Texas State Soil and Water Conservation Board Workplan 18-07

Final Report: Coordinating Facilitation and Implementation of the Double Bayou Watershed Protection Plan and Monitoring for Implementation Effectiveness

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Executive Summary

The Double Bayou Watershed is situated in the eastern portion of the Lower Galveston Bay watershed on the Upper Texas Gulf Coast and is comprised of two main subwatersheds: East Fork Double Bayou and West Fork Double Bayou. The Double Bayou Watershed drains 98 square miles (61,445 acres) of predominantly rural and agricultural land directly into the Trinity Bay system and, ultimately, into Galveston Bay. Today, the lands and waters in and around Double Bayou support: rice farming, cattle grazing, oil production, small town and country living, industry and commercial navigation, sailing, paddling, crabbing, oystering, recreational fishing, and wildlife watching.

The West Fork of Double Bayou (Segment 2422B) is listed as impaired (not meeting its water quality standards) on the 2020 Texas Integrated Report 303(d) for low dissolved oxygen (aquatic life usage listed since 2004) and for elevated levels of bacteria (recreation use listed since 2006). In addition, the East Fork of Double Bayou (Segment 2422D) is listed as impaired for bacteria in water (recreation use listed since 2014) (TCEQ 2020a).

The Texas State Soil and Water Conservation Board (TSSWCB) and the Galveston Bay Estuary Program (GBEP) provided funding to develop a Watershed Protection Plan (WPP) for the Double Bayou Watershed based on criteria that included the ongoing activities and level of stakeholder interest, presence on the Texas Integrated Report (303(d) list), and the potential for success (Figure 1). Public meetings were held in Anahuac and Double Bayou. Shortly thereafter, the Double Bayou Watershed Partnership was formed to guide the WPP development process. The Partnership works with citizens, businesses, public officials and state and federal agencies to improve water quality in the Double Bayou Watershed. The Partnership recognizes that success in improving and protecting water resources depends on the people who live, work, and recreate in the watershed. As of July 19, 2016, the stakeholder-approved and Environmental Protection Agency (EPA) reviewed Double Bayou WPP was final. The Double Bayou WPP serves as a guidance document for restoring and protecting nonpoint source (NPS) water quality.

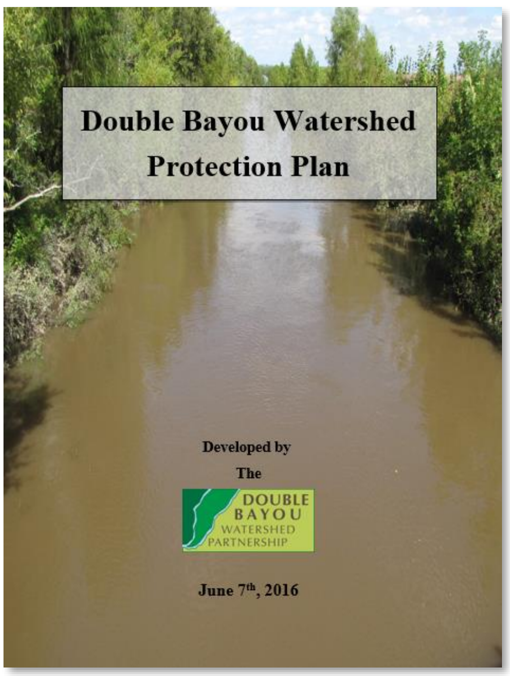


Figure 1. Cover of the Double Bayou Watershed Protection Plan

The *Coordinating Implementation of a Watershed Protection Plan for Double Bayou* project, jointly funded through GBEP and TSSWCB, was conducted from 2018 to 2022 and brought together the Partnership to successfully implement stakeholder-approved management measures outlined in the Double Bayou WPP. Management measures milestones reached during this project include the creation of new and maintenance of pre-existing Water Quality Management Plans (WQMPs), removal of feral hogs, additional stakeholder meetings and outreach activities, the replacement and maintenance of Onsite Sewage Facilities (OSSF) in the watershed, and water quality monitoring.

Analysis performed over the course of this project identified that Fecal Indicator Bacteria (FIB) concentrations are higher in the West Fork, during the Fall season, and in association with rain events of more than half an inch. To have the greatest potential of reducing NPS loads and improving water quality in the watershed, future management measures should be geared towards the West Fork subwatershed, designed to reduce FIB loads associated with wet weather, and to manage loadings during the Fall season. Results from this project will be useful to adaptively manage nonpoint sources of fecal waste pollution in support of the Double Bayou Watershed Protection Plan's implementation.

Introduction

The *Coordinating Implementation of a Watershed Protection Plan for Double Bayou* project funded water quality data analysis efforts, continued stakeholder coordination, and began implementation of management measures detailed in the WPP. These efforts are critical to bridge the gap between management measures developed through the Double Bayou WPP process and implementation activities. Water quality monitoring results were evaluated by the Houston Advanced Research Center (HARC) to describe ongoing changes in water quality. Water quality monitoring is critical in helping determine effectiveness, placement, and prioritization of management measures. The results can be used to support adaptive management, understand changes in water quality, track implementation progress, and update stakeholders about current water quality conditions.

Implementation Project Goals:

- Support and facilitate Double Bayou WPP stakeholders in prioritizing management measures to improve water quality.
- Evaluate progress of implementation projects toward achieving milestones established in the WPP.
- Analyze data of known and acceptable quality for surface water quality monitoring of both West Fork and East Fork stations.
- Communicate water quality to stakeholders supporting adaptive management to expand public knowledge and participation in the Double Bayou implementation project.

The Implementation of the Double Bayou WPP project was jointly funded by TSSWCB and GBEP. The TSSWCB-funded portion of the project, which concluded October 31, 2022, supported water quality monitoring, stakeholder meetings and communication, education and outreach, data analysis and development of visuals, and website maintenance including updated project materials and milestone tracking progress. The GBEP-funded portion part of the project, which concluded May 31, 2021, supported stakeholder meetings and communication and education and outreach. The data and materials discussed in this report include project activities supported by GBEP and the TSSWCB grant funding.

This project also leveraged other activities occurring in the watershed that were identified in the WPP. Through TSSWCB project #16-04 *Implementing Agricultural Nonpoint Source Components of the Cedar Bayou and Double Bayou Watershed Protection Plans*, the Trinity-

Bay Soil and Water Conservation District (SWCD) developed 9 new water quality management plans (WQMP), revised 9 WQMPs and conducted 8 status reviews on existing WQMPs. In addition, a 2017 study funded by the Galveston Bay Estuary Program *Bacterial Source Tracking (BST) on Tributaries of Trinity and Galveston Bays* was conducted at five sites around Galveston Bay, one of which was located in the Double Bayou watershed. Results from the BST study are used in the current project to help guide implementation of voluntary management measures described in the stakeholder-approved and EPA-accepted Double Bayou WPP (https://www.doublebayou.org/watershed-protection-planning/wpp-document).

The *Coordinating Implementation of a Watershed Protection Plan for Double Bayou* project supported plan priorities, action plans, and actions outlined in the Galveston Bay Comprehensive Conservation and Management Plan (CCMP), 2nd edition. The Galveston Bay CCMP, 2nd edition was developed by GBEP and approved by TCEQ and the EPA's National Estuary Program in 2018. Specifically, the Double Bayou WPP satisfied the following CCMP plan priorities. The Ensure Safe Human and Aquatic Life Use plan priority is supported through the implementation of an approved WPP, outreach and education activities geared towards watershed stakeholders including the Double Bayou Live digital stakeholder series, the hosting of NPS workshops such as the Watershed Texas Stream and Riparian Workshop, as well as the role of the Double Bayou WPP to improve contact recreation safety. In addition, the Protect and Sustain Living Resources plan priority is supported through the eradication of the highly invasive feral hog. The Engage Communities plan priority is supported by engaging the local community through stakeholder activities such as the hosting of meetings to provide updates. Lastly, the Inform Science-Based Decision Making plan priority is exemplified by increasing access to water quality data collected in the watershed through presentations and the Double Bayou interactive data viewer.

- **Plan Priority: Ensure Safe Human and Aquatic Life Use**
  - ***Action Plan***: Improve Water Quality Through Nonpoint Source Pollution Abatement (NPS)
    - ***Actions***: NPS-1: Support Watershed-Based Plan Development and Implementation
    - NPS-2: Support Nonpoint Source Education and Outreach Campaigns
    - NPS-3: Implement Nonpoint Source Best Management Practices
    - NPS-4: Host Nonpoint Source Workshops
  - ***Action Plan***: Improve Water Quality Through Point Source Pollution Abatement (PS)
    - ***Actions***: PS-1: Support Stormwater Education Program
    - PS-2: Achieve Sanitary Sewer System Capacity and Ensure Integrity
    - PS-3: Ensure Wastewater Treatment Facility Compliance
  - ***Action Plan***: Promote Public Health and Awareness (PHA)
    - ***Actions***: PHA-3: Improve Contact Recreation Safety Through Watershed-Based Plan
- **Plan Priority: Protect and Sustain Living Resources**
  - ***Action Plan***: Support Species Conservation (SC)
    - *Actions*: Invasive Species Management

- **Plan Priority: Engage Communities**

    - ***Action Plan***: Preserve Galveston Bay Through Stakeholder and Partner Outreach (SPO)
        - ***Actions***: SPO-1: Workshops and Events; SPO-4: Local Government Outreach
    - ***Action Plan***: Support Public Education and Awareness Initiatives (PEA)
        - ***Actions***: PEA-1: Key Issue Engagement; PEA-2: Adult Education

- **Plan Priority: Inform Science-Based Decision Making**
    - ***Action Plan***: Increase Access to Galveston Bay Ecosystem Information (ACS)
        - ***Actions***: ACS-1: Track Ecosystem Health Indicators

Project Significance and Background

The Double Bayou watershed is located on the Upper Texas Gulf Coast and is part of the Galveston Bay watershed. Situated in the eastern portion of the Lower Galveston Bay, it is comprised of two main subwatersheds; the East Fork and West Fork, which are also the two primary waterways in the watershed (Figure 2). The Double Bayou watershed drains directly into Trinity Bay of the Galveston Bay system. The majority (93%) of the watershed lies within Chambers County, Texas. The remaining 7% of the watershed is located in Liberty County, Texas.

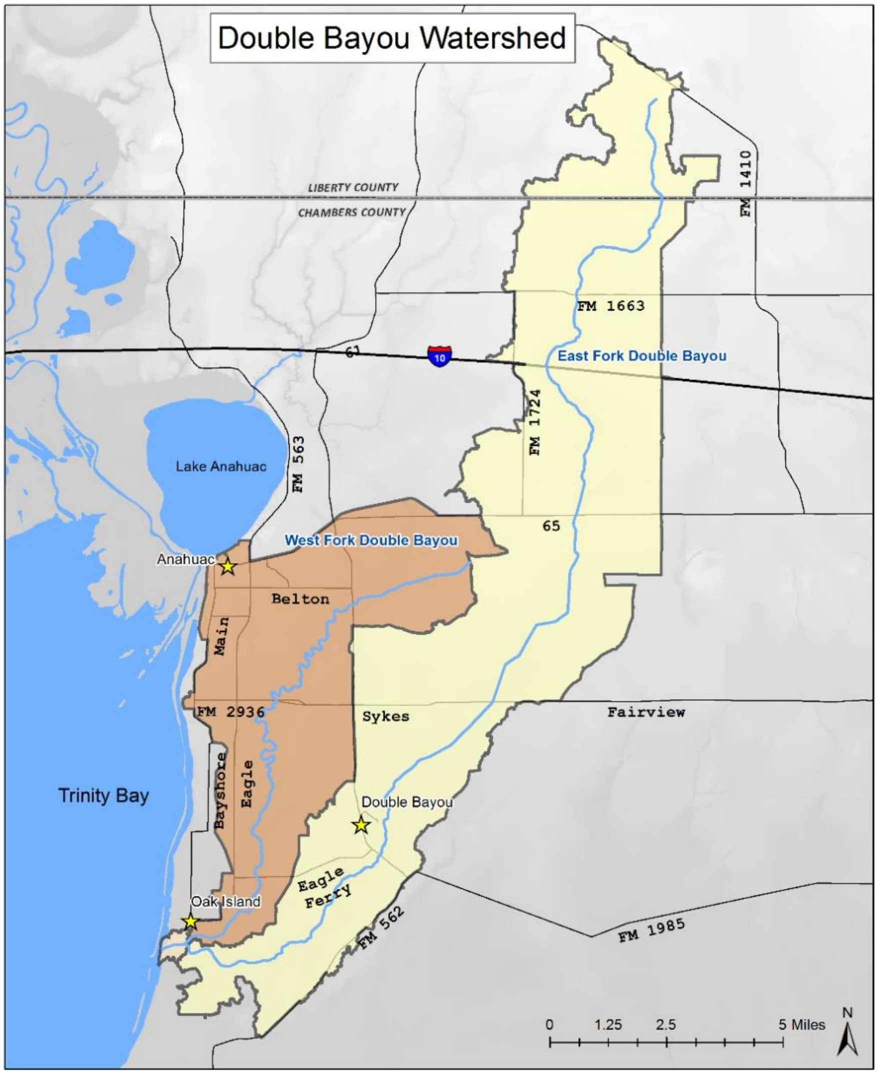


Figure 2. Double Bayou Watershed

Early Project Background

GBEP facilitated funding for an initial study in 2009, from grants under the American Recovery and Reinvestment Act, the EPA, state sources and United States Geological Survey (USGS), to explore whether a voluntary WPP could be beneficial for the Double Bayou Watershed. The funding provided resources for HARC to: (a) assemble and analyze existing water quality data for the watershed, (b) collect new water quality samples for both forks of Double Bayou and analyze the data, and (c) share the information with key stakeholders, as well as the general public.

The Watershed Protection Plan

In 2012, HARC worked with the USGS and Shead Conservation Solutions with funding from TSSWCB/EPA and GBEP/TCEQ to develop a WPP for Double Bayou. Through the WPP process, stakeholders in the Double Bayou watershed, including community leaders, elected officials, landowners, nonprofit organizations, and representatives of relevant local, state, and federal agencies met through a series of stakeholder meetings and breakout workgroup meetings to collaborate on development of the WPP. Water quality was monitored on the East and West Forks throughout the WPP process. HARC developed water quality data analysis and conducted Spatially Explicit Load Enrichment Calculation Tool (SELECT) modeling, prepared graphs and exhibits of water quality data and SELECT modeling results and prepared drafts of the WPP document chapters for stakeholder review and comment. Shead Conservation Solutions was responsible for the public participation component of the project, including maintaining communications with stakeholders through email and/or U.S. mail, preparing and distributing media items, providing notices of meetings and events, facilitating meetings, and preparing meeting documents. Working with the stakeholders, ideas for water quality management measures were discussed and analyzed by the three main workgroups (Agriculture/Wildlife/Feral Hog, Recreation/Hunting and WWTF/Septic) for inclusion in the Double Bayou WPP.

The Double Bayou WPP development process engaged stakeholders and included water quality monitoring, data assessment, and potential pollutant load modeling. The goal of the Double Bayou WPP was to provide a roadmap to improve the water quality of Double Bayou through a voluntary, collaborative approach that incorporates stakeholder ideas in the planning process. The Double Bayou WPP presented the current state of the watershed, discussed water quality sampling and results, described stakeholder-identified causes and sources of pollution, outlined stakeholder-recommended management measures, and included specifications for the technical and financial framework required for implementation. The Double Bayou WPP was developed using EPA's nine key elements for successful watershed-based plans. The Double Bayou WPP (https://www.doublebayou.org/watershed-protection-planning/wpp-document) was approved by stakeholders and accepted by the EPA in July 2016.

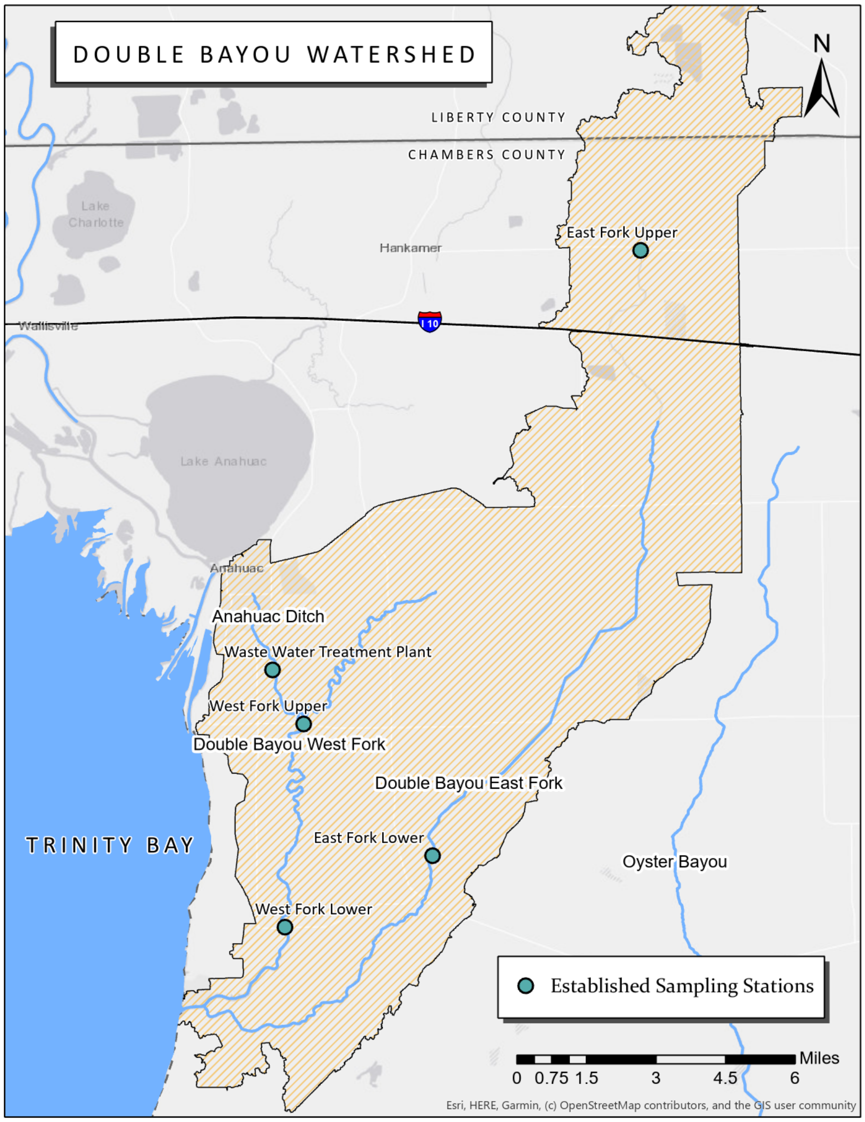
Technical Chapter

Methods

Water quality monitoring in support of the WPP implementation phase (*Coordinating Implementation of a Watershed Protection Plan for Double Bayou*) was funded by TSSWCB and conducted by Partnership partner, USGS. For the implementation project, USGS personnel began collection of the first water quality samples since Phase I (development of the WPP) concluded in June of 2015. The Phase II sampling program ran for 24-months between January 2020 and January 2022. A total of 70 water quality samples (60 routine and 10 targeted samples) were collected. USGS was able to continue monitoring during COVID-19 due to strict safety procedures which ensured the health of their field team and watershed residents.

The Phase II (implementation of the WPP) water quality monitoring schedule allowed USGS to collect samples at all four Double Bayou sites including East Fork Lower, East Fork Upper, West Fork Lower, and West Fork Upper once every other month (**Error! Reference source not found.**). In addition, samples were collected at the WWTF site once per quarter. Routine monitoring was conducted to assess ambient water quality conditions in the bayous. In addition, two targeted wet weather event samples were collected to evaluate water quality during periods of increased stormwater runoff and elevated flow conditions.

Figure 3. USGS monitoring stations in the Double Bayou Watershed



Each monitoring event included field, conventional, flow and bacteria parameter groups. Field parameters are pH, temperature, specific conductance, turbidity, and dissolved oxygen. Conventional parameters are suspended solids, sulfate, chloride, nitrite+nitrate nitrogen, ammonia nitrogen, total kjeldahl nitrogen, orthophosphorus, and total phosphorus. Bacteria parameters are *E. coli* and enterococci (tidal and nontidal sites). Flow parameters are quantitative and collected by a gage located at the West Fork Lower (https://waterdata.usgs.gov/nwis/uv?site_no=08042558) sample site using an index velocity method. Additionally, two 24-hour multi-parameter sonde deployments occurred in September 2020 and September 2021. The goal of the 24-hour sampling events was to monitor dissolved oxygen concentrations in the bayou over a diurnal period. The *Coordinating Facilitation and Implementation of the Double Bayou Watershed Protection Plan and Monitoring for Implementation Effectiveness Quality Assurance Project Plan*, developed in coordination with the TSSWCB, documents sampling methods, analytical methods, and quality control in further detail.

Results and Observations

For the purposes of this report, a historical water quality dataset collected between October 1984 and January 2022 was established. The historical water quality data set stems from two sources: 1) TCEQ's Surface Water Quality Information System (SWQIMS) database and 2) the final data report obtained from USGS on May 23, 2022. The historical dataset was analyzed to assess long-term trends with a primary focus on a Fecal Indicator Bacteria (FIB) assessment. To evaluate water quality trends, the complete period of record for dissolved oxygen (mg/L), water temperature (C), select nutrient parameters (mg/L), rainfall (inch), and discharge (cf\s) were analyzed.

Prior to 2010, sampling by TCEQ was restricted to tidal portions of the Double Bayou Watershed. USGS began collecting water quality data from nontidal streams within the watershed in 2010 for the Double Bayou Watershed characterization study, expanding the spatial coverage of the dataset. TCEQ did not start collecting measurements from nontidal streams until 2013. This temporal gap in data collection for nontidal areas of the watershed is represented by breaks in the data shown in the figures within this section of the report.

Dissolved Oxygen

A combined dataset of 1,031 dissolved oxygen (storet code 00300) measurements from water quality samples collected by TCEQ and USGS between 1984 and 2022 was assessed. The range of dissolved oxygen concentrations in tidal streams has increased over time with the widest ranges occurring in the last 20 years (**Error! Reference source not found.**). The greatest range in dissolved oxygen concentrations (2.8 mg/L on 03/20/2001 to 16.3 mg/L on 01/04/2001) occurred in tidal streams in 2001. A long-term trend in dissolved oxygen concentrations could not be assessed for the nontidal streams in the Double Bayou Watershed due to the large gap in the historical record.

The dissolved oxygen exceedances for each segment were determined by counting the number of measurements equal to or below stream type dependent screening levels (nontidal 4 mg/L) and (tidal 5 mg/L) as defined by TCEQ. There were 313 tidal and 32 nontidal single sample exceedances within the watershed. The highest percentage of exceedances (37%) occurred in the West Fork of Double Bayou (tidal). There were fewer exceedances (29%) in tidal areas of the East Fork. However, the East Fork had the most exceedances (33%) for the nontidal areas of the watershed (Table 1).

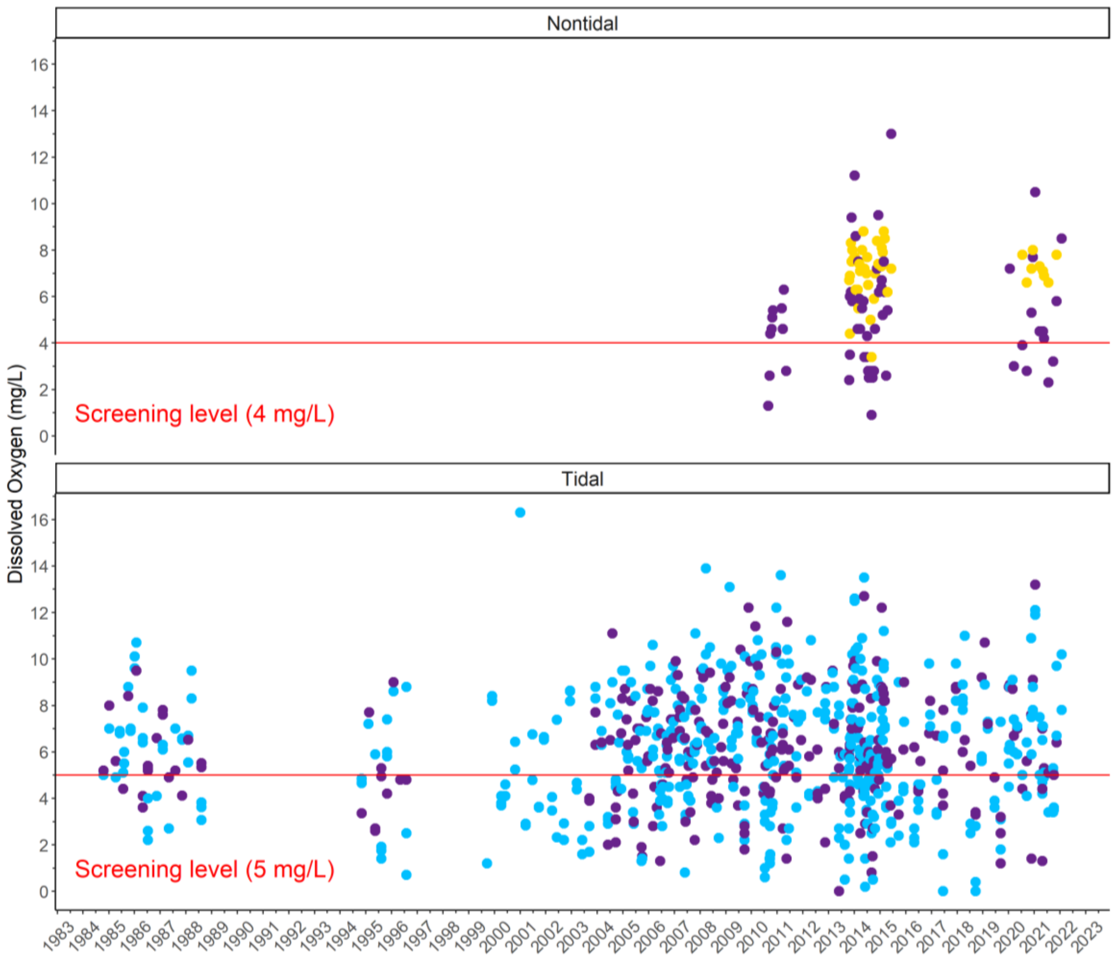


Figure 4. Dissolved oxygen concentrations (mg/L) for nontidal and tidal streams (West Fork – blue, East Fork – purple, and Anahuac Ditch – yellow) within the Double Bayou Watershed from 1984-2022

The most dissolved oxygen exceedances were observed in summer for the tidal West Fork (65%) and the nontidal sections of the East Fork (81%) and the least exceedances were observed in winter for all stream segments in the Watershed. While there were also more exceedances observed for tidal portions of the East Fork (39%) in summer, the highest exceedances for this stream segment occurred in the fall (54%) (Table 12, Appendix A Supplementary Figures & Tables.

Table 1. Number of dissolved oxygen event samples (n), number of single sample exceedances, and percent exceedances by stream segment and type from 1984-2022

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	567	215	37%
East Fork	Tidal	329	98	29%
East Fork	Nontidal	94	31	33%
Anahuac Ditch	Nontidal	41	1	2%

Water Temperature

Since 1984, 1,046 water temperature (storet code 00010) samples have been collected by USGS and TCEQ in the watershed. These samples include tidal and nontidal results collected from the East and West Forks as well as the Anahuac Ditch. The 906 tidal and 140 nontidal monitoring results are displayed in **Error! Reference source not found.**. No overall temporal or spatial trend is evident, indicating that water temperature has been relatively consistent across the period of record and throughout the watershed.

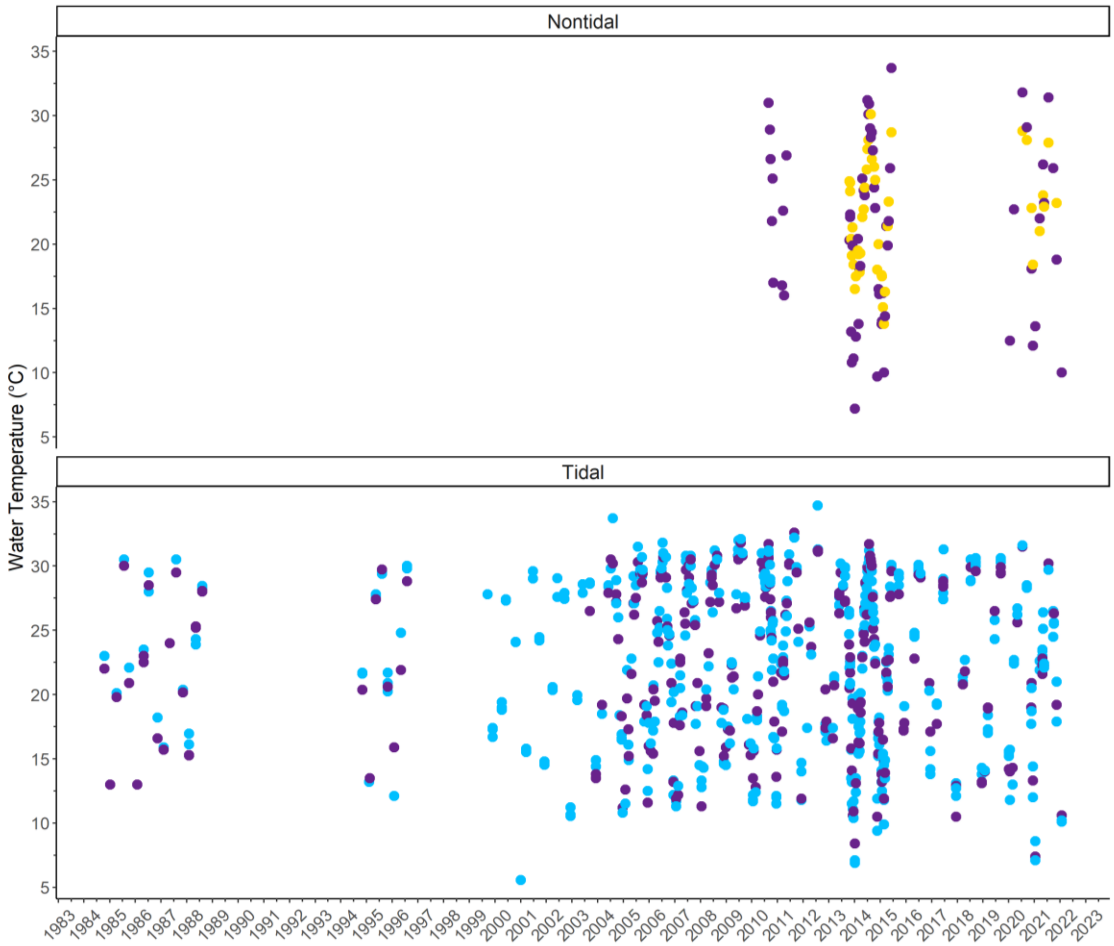


Figure 5. Water temperature (°C) samples collected in nontidal and tidal streams (West Fork – blue, East Fork – purple, and Anahuac Ditch – yellow) within the Double Bayou Watershed from 1984-2022

However, while the median water temperatures for the entire period of record are similar for all three stream segments (East Fork: 22.3°C, West Fork: 22.5°C, Anahuac Ditch: 22.4°C), the median water temperature for nontidal sections (21.4°C) of the East Fork is nearly 1°C cooler than the median water temperature for tidal sections (22.5°C) of this stream segment. As expected, water temperature in the bayous displays seasonal variation due to changes in air temperature and intra-annual weather patterns. The summer (June, July, and August) season has the highest water temperature followed by fall (September, October, and November) spring (March, April, and May), and winter (December, January, and February).

Nutrients

There were 820 phosphorus (storet code 00665) and 458 nitrate (storet codes 00618 and 00620) measurements from water quality samples collected by TCEQ and USGS between 1984 and 2022 analyzed. For the nitrate samples examined, 276 samples were nitrate (storet code 00618) and 182 were total nitrate samples (storet code 00620).

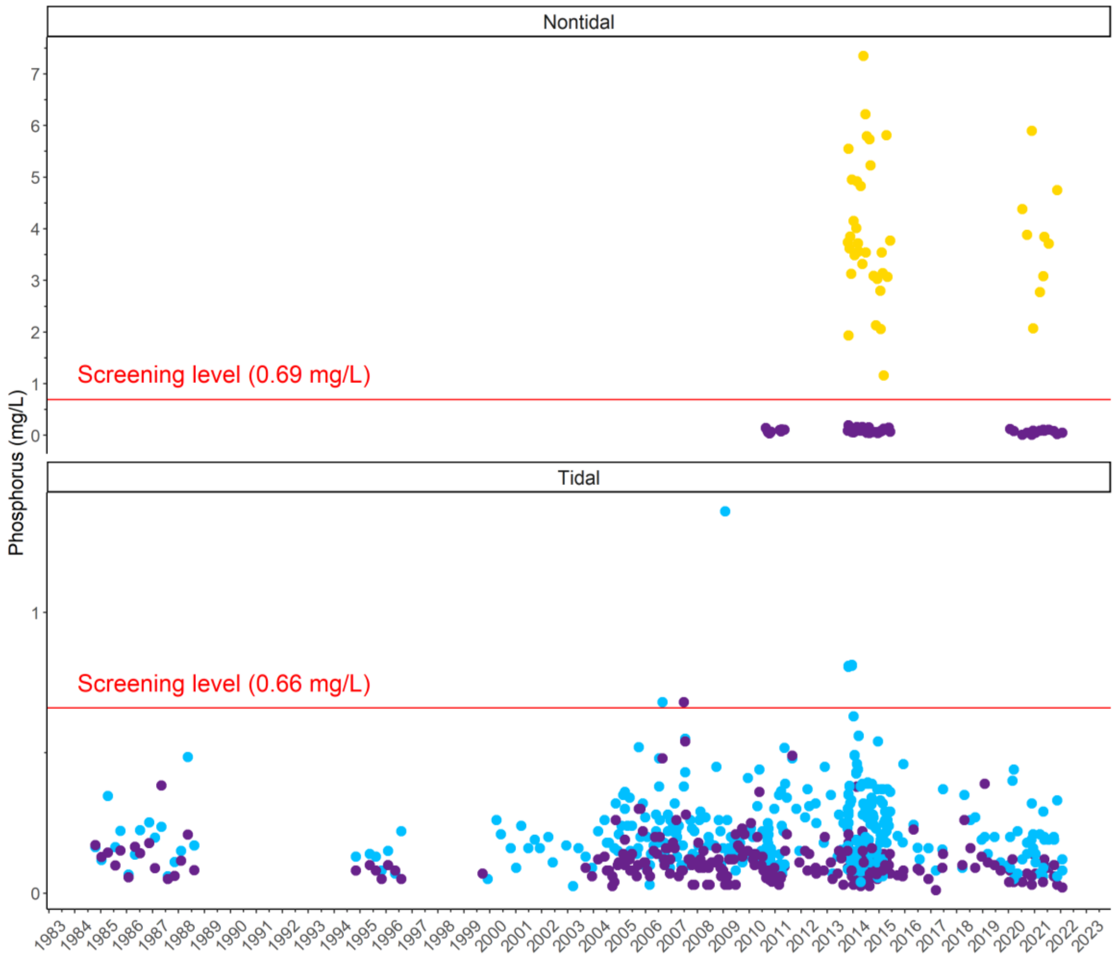


Figure 6. Phosphorus concentrations (mg/L) collected in nontidal and tidal streams (West Fork – blue, East Fork – purple, and Anahuac Ditch – yellow) within the Double Bayou Watershed from 1984-2022.

The phosphorus exceedances for each segment were determined by counting the number of measurements equal to or above stream type dependent screening levels (nontidal 0.69 mg/L) and (tidal 0.66 mg/L). Phosphorus samples collected in the tidal and nontidal waterways reveal that exceedances of the associated screening levels do not occur frequently for the East and West Forks of Double Bayou (**Error! Reference source not found.**). Most of the nontidal phosphorus sample exceedances occurred in the Anahuac Ditch at the outfall monitoring location of the WWTF. The tidal portions of the West and East Forks had a total of 7 phosphorus exceedances (**Error! Not a valid bookmark self-reference.**)**Error! Reference source not found.**. While the tidal West Fork had the greatest sample size (n=405), the percent exceedance (1%) was also greater than that of tidal portions of the East Fork (0.4%). All the samples collected from the Anahuac Ditch exceeded the nontidal screening level (0.69 mg/L) for phosphorus (Table 2).

Table 2. Number of phosphorus samples (n), number of single sample exceedances, and percent exceedances by stream segment and type from 1984-2022

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	405	6	1%
East Fork	Tidal	278	1	0.4%
East Fork	Nontidal	96	0	0%
Anahuac Ditch	Nontidal	41	41	100%

While there were few phosphorus exceedances for the West Fork of Double Bayou, all occurred in samples collected from the West Fork Upper stations. The exceedance for the West Fork Upper station was 3% (Table 3). No exceedances were observed at the West Fork Lower station. The West Fork Upper station also had the second highest median phosphorus concentrations observed for the entire period of record (0.26 mg/L), with the highest median phosphorus concentration reported (3.72 mg/L) at the Anahuac Ditch WWTP outfall station (Figure 7).

Table 3. Number of phosphorus samples (n), number of single samples exceedances, and percent exceedances by stations for the West Fork of Double Bayou from 1984-2022

Station Name	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork Upper	205	6	3%
West Fork Lower	200	0	0%

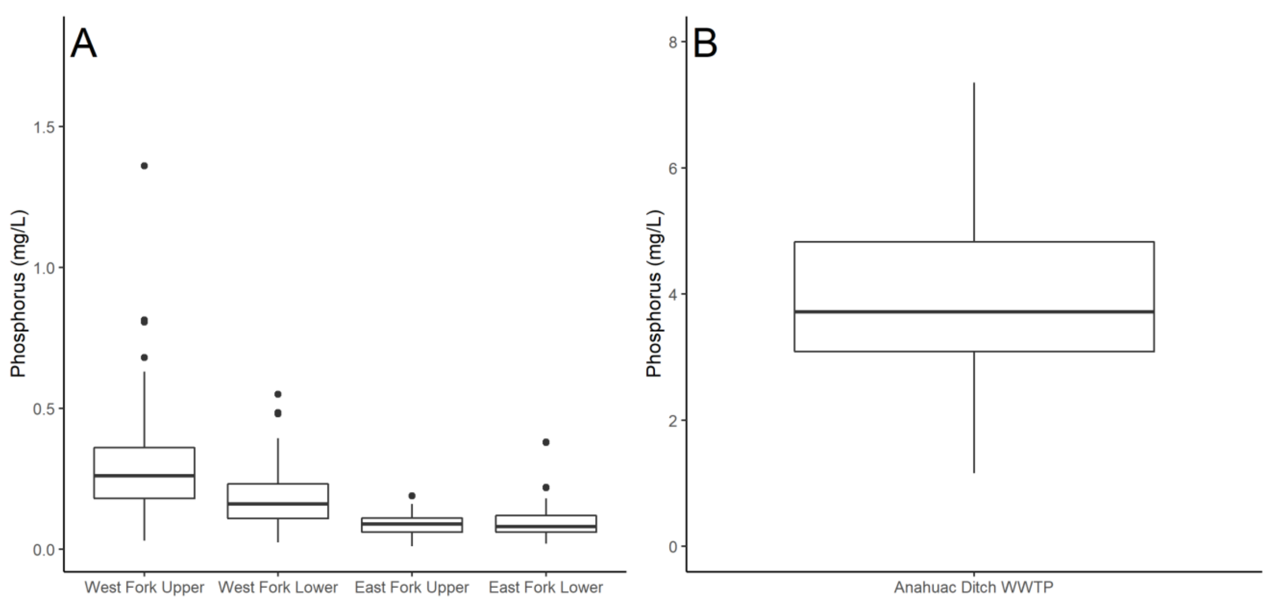


Figure 7. Boxplot of phosphorus concentrations by station from 1984-2022. 7A shows the stations on the East and West Fork of Double Bayou. 7B represents the station located at the outfall of the WWTP on the Anahuac Ditch.

Like the phosphorus exceedances, nitrate exceedances for each segment were determined by counting the number of measurements equal to or above stream type dependent screening levels (nontidal 1.95 mg/L) and (tidal 1.10 mg/L). Only nitrate (storet code 00618) samples were analyzed for nontidal areas of the watershed. Both nitrate and total nitrate (storet code 00620) samples were examined for the tidal areas. While nitrate exceedances were also uncommon for the East and West Forks of Double Bayou, there were more observed in these waterways than there were for phosphorus exceedances, specifically for the West Fork (**Error! Reference source not found.**).

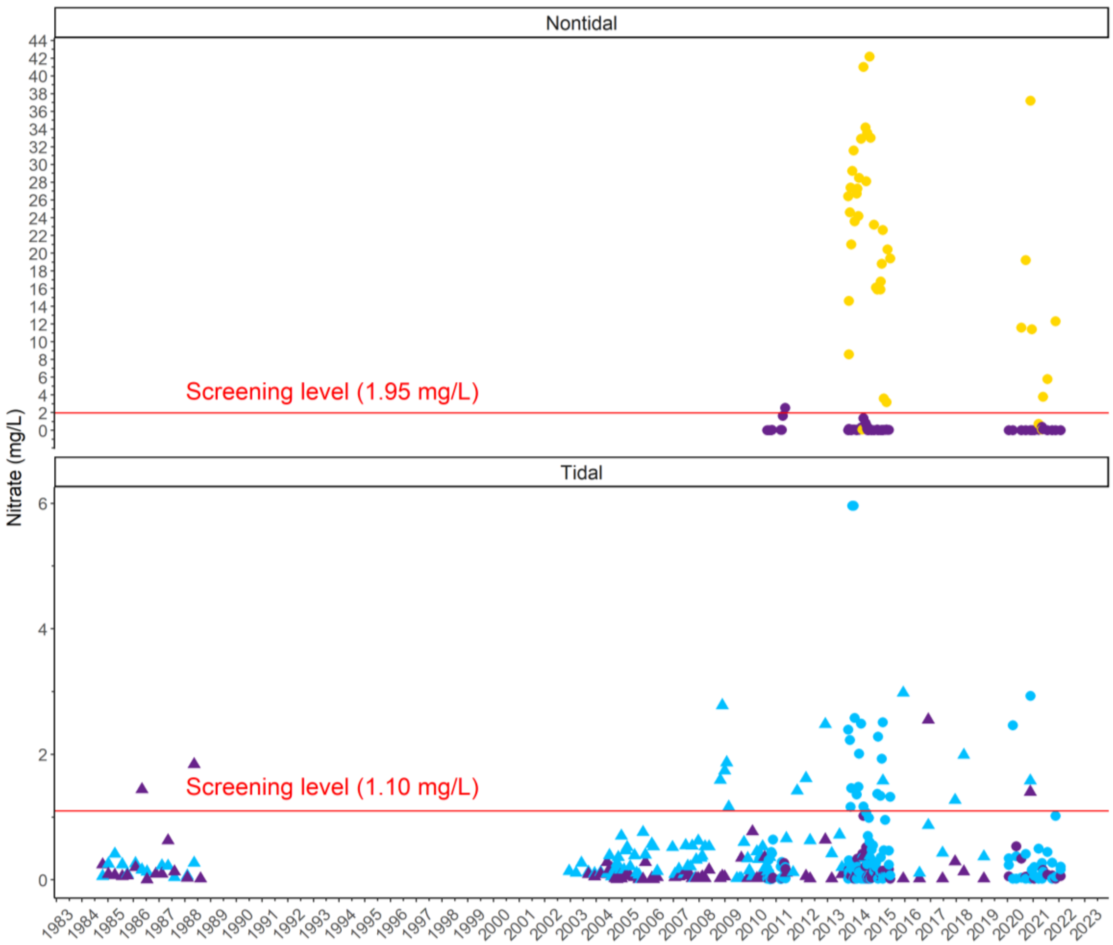


Figure 8. Nitrate (circles) and Total Nitrate (triangles) concentrations (mg/L) collected in nontidal and tidal streams (West Fork – blue, East Fork – purple, and Anahuac Ditch – yellow) within the Double Bayou Watershed from 1984-2022.

Also similar to the phosphorus exceedances, most (93%) of the nontidal nitrate sample exceedances occurred in the Anahuac Ditch (Table 4). The West Fork had the greatest percent exceedance (15%) for nitrate in the tidal sections of the Double Bayou Watershed. The East Fork only had 3% nitrate exceedances for the tidal portions of the waterway and 2% exceedances for nontidal sections.

Table 4. Number of nitrate samples (n), number of single sample exceedances, and percent exceedances by stream segment and type from 1984-2022

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	214	33	15%
East Fork	Tidal	145	4	3%
East Fork	Nontidal	58	1	2%
Anahuac Ditch	Nontidal	41	38	93%

Spatial differences in nitrate exceedances were also observed for the West Fork of Double Bayou, with the most exceedances (25%) resulting from samples collected at the West Fork Upper sampling station (Table 5). Like phosphorus, no nitrate exceedances occurred in samples collected from the West Fork Lower station. In addition, the West Fork Upper Station also had the second highest median nitrate concentration (0.42 mg/L), after the Anahuac Ditch WWTP station (21 mg/L), for the entire period of record (Figure 9).

Table 5. Number of nitrate samples (n), number of single sample exceedances, and percent exceedances by station for the West Fork of Double Bayou from 1984-2022

Station Name	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork Upper	133	33	25%
West Fork Lower	81	0	0%

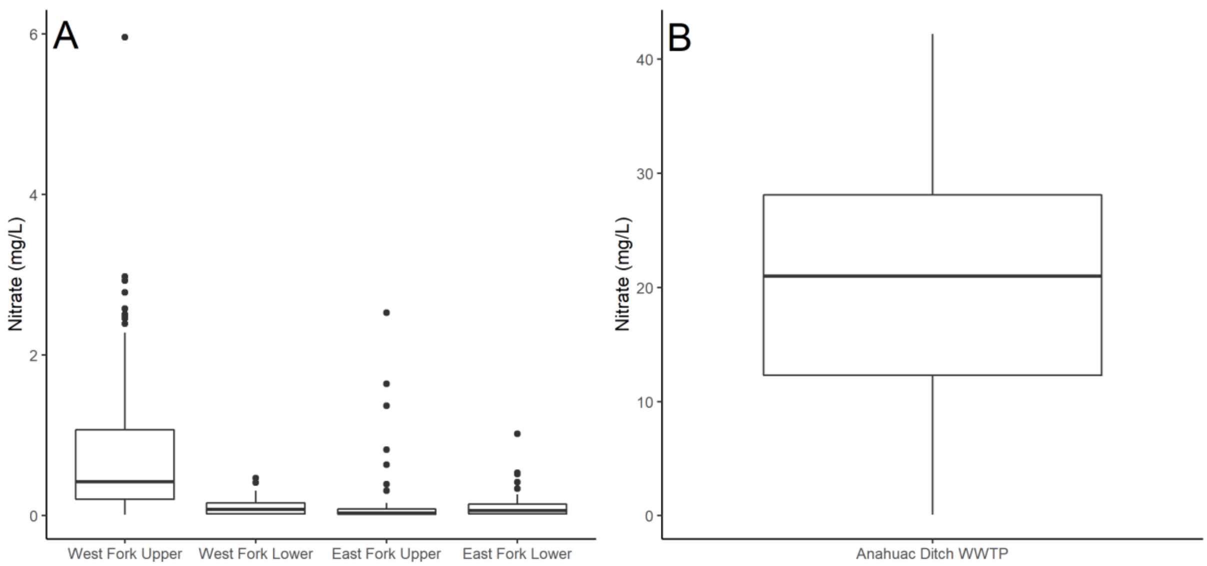


Figure 9. Boxplot of nitrate concentrations by station from 1984-2022. 7A shows the stations on the East and West Fork of Double Bayou. 7B represents the station located at the outfall of the WWTP on the Anahuac Ditch. Nitrate (storet 00618) and total nitrate (storet 00620) were analyzed in aggregate in these figures to assess overall nitrate concentration differences by station.

Discharge

To determine the extent of tidal influence and mixing in the Double Bayou Watershed, USGS continued maintenance of an Index Velocity Site Gage on the West Fork of Double Bayou at Eagle Ferry Road near Anahuac, TX (USGS 08042558, West Fork Lower station). The gage continuously measures stream stage and water velocity at a fixed cross-section (index velocity), which are used to compute discharge records by means of two correlations. The stage data are used with cross-sectional geometry data to develop a relationship between the measured stage and the cross-sectional area of the channel. The index velocity data are used with discharge measurements to develop a relationship between index velocity and the measured-mean channel velocity. These relations allow the computation of continuous mean velocity and cross-sectional area and are used to develop continuous records of discharge at the station.

The Index Velocity Site Gage measures discharge in cubic feet per seconds (cf/s) every fifteen minutes. “Positive discharge”, or ebb tide, indicates a positive flow rate – times at which the flow is occurring from upstream (north) towards downstream (south). “Negative discharge”, or flood tide, indicates a negative flow rate – times at which the flow is occurring from downstream (south) towards upstream (north), because of tidal or wind influence from Trinity Bay.

The monthly mean discharge in cf/s was calculated from the 15-minute interval index velocity measurements collected at the West Fork Lower gage station (Figure 10Figure 10**Error! Reference source not found.**). The monthly mean discharge is predominately driven by positive flow rates. During the drought period from 2010-2014, only one negative monthly mean discharge was observed (November 2012, -0.3 cf/s). In Spring 2020, the monthly mean discharge for five months (March, August, September, October, and November) was negative. This period reflected the most influence from negative flow rates of any year. The highest monthly mean discharge occurred in August 2018 (724.5 cf/s) when Hurricane Harvey struck the upper Texas coast. This was nearly double the next highest mean discharge value, which occurred in September 2019 (384.7 cf/s), due to Tropical Storm Imelda.

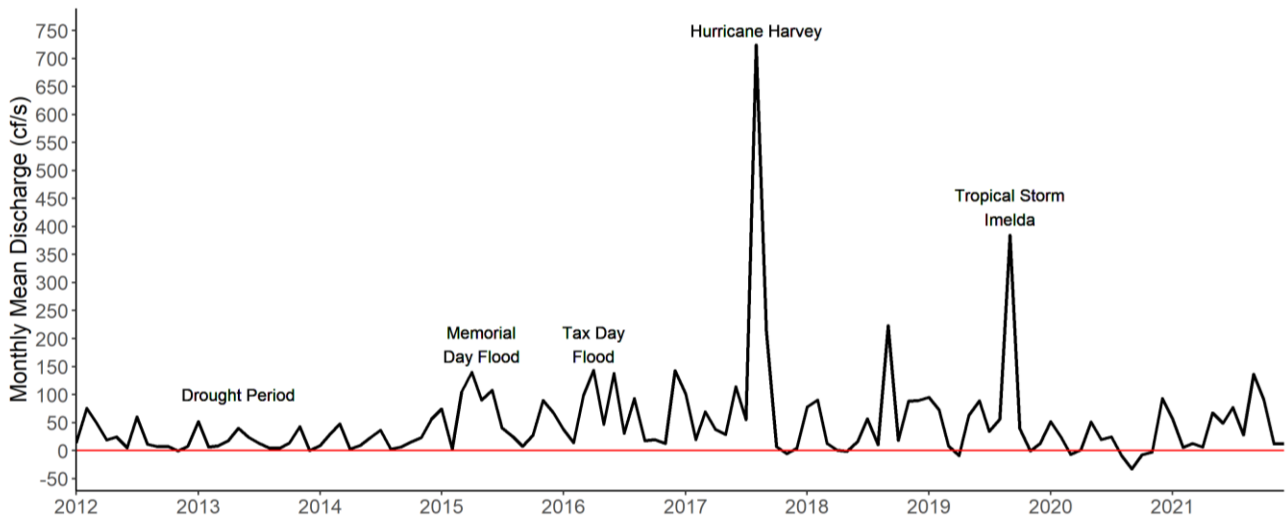


Figure 10. Monthly mean discharge (cf/s) for the West Fork Lower gage station (USGS Monitoring Gage 08042558) on Double Bayou from January 2012 to December 2021. Significant storm events and drought periods are labeled. The full drought period (2010-2015) is not shown because the period of record for the discharge data begins in 2012.

Rainfall

Precipitation data were acquired from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information Climate Data online portal to analyze how rainfall events affect FIB concentrations. Daily summary rainfall data was downloaded from the Anahuac (USC00410235) and Anahuac 5.7 N (US1TXCHM011) rain gages. The period of record for the rainfall data was from 1/1/1970 to 8/27/2022. The total monthly rainfall was calculated for the period from 1/1/2012 until 12/31/2021, while the total annual rainfall was calculated for the entire period of record. This smaller subset of monthly rainfall data (2012-2021) was used to compare with the monthly mean discharge data for the same temporal period.

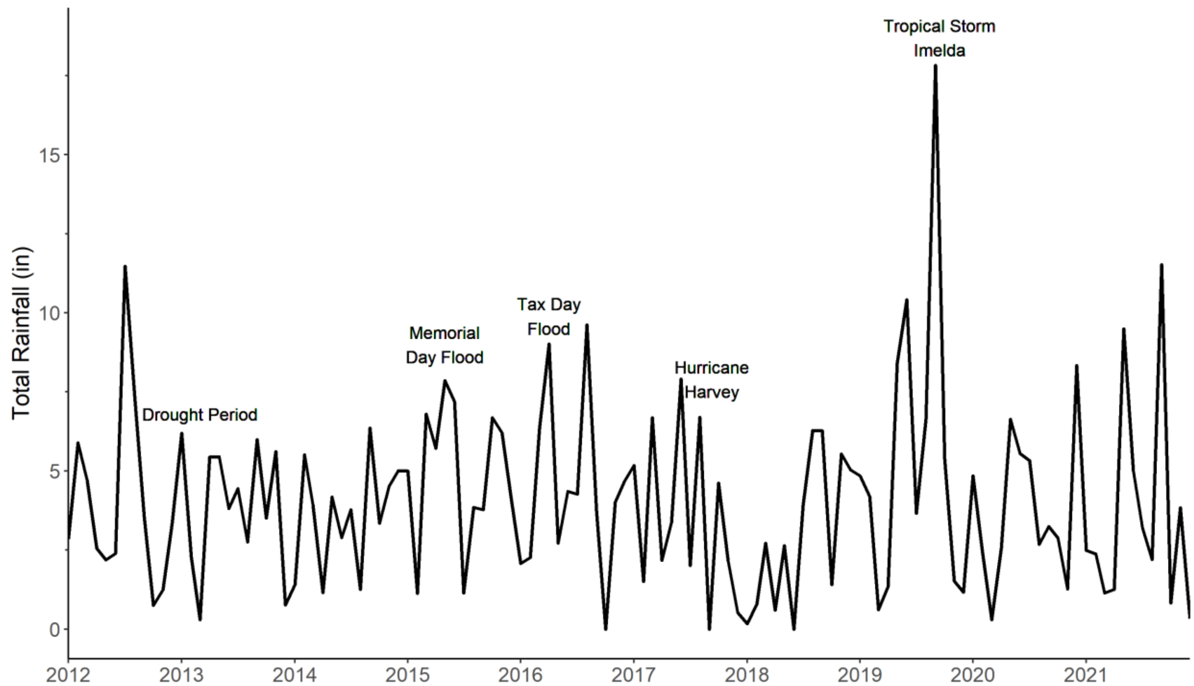


Figure 11. Total monthly rainfall in the Double Bayou Watershed from January 2012 to August 2022. Significant storm events and drought periods are labeled. The full drought period (2010-2015) is not shown. Rainfall measurements were not collected at this location during and after Hurricane Harvey due to impacts from the storm, and are, therefore, not representative of the actual rainfall totals.

While rainfall patterns appear sporadic, high total rainfall values correspond to years and months when extreme storm events occurred. For example, in 2001, there was a large peak from Tropical Storm Allison. This storm event resulted in a total of 91.7 inches of annual rainfall, which is the highest on record (Appendix A Supplementary Figures & Tables, Figure 22). Starting in 2015, Figure 22. Total annual rainfall for NOAA rain gages at Anahuac (USC00410235) and Anahuac 5.7 N (US1TXCHM011) from 1970 to 2022. Note that the 2022 total rainfall does not include measurements for the full year (the period of record ends on 7/14/2022).these events appear to be more predominate. Spikes in total monthly rainfall values correspond to the months in which extreme events occurred and include (chronologically) Memorial Day Flood (May 2015), Tax Day Flood (April 2016), Hurricane Harvey (August 2017), and Tropical Storm Imelda (September 2019) (Figure 11). It is important to note that the total rainfall measured for August

2017 is not representative of actual rainfall totals because rainfall measurements were not collected at this location during and after Hurricane Harvey due to impacts from the storm.

In addition to high monthly rainfall totals corresponding with major storm events, there is some evidence of the 2010 to 2015 drought shown in Figure 22 (Appendix A Supplementary Figures & Tables), which represents the full period of record. Specifically, the second lowest total annual rainfall (27.1 in) occurred in 2011, during the peak of the drought. It should be noted that the lowest total rainfall (12.5 in) was observed for 2022, which is an impartial record at the time of this report; rainfall measurements were collected from January 1st until August 27th of this year.

Fecal Indicator Bacteria

Since TCEQ began sampling in March of 2001 a total of 1,012 FIB samples have been collected in the Double Bayou Watershed. To appropriately evaluate the FIB results, samples were selected based on the stream type where they were collected. Only enterococci samples collected from tidal stations and *E. coli* samples collected from nontidal stations were used in this report. After filtering by stream type, the West Fork, classified as tidal, had 243 enterococci samples while the East Fork, which is tidal in the southern portion and nontidal to the north, included 140 enterococci and 83 *E. coli* records. An additional 33 *E. coli* samples have been collected in the nontidal Anahuac Ditch (WWTF). FIB results were grouped by the watershed's stream segments to allow for inter-waterway comparisons of the targeted and routine single sample and geometric mean calculations (Table 6Table 7Table 8).

Table 6. Primary contact single sample and geometric mean criteria

Fecal Indicator Bacteria	Single Sample (MPN/100 mL)	Geometric Mean (MPN/100 mL)
E. coli	399	126
Enterococci	130	35

Geometric means were evaluated against the primary contact recreation criteria for enterococci and *E. coli*, which are 35 MPN/100 mL and 126 MPN/100 mL, respectively (Table 6) (SWQMP 2019). Exceedance of individual grab samples was determined based on the related single sample primary contact recreation criteria of 130 MPN/100 mL for enterococci and 399 MPN/100 mL for *E. coli* (Table 6) (30 TAC § 307.7). The geometric mean (Table 7) and single sample (grab) exceedance (Table 8) calculations were performed using routine samples to represent ambient FIB concentrations. In addition, targeted event samples were analyzed based on the associated single sample criteria. Three additional analyses were conducted to discern differences in FIB by stream segment, wet and dry sampling events, and season using a nonparametric Wilcoxon or Kruskal-Wallis test with significance determined at 95% confidence (α=0.05). Two outliers were removed at the upper detection value of 49,000 (MPN/100 mL) for *E. coli* and 24,000 (MPN/100 mL) for enterococci.

Geometric Mean

Geometric means were computed by stream segment and stream type using the full period of record for routine samples (03/20/2001-01/26/2022) (Table 7). The geometric means calculated based on enterococci concentrations from the tidal portions in the East and West Fork exceed the associated primary contact recreation criteria. The West Fork's enterococci geometric mean of 91 MPN/100 mL is elevated compared to the East Fork's 57 MPN/100 mL. However, the *E. coli* geometric mean in the nontidal portion of the East Fork does not exceed the associated primary contact recreation criterion of 126 MPN/100 mL. In addition, the Anahuac Ditch's geometric mean is well below the associated primary contact recreation criterion.

Table 7. Number of samples (n), geometric mean concentrations, and geometric mean exceedance by stream segment and type from 2001 to 2022.

Stream Segment	Stream Type	n	Geometric Mean (MPN/100 mL)	Exceedance
West Fork	Tidal	243	91	**YES**
East Fork (entero)	Tidal	140	57	**YES**
East Fork (*E.coli*)	Nontidal	83	95	No
Anahuac Ditch	Nontidal	33	2.4	No

Single Sample Exceedance

In addition to geometric mean calculations, exceedances were evaluated based on routine grab sample results (Table 8). On the West Fork, 97 of 243 (41%) enterococci samples exceeded the primary contact recreation single sample criterion. Percent exceedance was found to be lower on the East Fork, where 29 of 140 (21%) enterococci and 10 out of 83 (12%) *E. coli* samples were greater than the respective single sample criteria. There are only two nontidal sampling stations in the watershed located on the East Fork Upper and Anahuac Ditch stream segments, resulting in fewer total *E. coli* samples. However, only one of the *E. coli* samples collected in the Anahuac Ditch, downstream of the WWTF, exceeded the 399 MPN/100 mL single sample criterion. During routine ambient sampling conditions, the West Fork had a 20% higher enterococci exceedance rate compared to the tidal portion of the East Fork. The non-tidal section of the East Fork had a lower overall percent exceedance compared to the tidal stream segments of the East and West Fork.

Table 8. Historical number of routine samples (n), number of single sample exceedances, and percent exceedance by stream segment and type from 2001 to 2022.

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	243	97	41%
East Fork (entero)	Tidal	140	29	21%
East Fork (*E.coli*)	Nontidal	83	10	12%
Anahuac Ditch	Nontidal	33	1	3%

To expand the single sample exceedance evaluation, a nonparametric Wilcoxon test (95% confidence) was performed to determine if enterococci concentrations collected in tidal sections of the East and West Fork were different. The test supports the percent exceedance results because a statistically significant difference (p=0.00003) was found between tidal enterococci concentrations in the West Fork compared to the East Fork (Figure 12). This analysis identified that enterococci concentrations collected from the West Fork are significantly higher than the East Fork. This result could be related to differences in land use/land cover, population, wildlife habitat, or land management that influence enterococci sources and amount of loading.

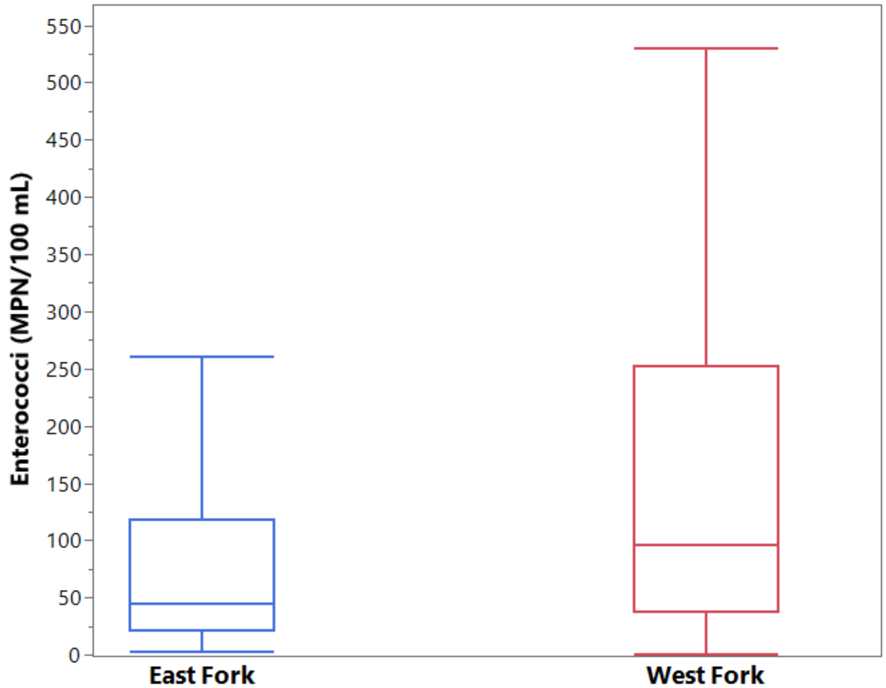


Figure 12. Boxplot of tidal enterococci concentrations collected in the East and West Forks (Percentile boxplot: Minimum, 25th, 50th, 75th, and maximum values shown; outliers have been removed for interpretation).

Wet Weather Events

To supplement the routine ambient analysis, historical targeted event samples from the USGS portion of the dataset were evaluated against primary contact single sample criteria (Table 9). A total of ten targeted event monitoring trips were conducted by the USGS from October 2013 to May 2021. The targeted samples, which were collected during or shortly after rain events, indicated that all sampling stations had at least a 75% rate of exceedance.

Table 9. Historical number of USGS event samples (n), single sample event exceedances, and percent exceedances by station and stream type from 2013 to 2021.

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	32	31	97%
East Fork (entero)	Tidal	16	13	81%
East Fork (*E.coli*)	Nontidal	15	13	87%
Anahuac Ditch	Nontidal	8	6	75%

To maximize the number of samples available for assessing potential rainfall-associated effects on FIB concentrations, a rainfall threshold of 0.5 inches was used to classify each sampling trip as having wet (more than 0.5 inches of rain) or dry (less than 0.5 inches of rain) conditions. A nonparametric Wilcoxon test (95% confidence) was applied to compare concentrations of enterococci samples collected on wet versus dry weather sampling days. A statistically significant difference ($p<0.0001$) was found indicating that enterococci samples collected on wet weather days that receive rainfall greater than 0.5 inches are higher compared to dry weather conditions in the watershed (Figure 13).

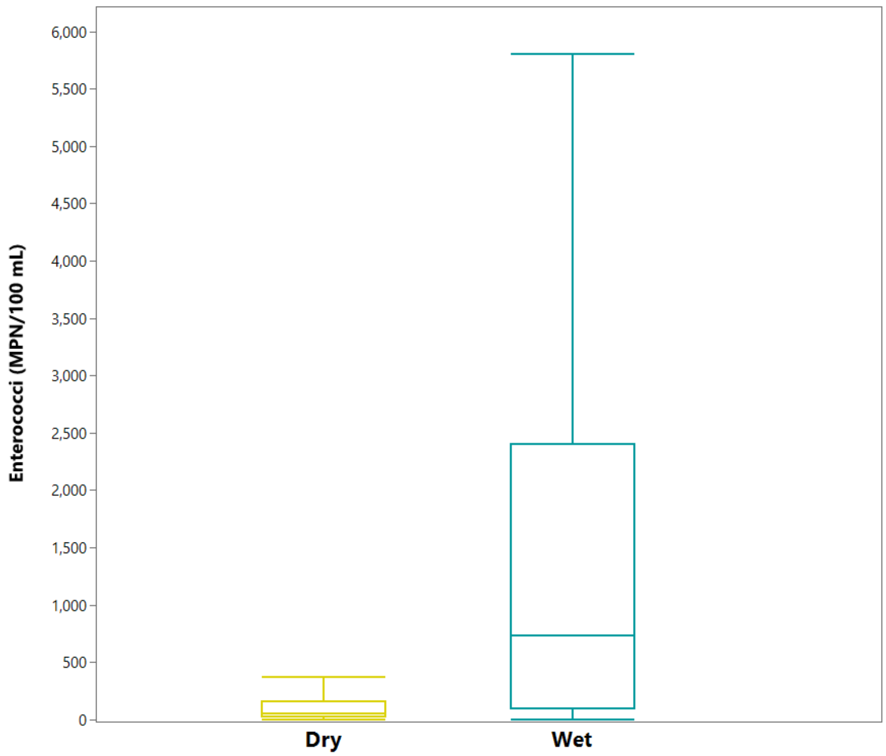


Figure 13. Boxplot of tidal enterococci concentrations collected during dry and wet weather (Percentile boxplot: Minimum, 25th, 50th, 75th, and maximum values shown; outliers have been removed for interpretation).

Seasonality

To explore how seasonal changes may influence enterococci concentration in the watershed, a Kruskal-Wallis test with significance determined at 95% confidence was performed using routine results only. The initial Kruskal-Wallis test found that seasonal variations in enterococci concentrations were statistically significant ($p=<0.0001$). Further analysis was performed to determine inter-seasonal variation utilizing nonparametric comparisons for each season under the Wilcoxon method. The Fall season was found to have statistically significant ($p=<0.0001$) higher enterococci concentrations compared to Spring, Summer, and Winter (Figure 14). However, no difference was found between the Spring-Summer, Spring-Winter, or Summer-Winter seasons.

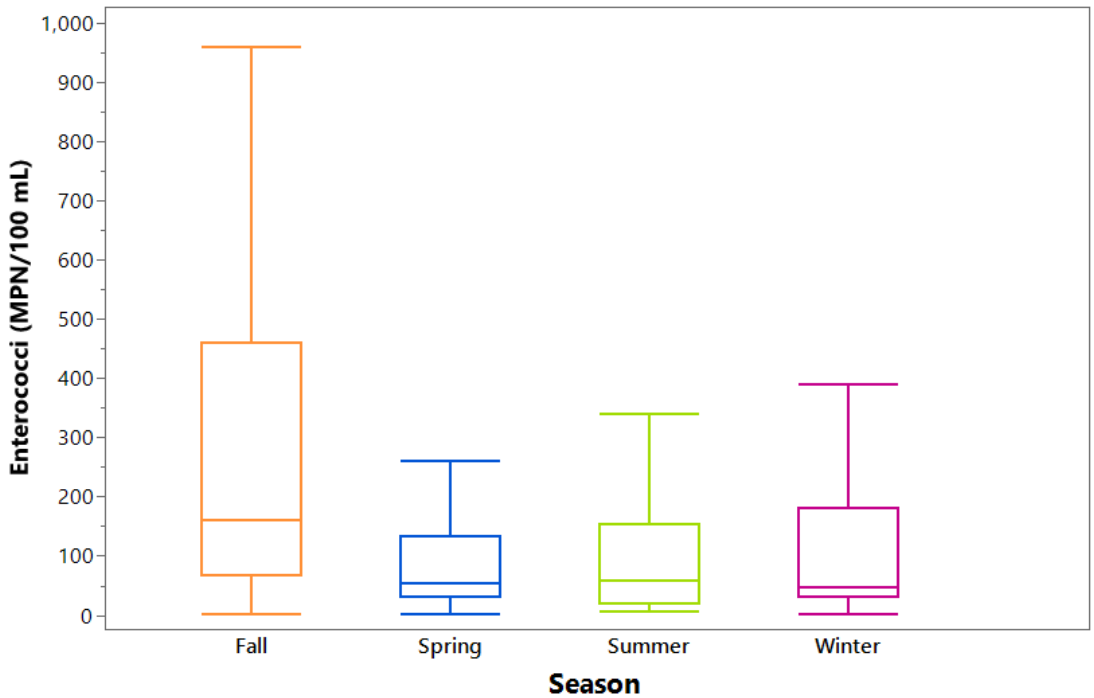


Figure 14. Boxplot of tidal enterococci concentrations collected in the Fall, Spring, Summer, and Winter (Percentile boxplot: Minimum, 25th, 50th, 75th, and maximum values shown; outliers have been removed for interpretation).

Bacteria Source Tracking

The *Bacterial Source Tracking (BST) on Tributaries of Trinity and Galveston Bays* project, conducted by Texas A&M AgriLife Research and funded by GBEP, was completed in 2020. The project collected *E. coli* samples from one monitoring site downstream of the East and West Fork Double Bayou confluence, in addition to four other sites around Galveston Bay.

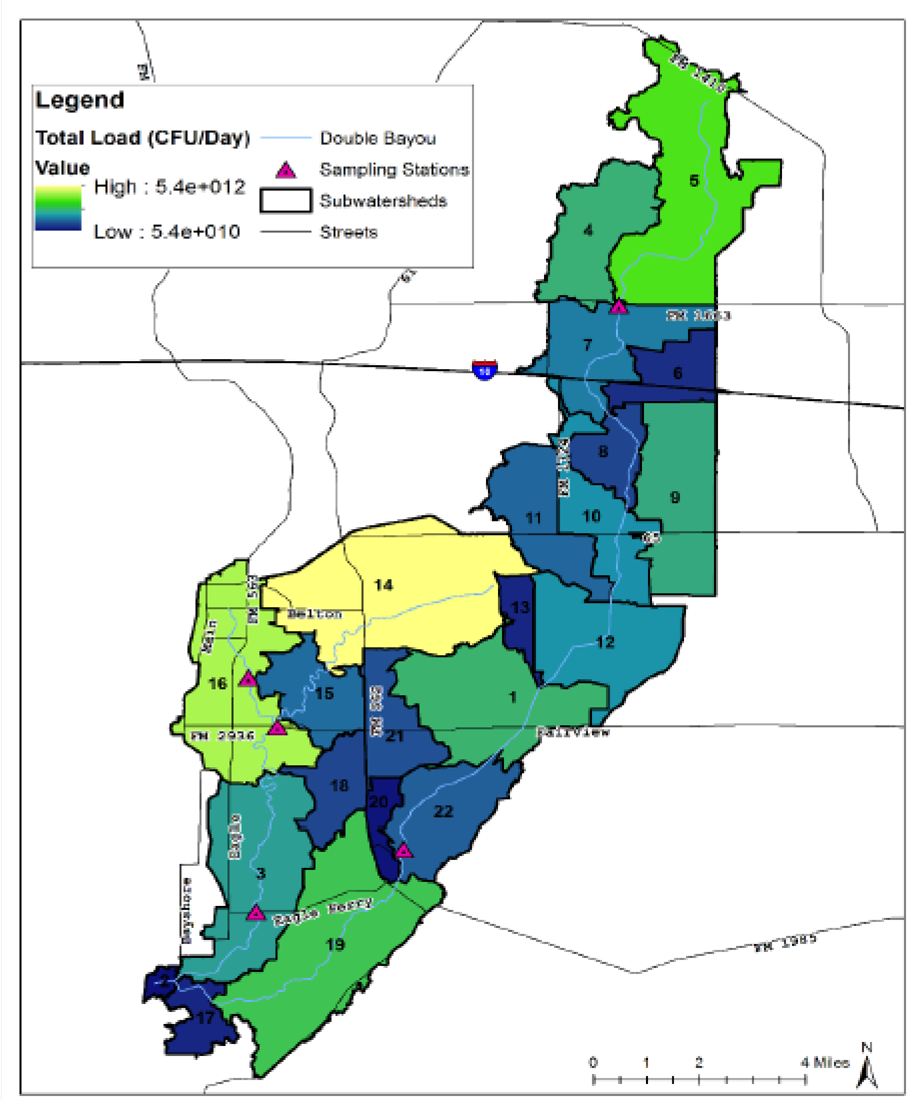


Figure 15. Total SELECT results

The percentage of *E. coli* source ID represents the portion of bacterial source load from PS and NPSs of fecal waste related to a category of pollution. Double Bayou was the most rural watershed where *E. coli* isolates were collected. The Double Bayou watershed results indicate that the portion of bacterial load from human sources was lower than most of the other sites surrounding Galveston Bay (Figure 16). However, Double Bayou had the second highest portion of bacterial load stemming from domestic animals which includes livestock. Wildlife was found to be the highest contributor to the bacterial source load accounting for about half of the total load. In addition, about a quarter of the bacterial source load was unable to be identified by BST.

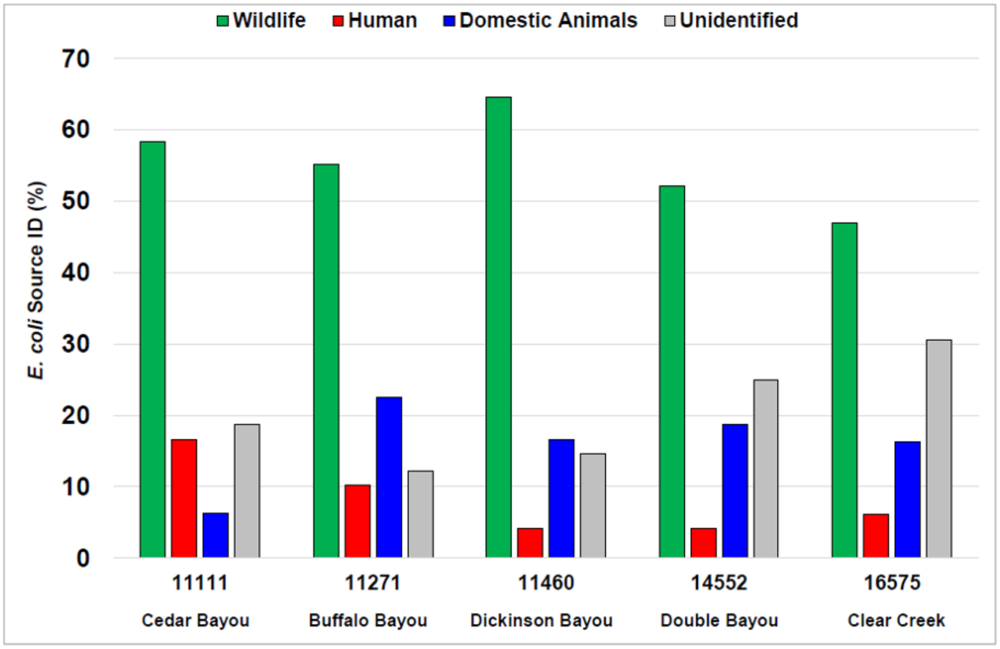


Figure 16. Three-way split of BST results at five sites around Galveston Bay (Texas Water Resources Institute, 2020)

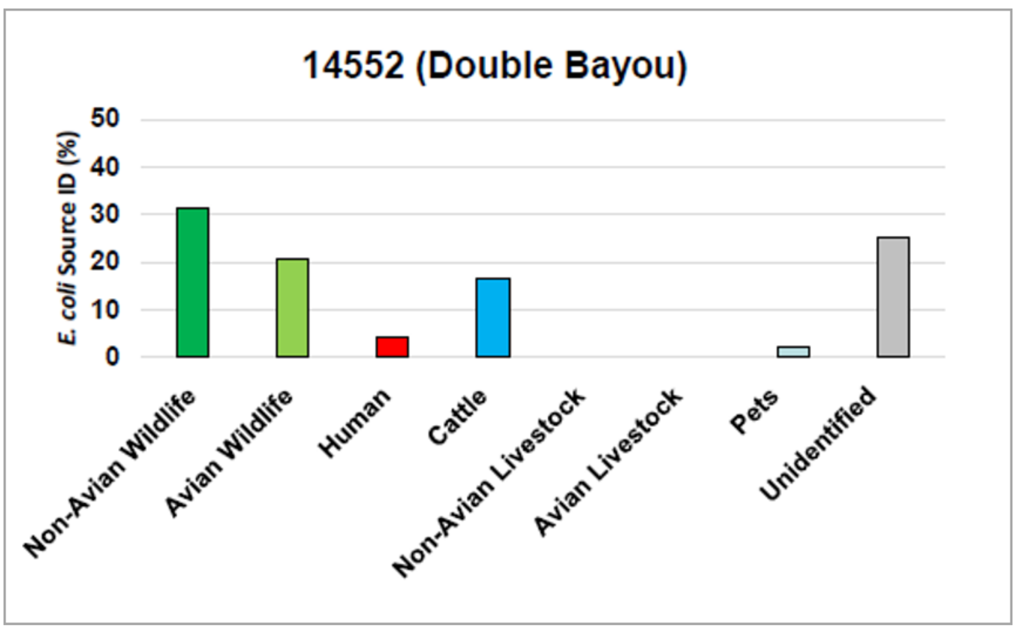


Figure 17. Seven-way split of BST results for the Double Bayou sampling site (Texas Water Resources Institute, 2020)

In the BST results for Double Bayou, the number one source category was identified as wildlife (Figure 16). Wildlife accounted for just over half of the *E. coli* source ID, comprised of approximately 30% non-avian wildlife, and 20% avian wildlife (Figure 17). At 30%, the non-avian wildlife is the single largest category contributing to *E. coli* source. After non-avian wildlife, the second highest loading category is cattle – making up about 18% of the total load. This fits the rural and agricultural landscape of the watershed. Lastly, the human source category was on the low end; however, bacteria from human sources have a higher potential to cause infection and illness in humans.

Feral Hog Management

The Chambers County Sheriff's office launched a highly successful feral hog eradication program which began in December of 2019. As of October 2020, the program has succeeded in removing 402 feral hogs (Figure 18). This equates to 43% of the bacteria load reduction goal for the watershed. The actual number of feral hogs removed is likely higher due to private landowner eradication efforts. Feral hog eradication efforts are ongoing within the watershed to accurately track and update progress the HARC team plans to continue coordination with Chambers County. The trapping efforts by the Chambers County Sheriff's Office marks substantial progress towards increasing public safety, reducing damage, and improving water quality conditions across Chambers County and within the Double Bayou Watershed.

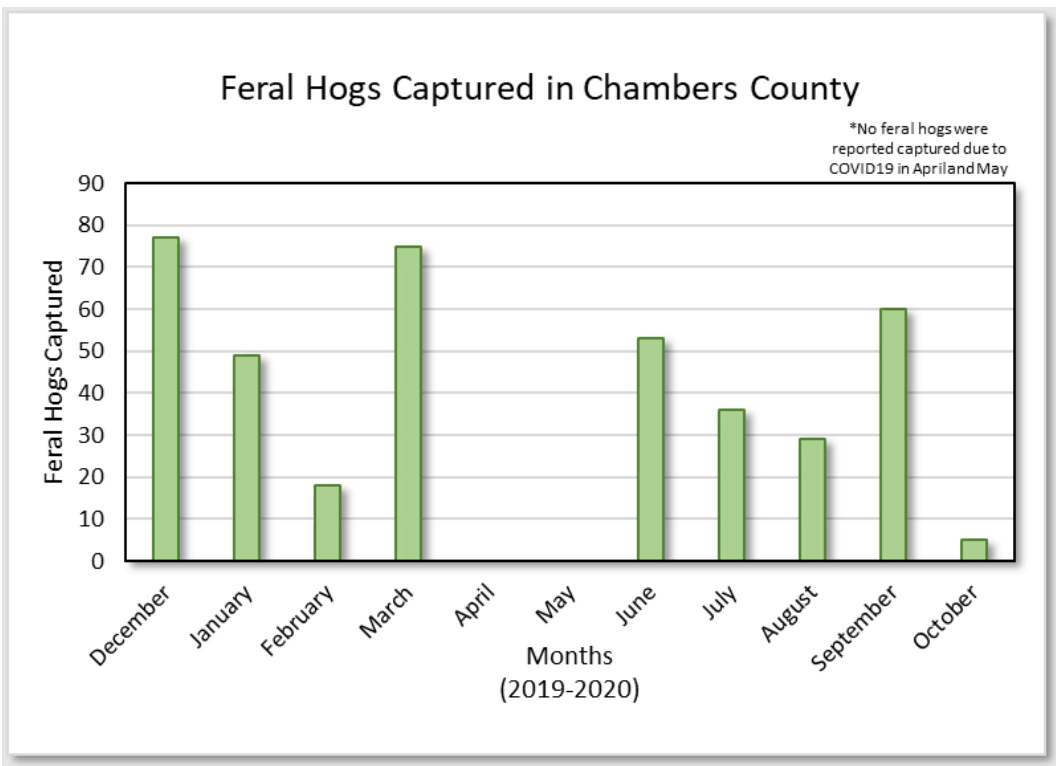


Figure 18. Feral Hogs Captured in Chambers County

Discussion

Dissolved Oxygen

Spatial differences in dissolved oxygen concentrations were observed within the watershed. For example, tidal sections of the West and East Forks had lower dissolved oxygen concentrations. Only 2% of the dissolved oxygen samples from the Anahuac Ditch (nontidal) were less than or equal to the 4 mg/L nontidal screening level (Table 1). The lower percent exceedances for this stream segment may result from the outflow pipe from the WWTF causing increased turbulence in the stream, and therefore, potentially oxygenating the water.

Tidal sections of the West Fork had more dissolved oxygen exceedances than tidal sections of the East Fork. Low levels of dissolved oxygen are not adequate to support aquatic life and may result in fish kills and loss of other aquatic species. In the TCEQ SWQIMS database, only one mention of a fish kill reported by a citizen three days prior to a sampling event in 1995 in the West Fork of Double Bayou was found in the comment field. However, the individual reported that the fish kill happened in a "bait camp pond" and not within the Double Bayou stream segments. Another comment for a sampling event in the West Fork of Double Bayou in 2003 mentioned that many gar fish were observed gulping air. One species of gar native to the watershed are Alligator gar (*Atractosteus spatula*), which are adapted to living in streams and rivers with low dissolved oxygen and are often observed gulping air. This provides limited anecdotal evidence of the low dissolved oxygen concentrations impact on aquatic life. No analyses were performed for this report to assess the link between low dissolved oxygen and fish kills. However, this relationship is important to investigate in the future.

Nutrients

The Anahuac Ditch (nontidal) was observed to have the highest nutrient percent exceedances (phosphorus 100% and nitrate 93%). These samples were collected from the WWTF monitoring station, which is located downstream of the facility's effluent and the City of Anahuac (Figure 3). These exceedances were considerably greater than the next highest phosphorus (1%) and nitrate (15%) percent exceedances, which occurred in the tidal West Fork (Table 2Table 4). In addition, the median nitrate concentration for the Anahuac Ditch WWTP monitoring station was 21 mg/L, which is more than 10 times the nontidal screening level (1.95 mg/L) (Figure 9). For context, the median nitrate concentration for the West Fork Upper station was only 0.42 mg/L and that of the West Fork Lower station was only 0.08 mg/L. Also, the median phosphorus concentration (3.72 mg/L) for the Anahuac Ditch station was slightly more than 5 times the nontidal screening level (0.69 mg/L) (Figure 7).

In contrast, the median phosphorus (East Fork Upper (nontidal): 0.09 mg/L, East Fork Lower (tidal): 0.08 mg/L) and nitrate (East Fork Upper (nontidal): 0.03 mg/L, East Fork Lower (tidal): 0.06 mg/L) concentrations are relatively similar and do not show the same spatial gradient that was observed on the West Fork at the monitored stations (Figure 7Figure 9). Both East Fork stations had lower median nutrient concentrations and fewer exceedances when compared with the median nutrient concentrations and exceedances at the Upper and Lower West Fork stations (Table 2 andTable 4, Figure 7Figure 9). Spatial variability in the occurrence of exceedances by station were also observed on the West Fork of Double Bayou, with phosphorus (3%) and nitrate (25%) exceedances occurring at the Upper West Fork station, but none occurring at the Lower West Fork station (Table 3Table 5). This is important because the Anahuac Ditch (nontidal) flows into the upper portion of the West Fork (tidal), so nutrient loads from this stream segment may account for the exceedances detected at the West Fork Upper station. However, it is important to note that these spatial gradients in nutrient concentrations appear to show a decrease in nutrient concentrations downstream of the Anahuac Ditch on the West Fork of Double Bayou as the flow moves towards the coast.

These spatial differences in phosphorus and nitrate exceedances, as well as median nutrient concentrations, occurring within the Double Bayou Watershed may be explained by different potential nutrient sources. As previously mentioned, the Anahuac Ditch, which had the greatest overall nutrient exceedances, receives effluent from the WWTF, which may contribute to some of the excess nutrients present in this stream segment. However, this is likely not the only source of nutrients for this waterway. The Anahuac Ditch also drains the most urbanized area of the Watershed, the City of Anahuac. Stormwater runoff from yards and streets flows into the Anahuac Ditch where it may accumulate in between storm events, as there is very little flow through this system during dry conditions. When rain events occur, concentrated nutrients may flush out of the Anahuac Ditch into the West Fork of Double Bayou. This should be further investigated to identify the sources contributing to elevated nutrients within the Anahuac Ditch and whether the excessive nutrient concentrations in this stream segment are driving those observed in the West Fork of Double Bayou, or if there are other nutrient sources contributing to the higher nutrient concentrations. A concern is that elevated nutrient concentrations may fuel algal blooms that can decrease dissolved oxygen concentrations, which negatively impacts aquatic life.

Discharge and Rainfall

Southeast Texas experienced a severe drought from 2010 to 2015 which peaked in 2011. Lower monthly average discharges representative of drought conditions were observed for the available discharge data between 2012 and 2015 (Figure 10 and Appendix A Supplementary Figures & Tables Figure 21). Drought conditions were also indicated to a lesser extent by relatively lower total annual rainfall amounts between 2010 and 2015, with some variability (Appendix A Supplementary Figures & TablesFigure 22). A historical rainfall event occurred in July of 2012 towards the end of the drought period. There was a total of 11.5 inches of rainfall measured for this month at the Anahuac rain gages, which is represented by a peak in the rainfall plot during the drought period (Appendix A Supplementary Figures & Tables Figure 22). There is also a small peak in the monthly mean discharge plot that occurred during this same month (Figure 10).

The named events (Memorial Day Flood, Tax Day Flood, Hurricane Harvey, and Tropical Strom Imelda) are associated with increased discharge and rainfall due to the intensity of the storm conditions (Appendix A Supplementary Figures & Tables, Table 13 and Figure 22). Tropical Storm Imelda is the most notable peak in total monthly rainfall and monthly mean discharge values, which occurred in September of 2019. The total rainfall for August 2018 is not reflective of observed rainfall because measurements were not able to be collected during Hurricane Harvey. However, it may be assumed that since Harvey resulted in the highest monthly mean discharge recorded, it is likely that the watershed received the highest amount of rainfall on record which contributed to elevated stream flow.

Fecal Indicator Bacteria Water Quality

The West Fork was the first stream segment in the watershed to be placed on the 303(d) list for elevated bacteria concentrations and has been declared impaired in the Texas Integrated Report since 2006. The East Fork was first placed on the 303(d) list for high bacteria concentrations in 2014 (TCEQ 2019a). The West Fork has been listed as impaired longer and has had historically higher concentrations of FIB compared to the East Fork, which is supported by this project’s findings. When evaluated by stream segment and stream type, the West Fork has an elevated enterococci geometric mean concentration compared to the East Fork in the tidally influenced portions (Table 7). Furthermore, the West Fork percentage of single sample exceedances is double that of the East Fork (Table 8). Although the tidal sections of the West and East Forks resulted in geometric mean and single sample exceedances, the nontidal portion of the East Fork did not exceed the geometric mean primary contact criterion or have any single sample *E. coli* exceedances. However, the majority of mainstem event-based monitoring trips resulted in FIB concentrations higher than the respective single sample criteria (**Error! Reference source not found.**Table 9). The high event concentrations indicate that rainfall events continue to result in the flushing of NPS fecal waste into the watershed's waterways.

The Anahuac Ditch, which receives effluent from the WWTF and drains to the West Fork, has had one routine single sample exceedance to date. In addition, routine geometric mean concentration of *E. coli* was 2.4 MPN/ 100 mL from 2001 to 2022 (Table 7). However, 75% of event-based samples have exceeded the single sample criterion in the Anahuac Ditch. A low routine sampling geometric mean and a lack of exceedances in the Anahuac Ditch indicate that the WWTF has been able to maintain operations during ambient conditions. The analysis suggests that the WWTF is a not major contributor of PS fecal waste to the watershed when rainfall is not present. However, the high percent exceedance (75%) of the event-based exceedance means that the WWTF is likely being overwhelmed by infiltration and inflow during higher intensity rain events. The new construction of a WWTF and overhaul of the sanitary sewer infrastructure which are currently under construction is expected to resolve future infiltration and inflow issues.

Additional analyses were performed to further evaluate how seasonality, stream type, and rain events may influence enterococci concentrations in the watershed. The West Fork was found to have a higher concentration of enterococci compared to the East Fork, which substantiates the geometric mean and single sample results. By comparing enterococci results collected during wet weather to dry weather conditions, the highest concentrations were found to be associated with wet weather days that received more than 0.5 inches of rainfall. The association of increased enterococci with rain events indicates that the primary way that FIB are transferred to the bayous is stormwater runoff. Additionally, enterococci concentration are highest in the Fall compared to all other seasons (Figure 14).

Enterococci concentrations are elevated in the West Fork, during the Fall season, and after rainfall events of more than half an inch. Management practices such as application of fertilizer, change in crops, or the rotation of cattle may be related to the higher FIB concentrations observed in the Fall. The project results can aid in the placement and prioritization of management measures during implementation through adaptive management. To have the greatest potential of reducing NPS loads and improving water quality in the watershed, management measures should be geared towards the West Fork subwatershed, designed to reduce FIB loadings associated with wet weather, and be able to manage higher FIB loadings during the Fall season. Ideal management measures include the continued education of and outreach to stakeholders who live in the City of Anahuac, which contains the highest population density and the most developed land in the West Fork's drainage. In addition, structural management measures geared towards preventing fecal waste loadings from reaching the waterways during rain events should be prioritized during implementation. Management measures such as the removal of feral hogs, restoration of riparian habitat, wetland and wildlife habitat management, and rain garden educational demonstrations, are critical to lowering the overall concentrations of FIB and potential pathogens within the watershed. Continued implementation of WQMPs that include conservation practices designed to reduce nonpoint source runoff from agricultural land uses is beneficial to improve the Watersheds water quality.

Bacteria Source Tracking

During the Double Bayou Watershed Protection Plan development process, SELECT was used to estimate potential pollutant loadings for bacteria sources across the Double Bayou Watershed. Cattle and feral hogs were found to be the two highest potential contributors of fecal waste pollution (Figure 15). To gain further insight and validate SELECT results, Double Bayou stakeholders recommended utilizing Bacteria Source Tracking (BST) as a management tool in the implementation phase of the WPP. BST can shed light on the proportion of bacterial load coming from three to seven pollutant categories including wildlife, human, and domestic animals further divided into non-avian wildlife, avian wildlife, human, cattle, non-avian livestock, pets, and an unidentified category.

During the SELECT process, Double Bayou stakeholders elected to exclude any avian livestock because no significant populations were known to exist in the watershed. The BST results provide further evidence supporting the avian livestock contributions – or lack thereof – in the watershed. In addition, stakeholders noted that horses are typically used to support cattle ranching operations and goats are not used for agricultural production but are kept by some landowners for subsistence use. The populations of these non-avian livestock are spread out over the watershed (not concentrated for agricultural production). As a result, low populations of non-avian livestock other than cattle - in this case horse (294) and goats (211) – were correctly represented in the SELECT model with low disbursed populations occurring in the watershed linked to less than 1% of the bacterial source load. The stakeholder assumption for a third category – pets that includes domesticated pets such as dogs and cats – not being a major contributor to bacteria loadings is also supported by the BST results.

At 30%, the non-avian wildlife is the single largest category contributing to *E. coli* source loads. This group includes feral hogs, which are known to be prevalent in the watershed. However, a portion of this loadings with this group could come from native wildlife such as deer, raccoons, and possums. The Double Bayou WPP stated that "Wildlife is likely a large contributor to bacteria loads in the watershed"; this assumption is supported by the BST results. Management measures that have resulted in the removal of feral hogs from the watershed are expected to show a decline in the bacteria concentrations within the bayous. During the 2017 BST study Texas Water Resources Institute (TWRI) was unable to distinguish between isolates of different non-avian species, such as deer and feral hogs. Feral hogs are a known contributor of bacteria and are being recommended to differentiate their load contributions in BST studies from other source of non-avian wildlife. In addition, recent studies indicate a higher potential for bacteria generated by feral hog to infect humans. TWRI is aware of the need to differentiate feral hogs from other non-avian sources and plan to do so, should funding be secured.

Overall, the BST results support conclusions of the stakeholder inputs into the SELECT modeling process that cattle and non-avian wildlife (which includes feral hogs) are the leading contributors to instream bacteria concentrations in the watershed. The BST milestone - long awaited by stakeholders and recommended in the WPP - has been met. The results show the importance of the stakeholders informing the SELECT process and the success of stakeholder-driven watershed planning efforts. Although, at least for now, a substantial portion of the *E. coli* source loads remain unidentified.

Feral Hogs

SELECT results highlighted feral hogs as the second highest potential source of bacteria contributions in the watershed. Stakeholders agreed that feral hogs and their bacteria contributions are a high priority to focus management measure efforts during implementation. Because feral hogs typically traverse waterways, the direct deposition of fecal waste by feral hogs into streams or bayous is a highly concentrated delivery mechanism of bacteria impacting instream water quality. In addition, feral hogs are responsible for economic and ecological impacts because they cause damage to crops, lawns and public spaces, as well as riparian habitats that help support a healthy Double Bayou Watershed (Figure 19).

Figure 19. Double Bayou Park Signage Indicating Closure due to Feral Hog removal in progress.

At the time of WPP development, the total feral hog population in the watershed was estimated to be 1,519. To determine an estimate of feral hogs that should be removed, the number of hogs for each subwatershed within the larger Double Bayou watershed was analyzed according to a bacteria load reduction goal. The process estimated that 927 hogs required removal to meet established bacteria load reduction goals. However, the estimated Double Bayou Watershed feral hog population should be considered a moving benchmark due to their high rate of reproduction and ability to move in and out of the watershed. Local experts have estimated the total Chambers County feral hog population to be higher.

Management Measure Milestones

HARC evaluated and tracked progress toward milestone success throughout this portion of the project. During the implementation phase of the Double Bayou WPP, many of the established milestones were met or are ongoing. Five management measures were completed including the hiring of a WQMP technician, a BST study, and the convening of a Watershed Texas Stream and

Riparian Workshop. An additional nine management measures are ongoing including development and recertification of WQMPs, water quality monitoring, and the distribution of outreach materials such as GBEP invasive species and Lone Star Healthy Streams materials (Table 10).

Table 10. Watershed milestones for stakeholder-developed management measures

Category	**Management Measures**	**Number per Implementation Years 1 to 3**	**Status**
Wastewater	Collection system study (smoke test and video lines) (high priority)	1	Completed
Septic Systems	Identify OSSFs in watershed and maintain OSSF database	1	Completed
Agricultural	Water Quality Management Plan (WQMP)	12 (3,4,5)	Completed
Agricultural	WQMP Technician (new position-shared with Cedar Bayou)	1	Completed
Monitoring	Targeted water quality monitoring	96	Completed
Monitoring	Bacterial Source Tracking	1	Completed
Outreach & Education	Watershed Texas Riparian & Stream Ecosystem Workshop	1	Completed
Outreach & Education	Galveston Bay Foundation Action Network (GBAN) application	1	Completed
O & E: Wastewater	Galveston Bay Foundation's Cease the Grease Campaign	3	In Progress
O & E: Wastewater	San Jacinto River Authority No Wipes in the Pipes/Patty Potty Campaign	1	In Progress
O & E: Septic	Septic systems Maintenance Workshop, exploring aerobic component addition	3	Canceled
O & E: Agriculture	Lone Star Healthy Streams (LSHS) program materials for distribution (feral hogs, horse and cattle)	1	Completed
O & E: Recreation	Illegal Boater Dumping Awareness Campaign/Galveston Bay Action Network	1	Completed
O & E: Wildlife/Invasive	GBEP invasive species materials for distribution	1	Completed

The goal of the implementation phase is to improve the water quality of Double Bayou. Now that the implementation phase of the watershed protection efforts has been underway, the partnership has started tracking progress of stakeholder identified management measure that were outlined in the WPP. The table provided here is a selection of agricultural management measures that have been completed or are in progress through WQMPs (Table 11). Refer to the WPP for a full list of management measures. The targeted number per implementation period has either been met or is tracking to be exceeded in addition to other ongoing efforts.

Table 11. Selection of completed and in-progress WQMP management measures

WQMP Practices	Total	
Fence	16,523	Feet
Prescribe Grazing	15,341	acres
Upland Wildlife Management	10,391	acres
Nutrient Management	10,107	acres
Wetland Wildlife Habitat Management	7,483	acres
Brush Management	6,088	acres
Forage Harvest Management	2,052	acres
Conservation Crop Rotation	1,658	acres
Irrigation Water Management	1,554	acres
Forage and Biomass Planting	1,045	acres

Stakeholder Meetings

HARC facilitated two in-person stakeholder meetings and three virtual stakeholder presentations (Double Bayou Live!) to provide updates on the status of WPP implementation efforts, progress in water quality monitoring and results, and to continue seeking input and further ideas as appropriate. HARC coordinated meetings, secured meeting locations, and prepared and disseminated meeting materials, notices, and agendas. Meeting materials were submitted to the TSSWCB Project Manager prior to dissemination. Meeting agendas and invitations are included in Appendix B Agendas & Stakeholders List Materials.

In cooperation with all project partners, HARC conducted a general stakeholder meeting on May 23, 2018. The topics for this meeting included an overview of events since the previous meeting, introduction of initial implementation activities such as WQMPs, introduction of the Bay-wide BST sampling project, overview of data since last meeting, an overview of Texas A&M University's (TAMU) OSSF program, and a presentation on Houston-Galveston Area Council's (H-GAC) Coastal Communities Project. Preparations for the May 2018 stakeholder meeting included: a schedule of specific tasks for the meeting; securing the meeting location and projector screen, from the County; preparing and sending email invitations and reminder emails to stakeholders; preparing and sending a meeting flyer by U.S. mail to those not using email regularly or at all (approx. 100); maintaining an RSVP list; developing agendas confirming refreshment sponsor; planning the meeting space; and preparing meeting handouts. All meeting documents – for sending by email or U.S. mail, or posting on the website, or for handouts – were approved by GBEP prior to public dissemination.

In cooperation with all the project partners, HARC conducted a second stakeholder meeting on

February 19, 2019. The primary topics for the meeting were presentation and discussion of: WQMPs progress and opportunities in the watershed; introduction of new WWTF director with overview of updates and changes to the WWTF; presentation of the Galveston Bay Foundation's G-BAN application. Preparations for the meeting included: schedule of specific tasks; securing the meeting location from the County; preparing and sending invitations and reminder emails to stakeholders; maintaining an RSVP list; developing an agenda; recruiting and coordinating with invited speakers; preparing and reviewing PowerPoint presentations; confirming refreshment sponsor; planning the meeting space; preparing meeting handouts; setting up the meeting space; facilitating the meeting; and preparing draft meeting notes. All meeting documents were approved by the TSSWCB prior to public dissemination.

In response to COVID-19 guidelines issued by public health officials for social distancing and group meetings, all external and public in-person events starting March 2020 through the end of the project were cancelled. This resulted in the cancellation of the May 2020 Double Bayou stakeholder meeting previously scheduled, as well as cancellation of the scheduled OSSF workshop.

To maintain communication with stakeholders and provide resources during COVID-19, HARC produced two digital stakeholder meetings for distribution through the Partnership website. HARC worked with partners in summer of 2020 to develop the next stakeholder meeting virtually. HARC investigated different software methods to deliver results in a downloadable or streaming method. In response to COVID-19, HARC began preparing digital resources for stakeholder meeting materials. HARC met with H-GAC to start preparations for filming an overview on the H-GAC Coastal Communities Project. HARC developed material for updated information on water quality monitoring data and data results. HARC developed material on updated information on feral hog counts and county control measures.

HARC met with H-GAC to film the Double Bayou Coastal Communities overview. HARC edited the video and prepared the material for posting on the website. HARC sent the Coastal Communities video to TSSWCB and GBEP for review and it was approved. HARC filmed the HARC Double Bayou December 2020 Stakeholder Update. HARC sent the HARC Double Bayou December 2020 Stakeholder Update to TSSWCB and GBEP for review and it was approved. HARC concluded the development of two initial presentations for the digital stakeholder web series and posted them (https://www.doublebayou.org/watershed-protection-planning/double-bayou-meetings/general-meetings). Announcements, approved by TSSCB and GBEP, were sent via email to the stakeholder list and through mailed postcards.

To share final project outcomes with stakeholders HARC plans to film a third Double Bayou Live presentation. The presentation will include final analysis results, a management measure update, concluding remarks, and brief overview describing the upcoming Double Bayou Phase Two implementation project.

Education and Outreach

Throughout the project, HARC continued to host and maintain the Double Bayou Partnership website (http://doublebayou.org/) to serve as a public clearinghouse for all project and watershed related information. Presentations, documents, and results were posted to the website, which serves to disseminate information to stakeholders and the public.

Education and Outreach was conducted at the May 23, 2018 and February 19, 2019 stakeholder meetings through overview of the TAMU OSSF program and H-GAC's coastal communities outreach project. HARC coordinated with H-GAC to discuss opportunities for H-GAC's Coastal Communities program to provide opportunities for outreach in Double Bayou. HARC contacted TWRI and TSSWCB to begin discussions regarding holding a landowner riparian restoration workshop in Chambers County. HARC contacted Extension Program Specialist, Ryan Gerlich, on October 19, 2018 regarding Homeowner Septic System Maintenance Workshop to be hosted in Chambers County in fall of 2019. In February of 2019 HARC completed coordination with TWRI and H-GAC to arrange a Chambers County Landowner Riparian Workshop to be held on May 1, 2019 at the Eddie V. Gray Wetland Center in Baytown, Texas.

HARC coordinated with the Anahuac WWTF to arrange a stakeholder tour (Figure 20). HARC circulated WWTF tour announcement to TSSWCB and GBEP for review and sent a WWTF tour invitation to Double Bayou stakeholders and posted the announcement to the Double Bayou website. HARC and partners conducted a City of Anahuac Wastewater Treatment Plant Tour for the Partnership on May 30, 2019. The tour was led by the Plant Operator Bobby Brasuell and covered the City of Anahuac Wastewater Treatment Plant and a lift station. TSSWCB, GBEP and HARC were in attendance.

Figure 20. Anahuac Wastewater Treatment Facility stakeholder tour

On April 16, 2019, HARC corresponded with Becki Begley of Coastal Communities regarding H-GAC's Supplemental Environmental Project for OSSF replacement, multilingual outreach materials (Spanish and Vietnamese), and a new Pharmaceutical Collection Box Systems Project. Three OSSFs have been replaced with two pending replacement on the East Fork of Double Bayou.

HARC sent an email invitation for the Texas Riparian & Stream Ecosystem Workshop - Double Bayou/Cedar Bayou to the Double Bayou list serve and posted the announcement to Double Bayou website. HARC circulated the stakeholder email invitation and website announcement for the upcoming Texas Riparian & Stream Ecosystem Workshop - Double Bayou/Cedar Bayou to TSSWCB and GBEP for review. HARC provided the presentation "Double Bayou Watershed Protection Planning: Past, Present & Future" at the Texas Riparian & Stream Ecosystem Workshop - Double Bayou/Cedar Bayou.

HARC developed a draft Sway digital newsletter, newsletter content included web maps, narrative, and images. HARC provided GBEP and TSSWCB with a draft fall 2019 Double Bayou Watershed Partnership newsletter for review and approval. HARC finalized the draft newsletter content and the digital newsletter multi-media content (Appendix C). HARC delivered the fall 2019 newsletter to stakeholders via an email blast. HARC provided a copy of the email blast containing the fall newsletter to GBEP and TSSWCB for approval (Appendix B Agendas & Stakeholders List Materials).

HARC provided GBEP and TSSWCB with a draft *Double Bayou Watershed Partnership Newsletter: Fall 2020* for review and approval. HARC finalized the draft newsletter content and the digital newsletter multi-media content (Appendix C). HARC delivered the fall 2020 newsletter to stakeholders via an email blast. HARC provided a copy of the email blast containing the fall newsletter to GBEP and TSSWCB for approval. Both newsletters were posted to the website (https://www.doublebayou.org/watershed-protection-planning/partnership-newsletters).

HARC provided TSSWCB with a draft *Double Bayou Watershed Partnership Newsletter:*

Spring 2022 for review and approval. HARC finalized the draft newsletter content and the digital newsletter multi-media content (Appendix C). The Spring 2022 newsletter was distributed to stakeholders through a Mail Chimp email release. The newsletter contained sections on the Double Bayou Tier 1 Project Location for Wetland Protection and Shoreline Stabilization, a Thanks to Galveston Bay Estuary Program for Their Support, an update on the Feral Hog Log, announcement for Double Bayou Live, a map figure for Watershed Protection Plans Around Double Bayou, and Management Measures - Making an Impact.

Summary

Since 2012, HARC in partnership with United Stated Geological Survey, Shead Conservation Solutions and the Double Bayou Watershed Partnership have planned for and implemented measures to manage nonpoint sources of pollution to improve water quality. The watershed protection planning efforts were supported thanks to funding provided by the Texas State Soil and Water Conservation Board from the United States Environmental Protection Agency and the Galveston Bay Estuary Program a Texas Commission of Environmental Quality program. The Double Bayou Watershed Partnership includes stakeholders such as community leaders, elected officials, landowners, nonprofit organizations, and representatives of relevant local, state, and federal agencies that developed the Double Bayou Watershed Protection Plan through a series of stakeholder and workgroup meetings. The 2016 completion and stakeholder approval of a Watershed Protection Plan for Double Bayou was the first step towards implementing management measures.

The Double Bayou Watershed Protection Plan’s implementation was carried out through the *Coordinating Implementation of a Watershed Protection Plan for Double Bayou* project. In support of the Double Bayou Watershed Partnership, HARC successfully implemented or tracked stakeholder requested management measures. Management measures achieved by HARC, the Double Bayou Watershed Partnership, and other entities within the watershed include the creation of new and maintenance of existing WQMPs, feral hog eradication, replacement and maintenance of OSSFs, the start of construction to build a new Wastewater Treatment Facility and improve sanitary sewer infrastructure, a completed water quality monitoring campaign and analysis, stakeholder meetings, education and outreach, and development of communication materials. HARC will begin the second phase of implementation of the Double Bayou Watershed Protection Plan in November 2022 and will continue implementing and tracking stakeholder approved management measures to improve water quality in Double Bayou.

References

SWQMP (2019) *Draft 2020 Guidance for Assessing and Reporting Surface Water Quality in Texas - In Compliance with Sections 305(b) and 303(d) of the Federal Clean Water Act.* Surface Water Quality Monitoring Program Monitoring and Assessment Section, Water Quality Planning Division. Retrieved from Austin, Texas. https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/gawg/2020/2020_guidance.pdf

TCEQ (2020a). *2020 Texas Integrated Report Texas 303(d) List (Category 5)*. Retrieved from Austin, Texas. https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/20txir/2020_303d.pdf

TCEQ (2020b). *Texas Surface Water Quality Monitoring Information System (SWQMIS)*. Surface Water Quality Monitoring data from the Texas Commission on Environmental Quality. Retrieved from Austin, Texas. https://www.tceq.texas.gov/waterquality/monitoring

Texas Water Resources Institute (2020). TR_528. *Bacterial Source Tracking (BST) on Tributaries of Trinity and Galveston Bays.* https://twri.tamu.edu/media/5472/tr-528.pdf.

Appendices

Appendix A Supplementary Figures & Tables

Table 12. Number of dissolved oxygen event samples (n), number of single sample exceedances, and percent exceedances by season, stream segment and type from 1984-2022

Winter

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	142	15	11%
East Fork	Tidal	83	3	4%
East Fork	Nontidal	28	0	0%
Anahuac Ditch	Nontidal	12	0	0%

Spring

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	151	51	34%
East Fork	Tidal	83	19	23%
East Fork	Nontidal	23	6	26%
Anahuac Ditch	Nontidal	10	0	0%

Summer

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	127	82	65%
East Fork	Tidal	79	31	39%
East Fork	Nontidal	16	13	81%
Anahuac Ditch	Nontidal	7	0	0%

Fall

Stream Segment	Stream Type	n	Single Sample Exceedance (count)	Exceedance (percent)
West Fork	Tidal	147	67	46%
East Fork	Tidal	84	45	54%
East Fork	Nontidal	27	12	44%
Anahuac Ditch	Nontidal	12	1	8%

Table 13. Monthly mean discharges in cf/s at USGS Monitoring Gage 08042558 West Fork Double Bayou

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jan	13.12	51.95	9.52	74.04	37.84	101.67	77.97	95.40	51.82	56.89
Feb	75.30	6.32	30.10	2.58	14.32	19.79	90.13	72.63	24.67	6.00
Mar	50.62	8.17	47.43	104.70	98.65	69.40	12.83	8.45	−6.58	12.80
Apr	19.06	17.22	3.02	139.91	143.15	38.03	0.66	−9.30	1.70	6.59
May	24.79	40.13	8.88	90.01	46.93	28.74	−1.65	63.34	51.20	67.25
Jun	4.78	23.69	23.28	107.69	137.59	113.83	15.89	88.78	19.93	48.88
Jul	60.11	13.30	36.13	40.47	30.74	55.13	56.41	34.58	24.67	76.65
Aug	11.55	5.07	3.01	25.44	93.17	724.47	10.36	55.97	−9.14	28.27
Sep	7.11	4.26	6.44	7.52	17.76	213.52	223.24	384.74	−32.56	136.70
Oct	7.59	13.47	15.35	27.58	19.71	7.23	18.36	39.41	−7.55	90.81
Nov	−0.32	42.88	23.49	89.43	12.70	−5.25	87.83	−0.52	−2.73	11.85
Dec	7.87	0.29	56.10	67.86	142.40	4.56	89.53	12.88	92.73	11.64

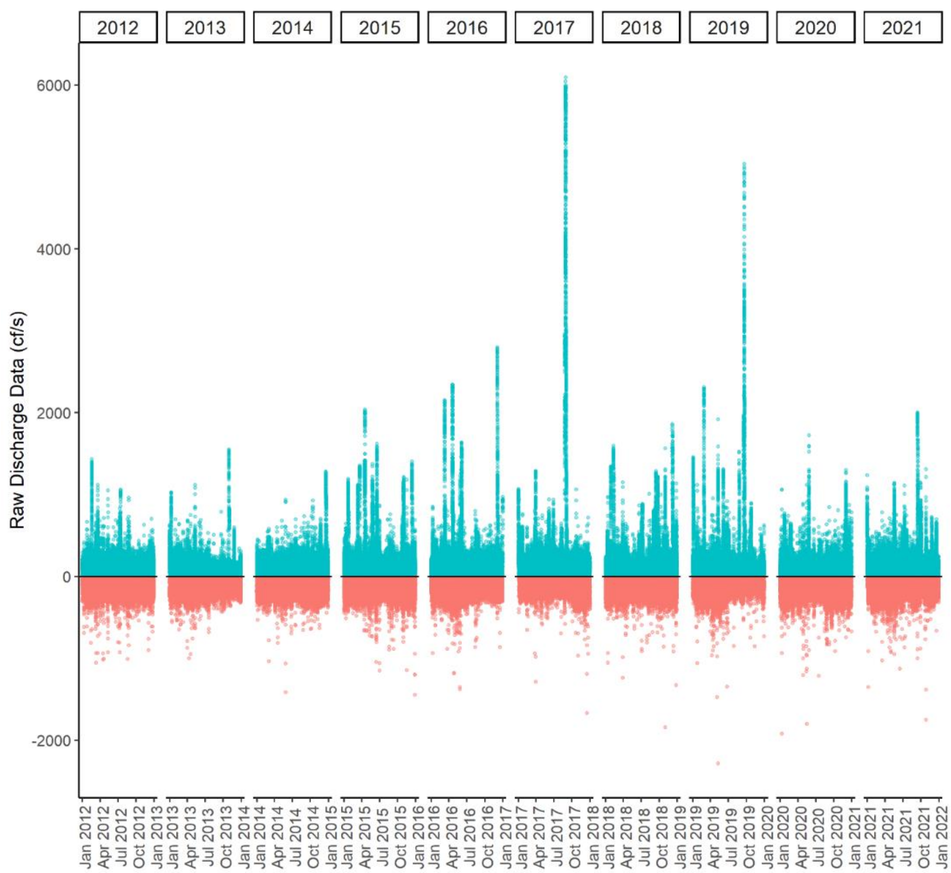


Figure 21. Raw discharge data in cf/s collected every 15-minutes at USGS Monitoring Gage 08042558 West Fork Double Bayou by year from 2012 to 2021.

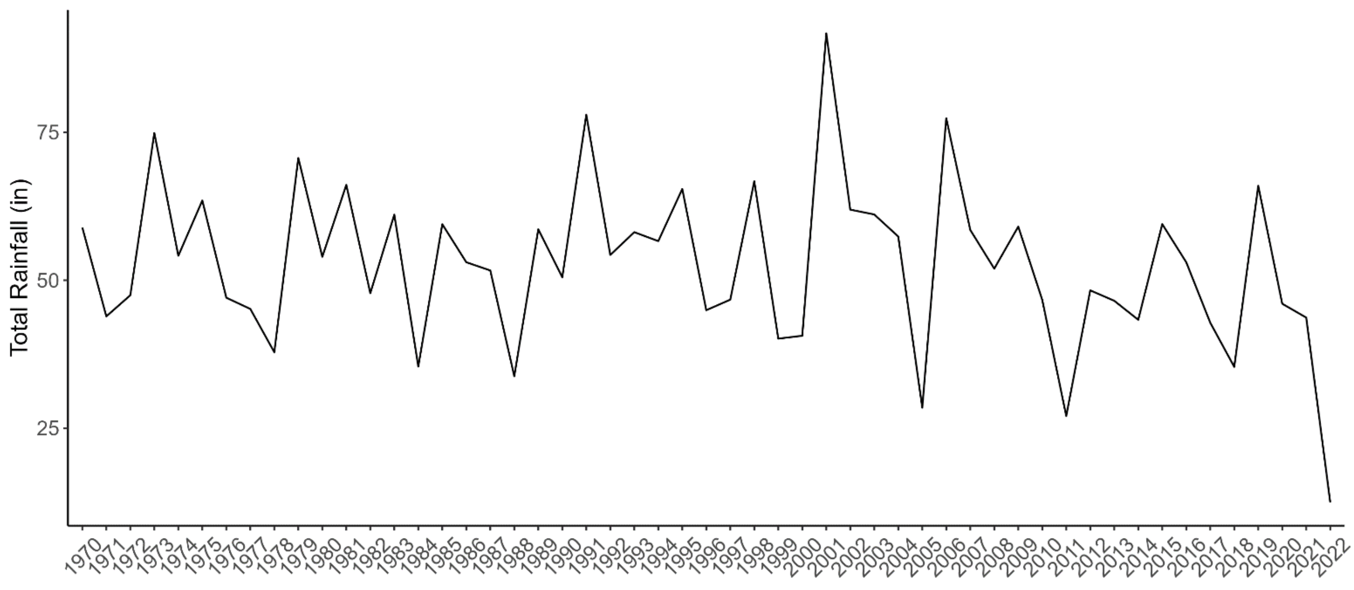


Figure 22. Total annual rainfall for NOAA rain gages at Anahuac (USC00410235) and Anahuac 5.7 N (US1TXCHM011) from 1970 to 2022. Note that the 2022 total rainfall does not include measurements for the full year (the period of record ends on 7/14/2022).

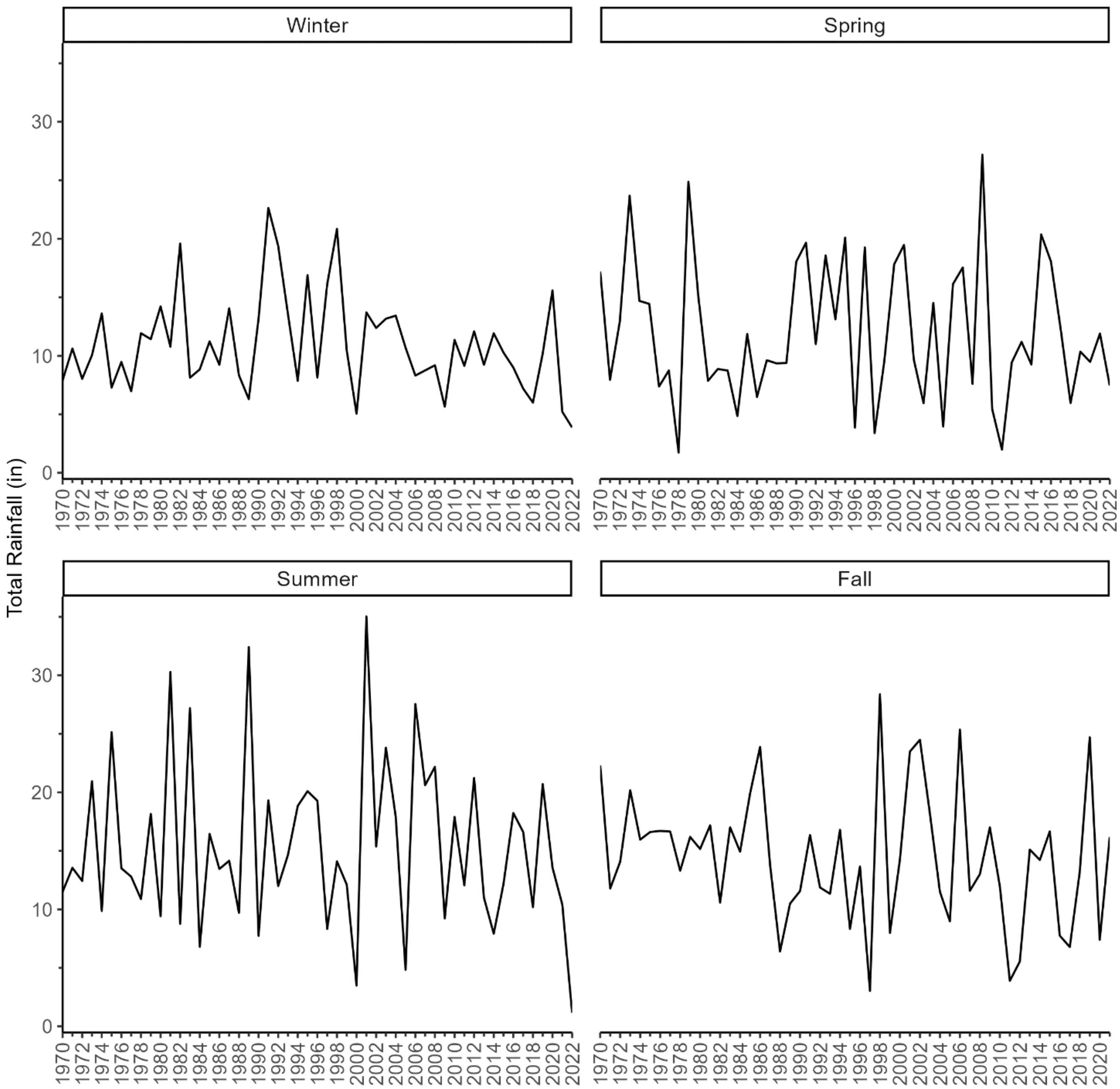


Figure 23. Total annual rainfall by season for NOAA rain gages at Anahuac (USC00410235) and Anahuac 5.7 N (US1TXCHM011) from 1970 to 2022. Note that the 2022 total rainfall does not include measurements for the full year (the period of record ends on 7/14/2022).

Appendix B Agendas & Stakeholders List Materials

May 7, 2018

Dear Stakeholder,

The Galveston Bay Estuary Program (GBEP) and the Houston Advanced Research Center (HARC) cordially invite you and your neighbors to the first ***implementation*** meeting of the **Double Bayou Watershed Partnership**.

Please join us on **Wednesday, May 23, 2018**, at The Double Bayou Community Building, 2211 Eagle Ferry Road, Double Bayou, TX from **5:30-7:30 p.m**. This meeting will serve to provide updates on watershed news, community resource information for on-site sewage facilities (septic systems), and upcoming implementation plans. ***Refreshments will be provided.***

Please, RSVP to Ryan Bare at 281-364-6050 or via email to Doublebayouwpp@harcresearch.org.

The Texas State Soil and Water Conservation Board (TSSWCB) and the GBEP provided funding to develop a Watershed Protection Plan (WPP) for the Double Bayou Watershed. The goal of the Double Bayou Watershed Protection Plan is ***implementation of management measures*** aimed at reducing bacteria levels in the bayous. The final stakeholder-approved Double Bayou WPP was accepted by the U.S. Environmental Protection Agency in June of 2016. Instead of a regulatory process, a watershed protection plan project is a voluntary, stakeholder-driven process that utilizes a series of cooperative, iterative steps to: (a) characterize existing conditions; (b) identify and prioritize potential sources of pollution; (c) define management objectives and practices; and (d) ***implement protection or remediation strategies***.

For more information, I encourage you to go to our website at www.doublebayou.org. There, you will find meeting notes as well as other documents that give more background on the project. If you still have questions, or want a more detailed overview of the project, please feel free to contact The Double Bayou Watershed Partnership at Doublebayouwpp@harcresearch.org.

Sincerely,

The Double Bayou Watershed Partnership

Double Bayou Watershed Partnership
Stakeholder Meeting
May 23, 2018
5:30 P.M.
Double Bayou Community Building

5:00 **Refreshments and Sign In**

5:30 **Welcome, Introductions and Agenda Review –** *Stephanie Glenn*

- Thanks to:
  - Jerry Shadden, Trinity Bay Conversation District, for the dinner
  - Chambers County Precinct Two, for the meeting room
- Goals/Agenda for Today's Meeting:
  - Welcome Back
  - Updates on implementation and plan
  - Learn about next steps
- Introductions (note any elected officials)
- Logistics: Remind everyone about dinner, restrooms, available documents

5:40 **Overview–** *Stephanie Glenn / Ryan Bare*

- Brief update on where we are; BST project details (Stephanie)
- Water Quality Review (Ryan)

6:00 **Implementation Update –** *Brian Koch*

- Catch-up on TSSWCB progress
- SWCD Technician/Introduction of Jimmy Weaver

6:10 **Overview of Water Quality Management Plans –** *Brian Koch*

6:30 **OSSF survey and pump out/inspections –** *Ryan Gerlich*

- OSO Watershed in Corpus Christi Area, Double Bayou Watershed

7:00 **Galveston Bay: Coastal Communities Outreach –** *Becki Begley*

- H-GAC's Coastal Communities Outreach Project

7:25 **Final Wrap-up, Announcements**

7:30 **Adjourn**

Stakeholder meeting
February 19th from 5:30-7:30 pm
@ Double Bayou Community Building

View this email in your browser

DOUBLE BAYOU WATERSHED PARTNERSHIP

Dear Double Bayou Stakeholders,

The execution of the Double Bayou Watershed Protection Plan is in full swing. Learn about current activities and more at the *2019 Double Bayou Watershed Partnership implementation meeting*!

Join Us:

Tuesday, February 19th

from 5:30-7:30 pm

at the Double Bayou Community Building

2211 Eagle Ferry Rd

Boots are on the ground actively implementing the management measures designed and selected by you with promising results. The agenda includes a Water Quality Management Plan update and overview and a wastewater treatment infrastructure update and overview.

We hope to see you there!

Happy New Year,
The Double Bayou Watershed Protection Plan Team

TEXAS STATE Soil & Water CONSERVATION BOARD · TCEQ · GALVESTON BAY ESTUARY PROGRAM · HARC · USGS science for a changing world

Funding provided through a Clean Water Act §319(h) Nonpoint Source Grant from the Texas State Soil and Water Conservation Board and the U.S. Environmental Protection Agency.

Double Bayou Watershed Partnership
Stakeholder Meeting

February 19th, 2019
5:30 P.M.
Double Bayou Community Building

5:00 **Refreshments and Sign In**

5:30 **Welcome, Introductions and Agenda Review –** *Stephanie Glenn*

- Thanks to:
  - Chambers County Precinct Two, for the meeting room
- Goals/Agenda for Today's Meeting:
  - Updates on implementation and plan
  - Upcoming
- Introductions (note any elected officials)

5:40 **Overview–** *HARC*

- TSSWCB grant
- WPP milestones – short list/progress
- SEP funding
- Landowner Riparian & Stream Ecosystem workshop – early April
- TWRI request for BST sample collection
- Soil Health Workshop in Victoria - April 23rd and 24th

6:00 **Water Quality Management Plans Overview/Update –** *Jimmy Weaver*

- WQMP overview
- WQMP progress update

6:20 **Wastewater Infrastructure –** *Bobby Brasuell*

- WWTF overview
- Infrastructure upgrade status update

6:40 **Galveston Bay Action Network (GBAN) –** *Sarah Gossett*

- GBAN is a pollution reporting and monitoring app that will report across the four counties that touch Galveston Bay (Brazoria, Chambers, Harris, and Galveston Counties).

7:00 **Final Wrap-up, Announcements**

7:05 **Adjourn**

Double Bayou Watershed Protection Plan Implementation: 2020

DOUBLE BAYOU WATERSHED PARTNERSHIP

TEXAS STATE Soil & Water CONSERVATION BOARD

HARC

USGS science for a changing world

Double Bayou Live!

In response to COVID-19 guidelines issued by public health officials, the stakeholder meeting planned for this fall had to be canceled. So we will be making the stakeholder meetings available virtually! Stay tuned to www.doublebayou.org for updates on upcoming webinars on recent water quality sampling results, feral hog updates, coastal community updates and more about the Double Bayou watershed. Sign up for the newsletter on the website and get the latest news.

The Double Bayou Watershed Partnership

Double Bayou Digital Stakeholder Web Series

View this email in your browser

DOUBLE BAYOU WATERSHED PARTNERSHIP

Dear Double Bayou Stakeholders,

The Double Bayou Watershed Protection Plan (WPP) Team is happy to announce Double Bayou Live! Two Web Series presentations are now available 1) Double Bayou Watershed Protection Plan Implementation Overview: 2020 and 2) Coastal Communities: Double Bayou Watershed Update presented by H-GAC. Additional Web Series topics will be released on a rolling schedule and are expected to include an in-depth review of feral hog management activities.

The Double Bayou implementation update presentation includes details on implementation activities occurring in 2020 such as WPP milestones, water quality samples, and more.

The Coastal Communities update covers the H-GAC Coastal Communities' Plan roadmap, outreach resources, and other useful information.

The presentations can be accessed through the Double Bayou website under the General Meetings tab.

*Visit **DoubleBayou.Org** to stay up to date on watershed activities.*

Thank You,
The Double Bayou Watershed Protection Plan Team

TEXAS STATE Soil & Water CONSERVATION BOARD · HARC · USGS science for a changing world

Funding provided through a Clean Water Act §319(h) Nonpoint Source Grant from the Texas State Soil and Water Conservation Board and the U.S. Environmental Protection Agency.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DOUBLE BAYOU WATERSHED PARTNERSHIP

> Watershed Protection Planning > Double Bayou Meetings > General Meetings

General Meetings

Digital Stakeholder Web Series

Double Bayou Watershed Protection Plan Implementation: 2020 from HARC on Vimeo.

Double Bayou Virtual Stakeholder Meeting: Update on H-GAC's Coastal Communities Program from HARC on Vimeo.

Search ...

UPCOMING

In response to COVID-19 guidelines issued by public health officials, the **Introduction to Septic Systems Workshop scheduled on March 31st has been postponed** until further notice.

SUBSCRIBE TO OUR MAILING LIST

Sign-up for our mailing list to stay up to date with Double Bayou watershed activities and planning efforts

Subscribe

CONTACT

The Double Bayou Watershed Partnership doublebayouwpp@harcresearch.org

Appendix C Double Bayou Newsletters 2019, 2020, and 2022

Link: **https://sway.office.com/EsbYcvOWtcLCmAqC?ref=email**

Link: **https://sway.office.com/GX1XsFjKtuItOGZQ**

Double Bayou Watershed Partnership Newsletter: Spring 2022

Double Bayou Tier 1 Project Location for Wetland Protection and Shoreline Stabilization