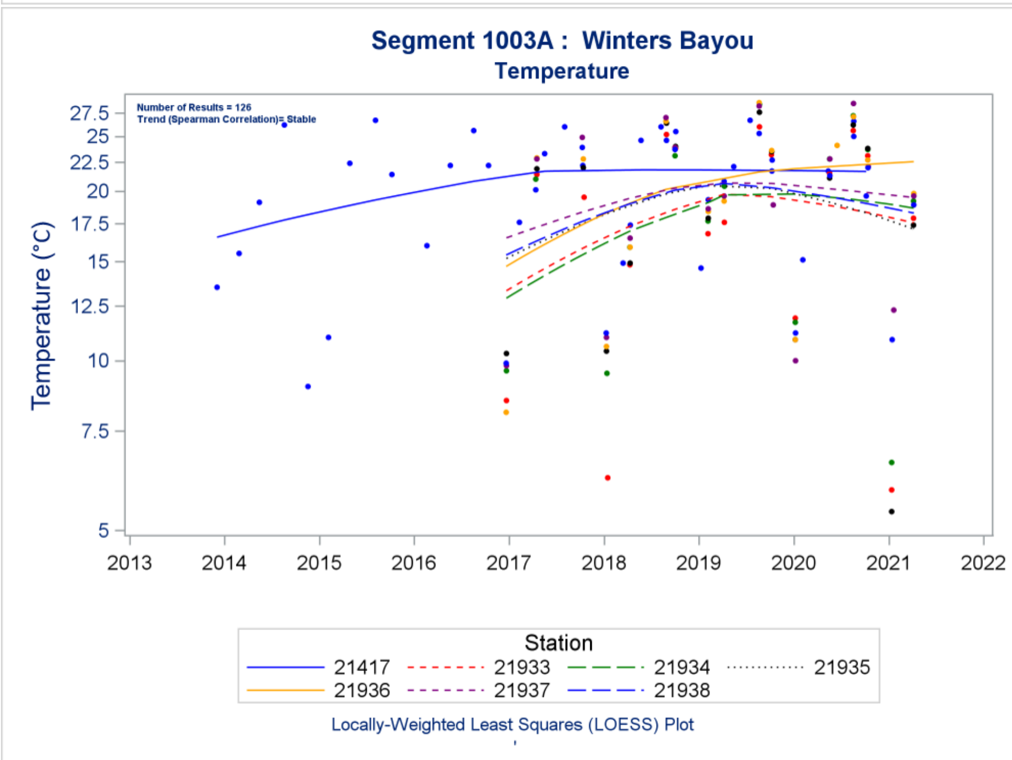

Segment 1003A : Winters Bayou
E. coli
Number of Results = 126
Trend (Spearman Correlation)= Stable
E. coli (cfu/100 mL)
100000
10000
100
100
10
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 Water Quality Standard: 126 MPN/100 mL

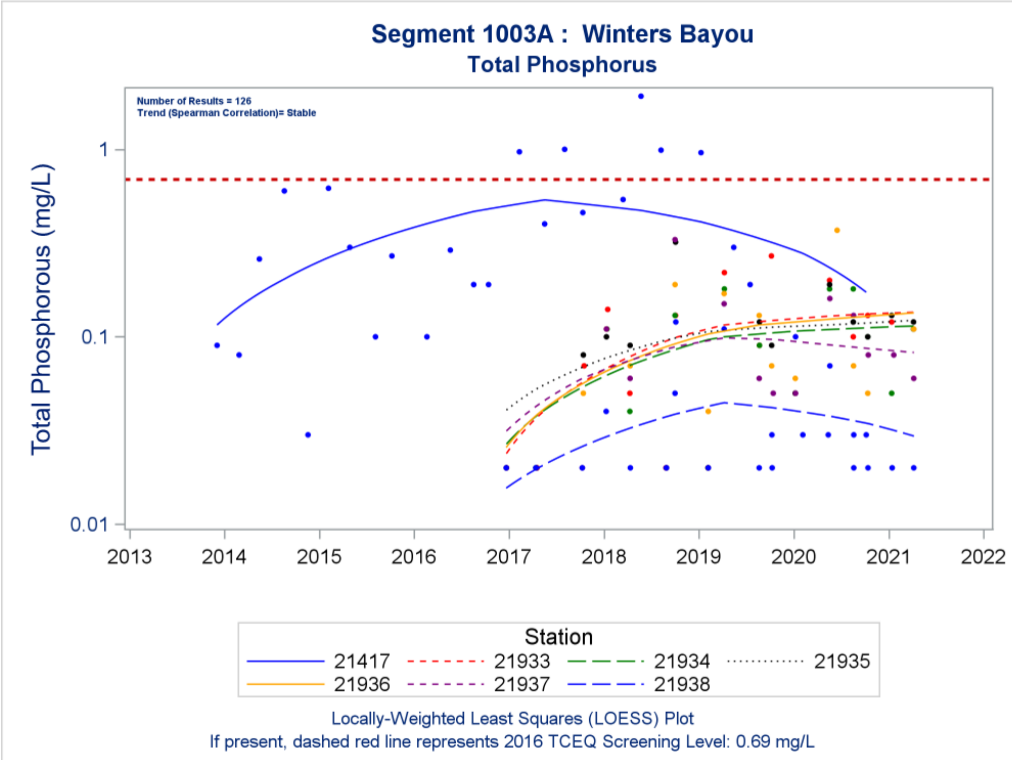

Segment 1003A : Winters Bayou
Nitrite-N
Number of Results = 90
Trend (Spearman Correlation)= Decreasing
Nitrite-N (mg/L)
0.6
0.4
0.2
0.0
Jul 2016
Jan 2017
Jul
Jan 2018
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot

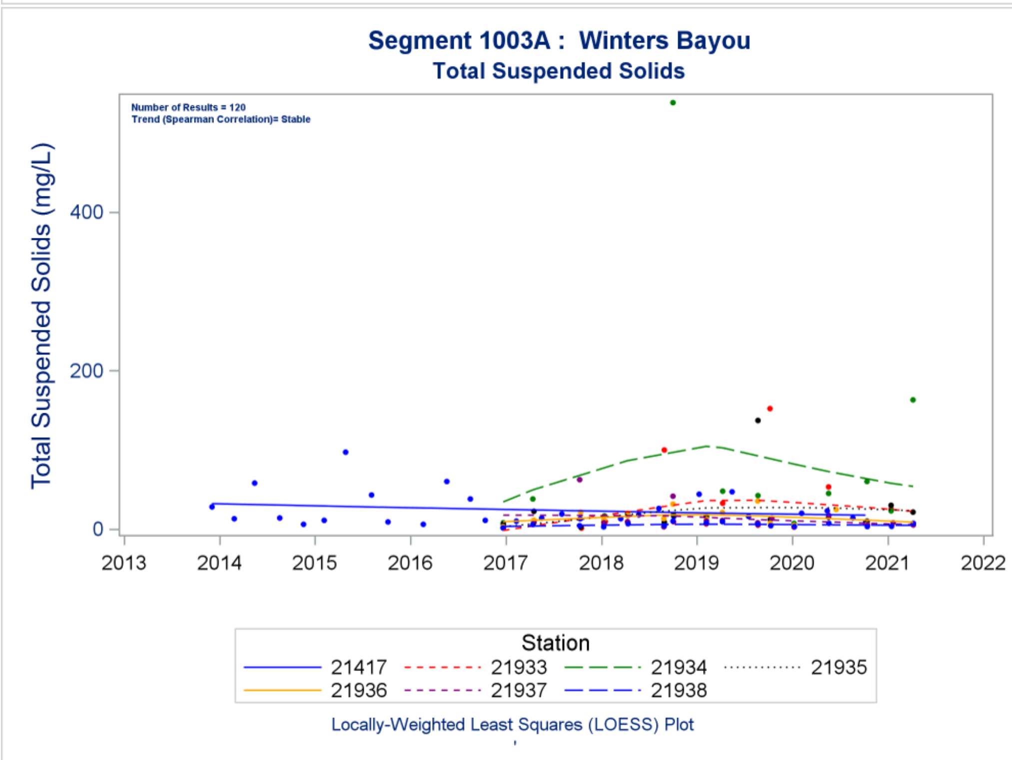

Segment 1003A : Winters Bayou
Nitrate-N
Number of Results = 92
Trend (Spearman Correlation)= Stable
Nitrate-N (mg/L)
1.5
1.0
0.5
0.0
Jul 2016
Jan 2017
Jul
Jan 2018
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 1.95 Mg/L


Segment 1003A : Winters Bayou
Nitrate+nitrite
Number of Results = 28
Trend (Spearman Correlation)= Stable
Nitrate+nitrite (mg/L)
1
0.1
0.01
2013
2014
2015
2016
2017
2018
2019
2020
Station
21417
21933
21935
21936
21937
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 1.95 Mg/L


Segment 1003A : Winters Bayou
pH
Number of Results = 126
Trend (Spearman Correlation)= Stable
pH
8.25
8
7.75
7.5
7.25
7
6.75
6.5
6.25
6
5.75
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2014 Water Quality Standard of . S.U.


Segment 1003A : Winters Bayou
Temperature
Number of Results = 126
Trend (Spearman Correlation)= Stable
Temperature (°C)
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot


Segment 1003A : Winters Bayou
Total Phosphorus
Number of Results = 126
Trend (Spearman Correlation)= Stable
Total Phosphorous (mg/L)
1
0.1
0.01
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot
If present, dashed red line represents 2016 TCEQ Screening Level: 0.69 mg/L


Segment 1003A : Winters Bayou
Total Suspended Solids
Number of Results = 120
Trend (Spearman Correlation)= Stable
Total Suspended Solids (mg/L)
400
200
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Station
21417
21933
21934
21935
21936
21937
21938
Locally-Weighted Least Squares (LOESS) Plot