2025 BASIN HIGHLIGHTS REPORT

Characterization of the Luce Bayou Watershed

Luce Bayou (Segment 1002B) and
Tarkington Bayou (Segment 1002A)

Houston-Galveston Area Council

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INTRODUCTION

H-GAC's CLEAN RIVERS PROGRAM

The Texas Clean Rivers Program is a partnership between the Texas Commission on Environmental Quality (TCEQ) and regional water authorities to monitor water quality and engage stakeholders in Texas. The Houston-Galveston Area Council (H-GAC) coordinates the efforts of local partners to monitor health of water bodies throughout the region. In addition to analyzing monitoring data, H-GAC assesses factors and activities affecting water quality. Through an extensive public education and outreach program, H-GAC provides information on regional water quality and recommendations on what individuals, industry, and local governments can do to conserve and make improvements to local waterways. Data acquired through the Clean Rivers Program provides support for all watershed-based activities in the region. The H-GAC's Clean Rivers Program uses a coordinated approach to water quality monitoring with activities occurring throughout four river basins and coastal waters (Figure 1).

BASINS AND COUNTIES

The four river basins included in H-GAC's Clean Rivers Program study area are:

- San Jacinto River Basin
- Brazos-Colorado Coastal Basin
- San Jacinto-Brazos Coastal Basin
- Trinity-San Jacinto Coastal Basin

A portion of the Bays and Estuaries (Basin 24) is also included.

The fifteen counties included in the H-GAC's Clean Rivers Program area are:

- Austin
- Brazoria
- Chambers
- Colorado
- Fort Bend
- Galveston
- Grimes
- Harris
- Liberty
- Matagorda
- Montgomery
- San Jacinto
- Walker
- Waller
- Wharton

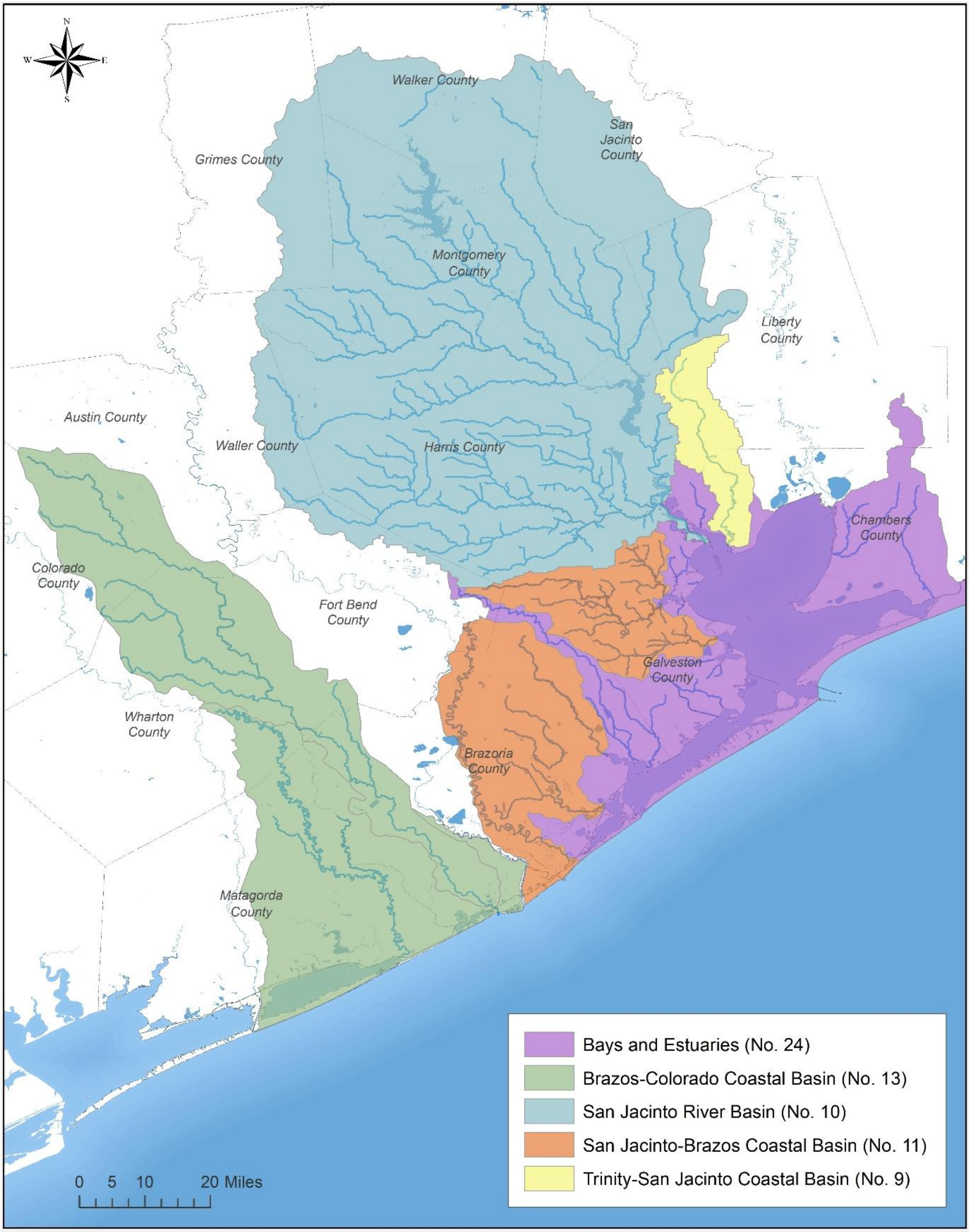


Figure 1. River and Coastal Basins in the Houston-Galveston Area Council's Clean Rivers Program Area.

MONITORING PARTNERS AND CONTRACTORS

H-GAC's Clean Rivers Program monitoring includes more than 370 coordinated sampling sites and six regional partners (Figure 2).

These partners are:

- City of Houston Health Department (HHD)
- City of Houston Drinking Water Operations (DWO)
- Environmental Institute of Houston (EIH) at the University of Houston-Clear Lake
- Harris County Pollution Control Services (HCPCS)
- San Jacinto River Authority (SJRA) – Lake Conroe Division & The Woodlands Division
- Texas Research Institute for Environmental Studies (TRIES) at Sam Houston State University

Other agencies contributing data used by the Clean Rivers Program include:

- Texas Commission on Environmental Quality
- United States Geological Survey

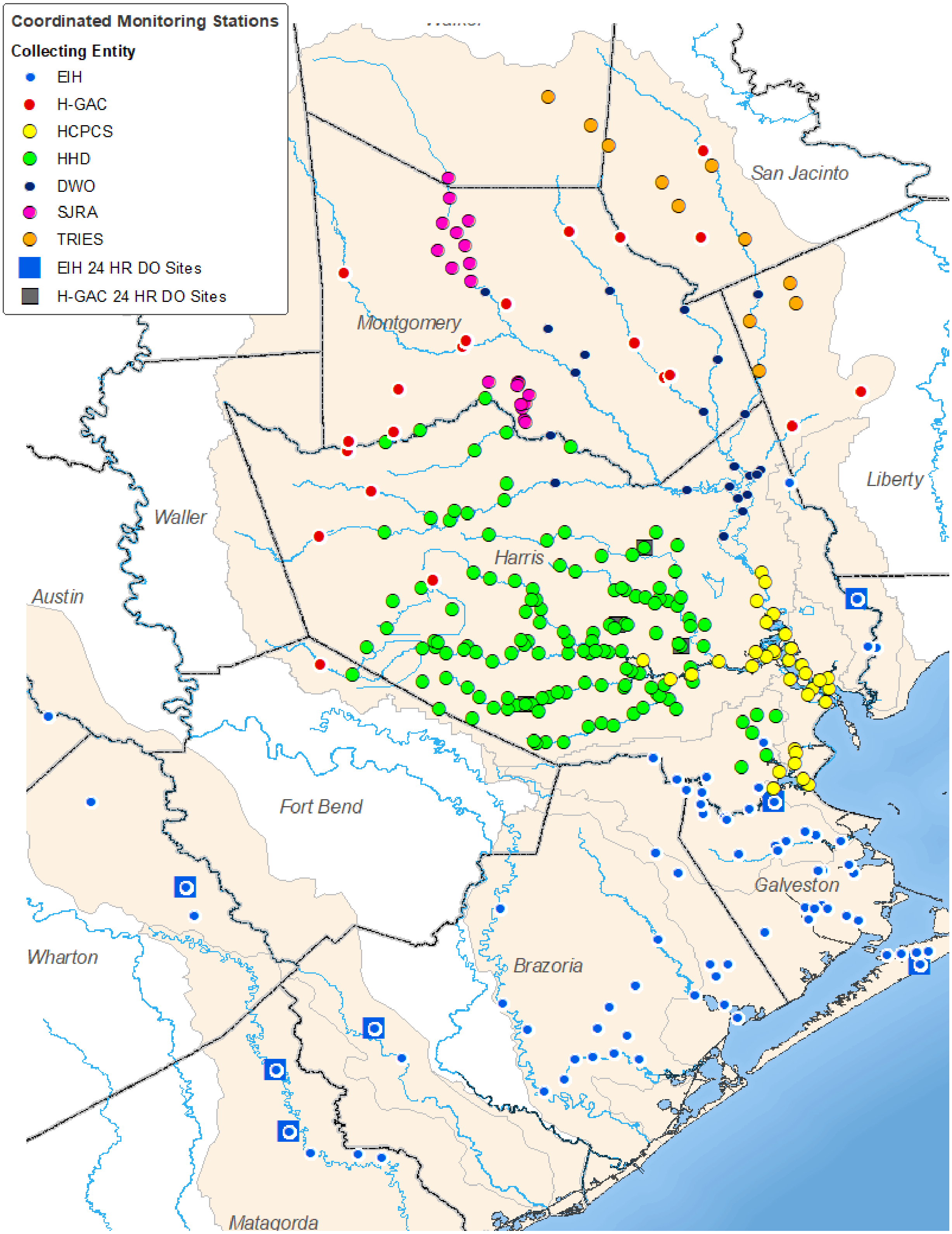


Figure 2. Map of FY2025 monitoring sites by collecting partner for the Clean Rivers Program in the H-GAC region.

REGIONAL IMPAIRMENTS AND CONCERNS

PATHOGEN INDICATOR BACTERIA

44% of the assessed stream miles in our region are impaired for recreational use due to elevated levels of pathogen indicator bacteria.

In the Houston-Galveston region, one of the most significant water quality issues faced is elevated levels of pathogen indicator bacteria in our local waterways. State pathogen indicator bacteria standards are set based on the level of recreational use assigned to the waterbody. The pathogen indicator bacteria collected in tidal waterways is enterococci, while *Escherichia coli* (*E. coli*) is collected in freshwater. Both are found in digestive tracts in people and animals and are used as indicators of the likely presence of fecal matter and associated pathogens. High bacterial concentrations may cause gastrointestinal illnesses or skin infections in swimmers or others who come into direct contact with the water. Even where the concentration of pathogen indicator bacteria is less than the standard, there can still be a risk of contracting waterborne diseases.

Sources of bacterial contamination include:

- Wastewater treatment facility (WWTF) releases;
- Sanitary sewer overflows (SSOs);
- Failing on-site sewage facilities (OSSFs); and
- Fecal waste from livestock, pets, feral hogs, and other wildlife.

DISSOLVED OXYGEN

21% of the assessed stream miles in our region are impaired for aquatic use due to low levels of dissolved oxygen.

Dissolved oxygen (DO) levels are measured to evaluate a water body's ability to support aquatic life. As a general rule, higher levels of DO can support more abundant and diverse aquatic species. DO levels fluctuate naturally based on season and time of day; however, human activities can further depress DO concentrations in water bodies. Sudden or prolonged decreases in DO could result in fish kills.

DO levels can be negatively impacted by many factors, including:

- High concentrations of nutrients that cause algal blooms;
- Sediment from construction sites;
- Overgrazing of livestock;
- Stream channel modification and development; and
- Reduced riparian tree cover.

NUTRIENTS

33% of the assessed stream miles in our region exceed state screening levels for nutrients, such as nitrate, ammonia, or phosphorus.
24% of the assessed stream miles in our region exceed state screening levels for chlorophyll-a.

Nutrients, including phosphorus, nitrate, and ammonia, occur naturally in surface waters. They are an important part of a healthy aquatic ecosystem. However, human activities can contribute excessive nutrients to water bodies. High concentrations of nutrients can result in algal blooms, which can depress DO levels and produce toxins that are harmful to humans and aquatic species.

Sources of nutrient pollution include:

- Sewage treatment plant discharges;
- Stormwater runoff;
- Failing on-site sewage facilities, including septic systems.
- Fertilizer runoff from lawns and agricultural fields; and
- Animal manure.

PCBS AND DIOXINS

68% of the assessed tidal streams and bays in our region are impaired for PCBs and dioxins.

PCBs, or polychlorinated biphenyls, and dioxins are broad groups of synthetic organic compounds developed for industrial purposes or are by-products of industrial processes. PCBs and dioxins are toxic and carcinogenic. PCBs and dioxins are legacy pollutants, meaning they can remain in the environment long after they are introduced. Both accumulate in the fatty tissue of marine life, and humans can be exposed through consumption of contaminated fish and shellfish.

FROG CHART REGIONAL WATER QUALITY SUMMARY

Finding a way to summarize water quality can be complicated because there are several different standards that can be used to evaluate the health of a waterbody. The H-GAC has created a “frog chart” to provide a summary of water quality using the percent of total segment lengths that are impaired or of concern for each of the water quality standards or screening levels that the TCEQ evaluates (Table 1). In addition to listing levels of impairments, H-GAC staff also interpreted these data and assigned one to five “frogs” to give a snapshot of water quality. The “frog” count is based on the percentage of each segment that is impaired, and the severity and type of the impairment.

Table 1. 2025 Frog Chart by segment. Numbers represent the percent of total segment length that is impaired or of concern for each parameter. Cells without numbers (blanks) represent stream segments that are currently meeting state standards or screening levels but may be improving or degrading for each parameter.

Houston-Galveston Area Council

2025 REGIONAL WATER QUALITY SUMMARY

DO = Dissolved Oxygen Bact = Bacteria Chl-a = Chlorophyll-a Nutr = Nutrients PCB = PCBs/Dioxins OTHER = See Chart Key

Basin	Watershed	Segment	DO	Bact	Chl-a	Nutr	PCB	Other*
Trinity-San Jacinto Coastal	Cedar Bayou Tidal	0901	14.2	100	85.8		85.8	
	Cedar Bayou Above Tidal	0902	82.7	82.7		17.3		82.7
San Jacinto River	Buffalo Bayou Above Tidal	1014	3.1	77.9		69		0.7
	Buffalo Bayou Tidal	1013	34.2	77.8		47.9		29.9
	Caney Creek	1010		69.2				
	Cypress Creek	1009	18.8	80.3	9.3	80.3		10.3
	East Fork San Jacinto River	1003		85.7				
	Greens Bayou Above Tidal	1016	17.4	95.8		85.3		
	Houston Ship Channel	1006	7.6	43.6	3.3	78.2	38.9	21.7
	Houston Ship Channel Buffalo Bayou Tidal	1007	16.7	70.2		83.4	28.7	0.9
	Houston Ship Channel/San Jacinto River Tidal	1005				82.3	100	
	Lake Conroe	1012						4.3
	Lake Creek	1015	40.1	52.2				30.7
	Lake Houston	1002	9.8	9.8		9.8		10.6
	Peach Creek	1011		100				15.4
	San Jacinto River Tidal	1001			31.7		53.2	
	Spring Creek	1008	10.3	76.1		35		11
	West Fork San Jacinto River	1004		60.8	16.6	3.2		16.6
	White Oak Bayou Above Tidal	1017	11.7	87		83.2		
San Jacinto-Brazos Coastal	Armand Bayou Tidal	1113	61.7	69.6	28.6	17	23.4	12.1
	Bastrop Bayou Tidal	1105	31.4	81.7				
	Chocolate Bayou Above Tidal	1108		100				
	Chocolate Bayou Tidal	1107		100	100		100	
	Clear Creek Above Tidal	1102	11.9	78.8		76.1	48.4	13.1
	Clear Creek Tidal	1101	29.1	78	4.7	31.8	29.2	
	Dickinson Bayou Above Tidal	1104		54.5				
	Dickinson Bayou Tidal	1103	86.9	85.2			43.6	
	Old Brazos River Channel Tidal	1111						
	Oyster Creek Above Tidal	1110	96.8	96.8		32.3		96.8
	Oyster Creek Tidal	1109	100	100				
Brazos-Colorado Coastal	Caney Creek Above Tidal	1305	44.6	57.7		57.7		13.9
	Caney Creek Tidal	1304		61	46.8			
	San Bernard River Above Tidal	1302	61.5	68.2		20.9		7.3
	San Bernard River Tidal	1301	100	100				
Bays & Estuaries	Barbours Cut	2436				100	100	
	Bastrop Bay / Oyster Lake +, ++	2433						
	Bayport Ship Channel	2438	100		100	100	100	100
	Black Duck Bay	2428			100	100	100	
	Burnett Bay	2430			69.2	100	100	
	Cedar Lakes +	2442						
	Chocolate Bay	2432	81.6	86.3	13.7		33	
	Christmas Bay	2434						
	Clear Lake	2425	2.4	4.3	58.4	69.6	73.9	45.3
	Drum Bay +, ++	2435						
	East Bay	2423	33.9		75.6		100	
	East Matagorda Bay	2441						
	Lower Galveston Bay	2439			92.8	13.6	92.8	
	Moses Lake	2431	18.5	30.1	52.8		56.8	
	San Jacinto Bay	2427			100	100	100	
	Scott Bay	2429				100	100	
	Tabbs Bay	2426			48.3	48.3	69.5	
	Texas City Ship Channel	2437			100	100	100	
	Trinity Bay	2422	13.3	29.1	72.7	43.9	88.5	
	Upper Galveston Bay	2421		7.1	98.9	57.3	87.9	
	West Bay	2424	10.4	7.4	10.6	5.7	91.1	
	Gulf of Mexico	2501						100

Chart Key

The numbers in the chart represent the percent of total segment length that is impaired or of concern for each parameter.

STABLE

GETTING BETTER

GETTING WORSE

NO TREND ANALYSIS

Severe, multiple water quality impairment(s) or concern(s) exist in a majority of the water body.

Significant, multiple water quality impairment(s) or concerns exist in the water body.

Water quality impairment(s) or concern(s) exist in a substantial portion of the water body.

Water quality impairment(s) or concern(s) exist in the water body.

No significant water quality impairments or concerns exist in the water body.

* Other includes parameters such as high and low pH, water temperature, metals in water, metals in sediment, impaired habitat, impaired benthic macroinvertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissues and fish consumption

** Frog Chart trend analysis differs from the TCEQ Integrated Report 2024 due to an updated period of record (1/1/2017 - 8/31/2024)

\+ This segment was not assessed due to insufficient data

++This segment was not assessed for routine parameters, but was assessed for fecal coliform in Oyster Waters

WATERSHED CHARACTERIZATIONS

The watershed characterization is a type of Basin Highlights Report that characterizes select water bodies within the Houston-Galveston region (Table 2). For this 2025 report, H-GAC has chosen to characterize the Luce Bayou watershed, including Luce Bayou (Segment 1002B) and Tarkington Bayou (Segment 1002A). Watershed characterizations may be used to help prioritize monitoring efforts and in the development of watershed-based plans (such as Total Maximum Daily Loads [TMDLs] or Watershed Protection Plans [WPPs]) to improve water quality.

Table 2. Descriptions of sections that are included in the Watershed Characterization.

Content	Description
Segment Description	A description of the segment, assessment unit (AU) boundaries, and monitoring sites within each segment.
Hydrologic Characteristics	Streamflow variability, reservoir dynamics, seasonality of flow and typical flow trends.
Land Cover and Natural Characteristics	A description of the land surrounding a segment, including developed lands, agricultural lands, forest/shrubs, barren land, open water, and wetlands.
Description of Water Quality Issues	Identification of the reason why the water body is listed as impaired and when it first appeared on the 303(d) List or why it is in an area of interest. This includes the number of samples, parameters of concern or impairment, assessment results, and the designated state water quality standard for comparison.
Potential Sources of Water Quality Issues	Possible sources of water quality issues identified through land use and land cover, watershed surveys, and communications with stakeholders and staff from local and state agencies.
Potential Stakeholders	Governmental agencies (Federal/State/Local), organizations, companies, or individuals that have a vested interest in the area and who may have a representative serve as a stakeholder.
Recommendations for Improving Water Quality	Proposed next steps based on the potential sources of impairment or concern.
Watershed Projects	Current or future projects within the segment (TMDLs, WPPs, special studies, etc.).
Major Watershed Events	Anticipated or known occurrences that have the potential to either positively or negatively affect water quality.
Community Engagement	Public engagement activities within the watershed.
Images of the Watershed	Photographic images of the watershed (monitoring stations, public access, and recreational activities, etc.).
Maps	Maps of stream segments, assessment units, monitoring stations, land use, soils, water quality impairments/concerns, wastewater treatment facility outfalls, sanitary sewer overflows, on-site sewage facilities, and other areas of interest.

ADDITIONAL INFORMATION

For more information, including a list of acronyms, a glossary of water quality terminology, a technical primer, and information regarding the statistical methodology used for H-GAC's water quality analyses presented in this report, please refer to the appendices. For more information on H-GAC's Clean Rivers Program, please visit: https://www.h-gac.com/clean-rivers-program

THE LUCE BAYOU WATERSHED

WATERSHED OVERVIEW

The Luce Bayou watershed covers 206 square miles of rural and developing areas within Harris, Liberty, and San Jacinto Counties (Figure 3). The watershed inhabits the southern extent of the Pineywoods Ecoregion (TPWD, 2025), includes a portion of the Sam Houston National Forest (SHNF), and much of the watershed is used as managed timberland. The City of Cleveland is the largest city within the watershed. Like much of the outer Houston Region, the watershed is in transition with new roads, including the completion of State Highway 99/the Grand Parkway, serving a growing population and new subdivisions. The western portion of the watershed has seen the largest increase in suburban development, particularly within unincorporated Liberty County.

Streams and tributaries within the Luce Bayou watershed face potential water quality challenges like many Houston area waterways including contact recreation impairments due to elevated pathogen indicator bacteria concentrations. Depressed dissolved oxygen levels and elevated nutrient concentrations impede the waterway's ability to support its designated uses. This Watershed Characterization Report addresses the following unclassified segments that comprise the Luce Bayou Watershed: Tarkington Bayou (1002A) and Luce Bayou (1002B).

Tarkington Bayou, 1002A, is likely named for Burton B. Tarkington, a settler during the time of Texas Independence (Anderson, 2024). The bayou begins within the Double Lake Recreation Area of the SHNF near Farm to Market (FM) Road 2025 (TSHA, 1995a), about 3.96 kilometers (km) south of the City of Cold Springs, San Jacinto County. The bayou meanders southeastward through the managed forest before flowing to the south while entering Liberty County, northeast of the City of Cleveland. Here, Tarkington Bayou exits SHNF and enters a watershed where rural land uses are dominated by pastures and fields. However, the riparian areas and adjacent uplands along the bayou are timbered by hardwoods, pines, and cypress, much of which is owned by timber interests. The 40.5 km stream ends at the confluence with Luce Bayou, at the point where the western side of the watershed has seen recent expansive suburban development within the unincorporated portions of Liberty County. Marsh Branch, a major tributary that joins Tarkington Bayou south of Cleveland, drains the watershed's eastern side that is composed mostly of wetlands and rural land uses, with a few dispersed large acreage subdivisions.

Luce Bayou, 1002B, begins as an intermittent stream near FM Road 1008, about 15.6 km north of the City of Dayton, Liberty County. The bayou's name has been attributed to a runaway slave (TSHA, 1995b). From its headwaters, the bayou flows generally westward. The watercourse and surrounding watershed mostly consist of managed forest lands owned by timber interests, with the riparian areas made up of hardwood, pine, and cypress trees. There are some large acreage rural subdivisions located within the watershed interspersed with fields and pastures. The confluence with Tarkington Bayou occurs near the midpoint of the stream's 21.43 km course, at which point it turns south westward. Luce Bayou ends just after entering Harris County at Lake Houston, the principle public water supply for the City of Houston and other regional cities. Camp Branch and Long Branch are additional named tributaries to Luce Bayou. The Luce Bayou Diversion Project, proposed in the

1970s, originally considered using Luce Bayou as a conveyance feature, following modifications, to conduct an interbasin transfer of water from the Trinity River basin into the San Jacinto River basin (TSHA, 1995b). While the project was eventually completed, the route was revised and did not include Luce Bayou. This project is reviewed in the subsequent Major Watershed Events section.

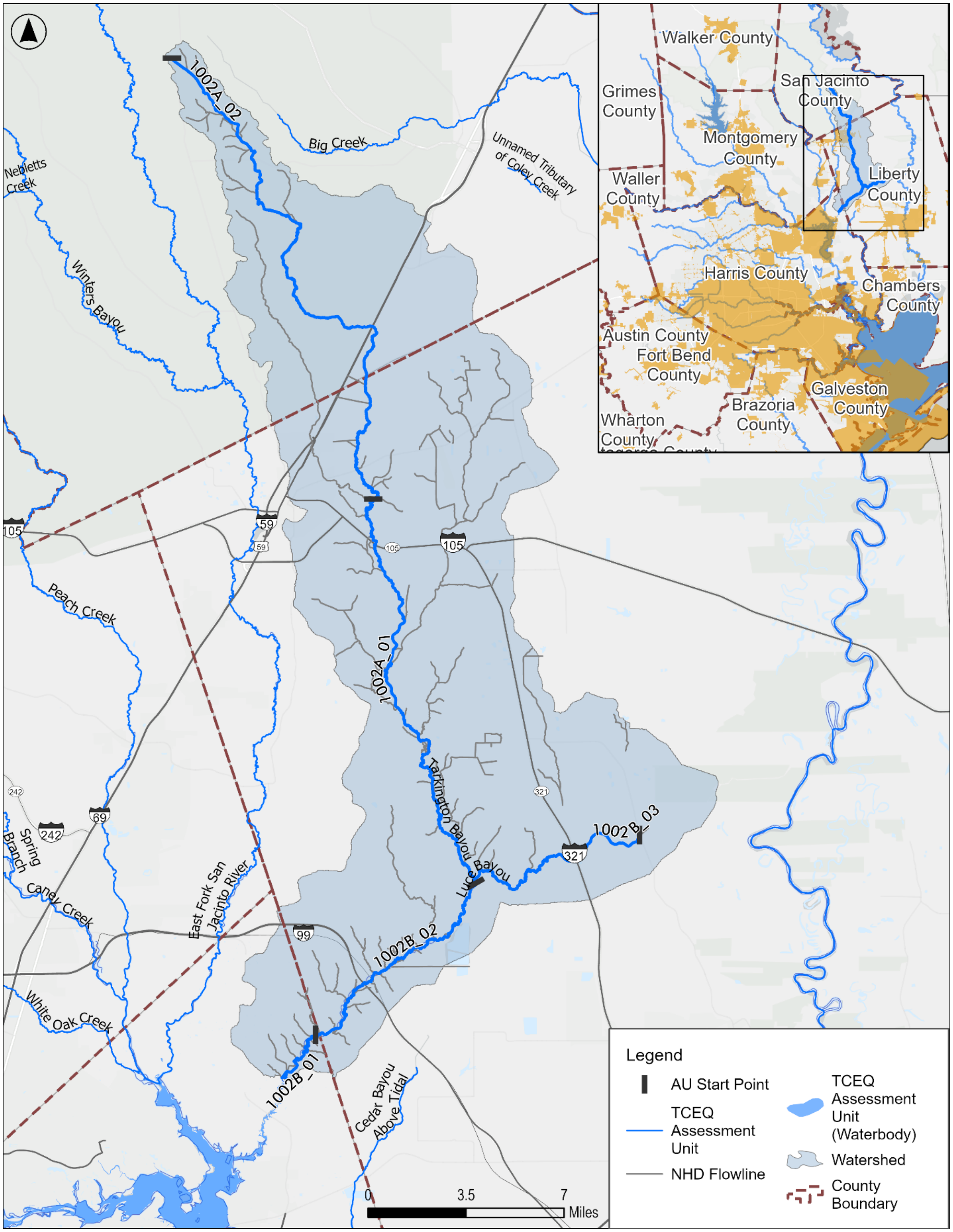


Figure 3. Luce Bayou Watershed Boundary and Location

HYDROLOGIC CHARACTERISTICS

The unclassified segments 1002A and 1002B are freshwater tributaries to Lake Houston, Segment 1002. All assessment units in these segments have perennial flow except for the most upstream extents of 1002A_02 and 1002B_03, which serve as their waterbody's respective headwaters and primarily exist as intermittent streams with pools.

Instantaneous discharge readings (collected in cubic feet per second [cfs]) vary by assessment unit. In summary, instantaneous discharge collected during routine monitoring at sites on Tarkington Bayou (1002A) range from <0.01 to 15.0 cfs (n = 27) and on Luce Bayou (1002B) range from 0.7 to 198 cfs (n = 3) under "normal" flow severity conditions (Figure 4 and Figure 5). Fourteen percent (28.9 mi^2) of the total Luce Bayou Watershed is in the 100-year floodplain, 8.7% (18.0 mi^2) is in the 500-year floodplain, and 6.0% (12.3 mi^2) is in the regulatory floodway (Figure 6).

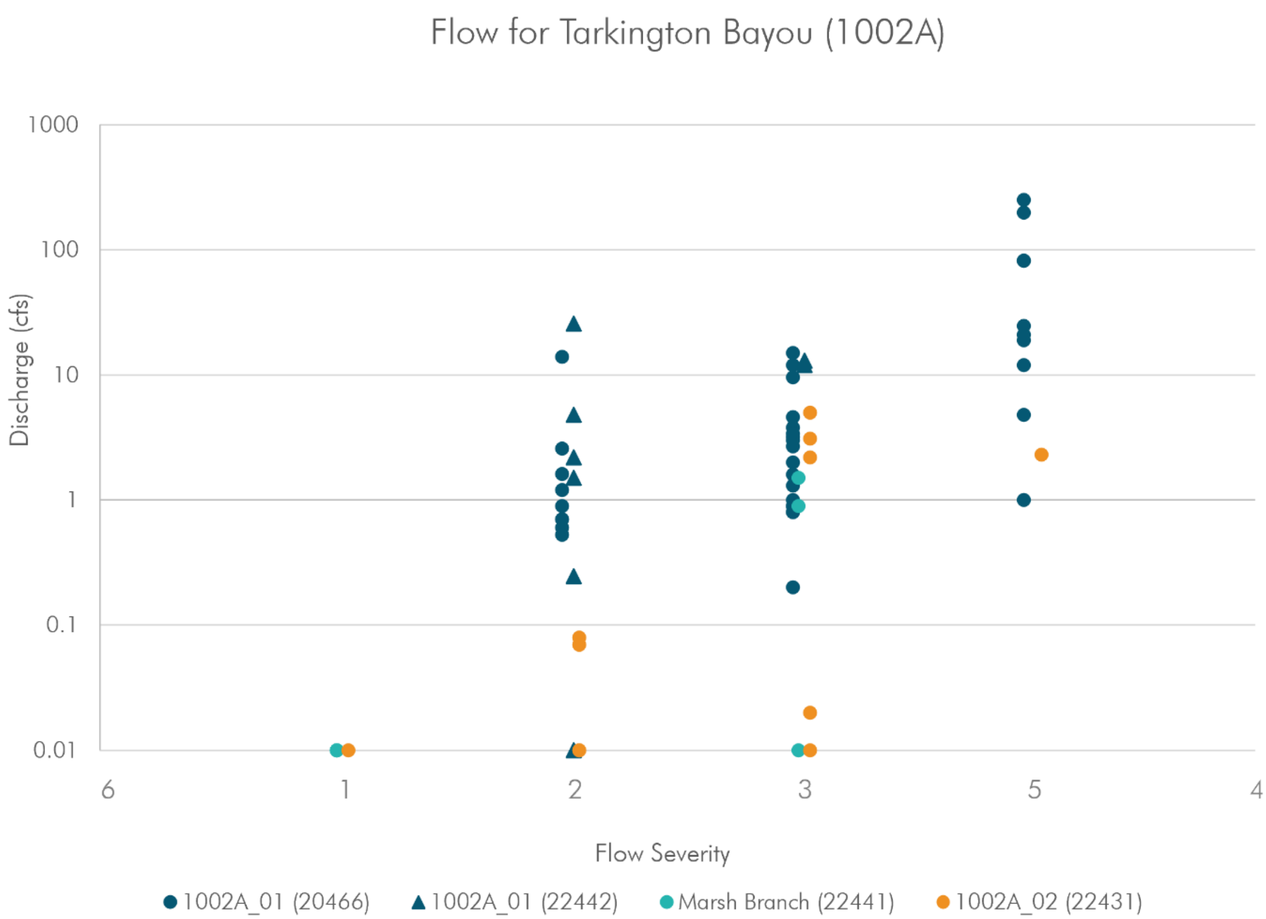


Figure 4. Instantaneous discharge (cfs = cubic feet per second) and flow severity recorded at routine monitoring events (collected between 2/9/2017 and 12/18/2024) by assessment unit (and monitoring station). Flow severity: 6 = dry, 1 = no flow, 2 = low, 3 = normal, 5 = high, 4 = flood.

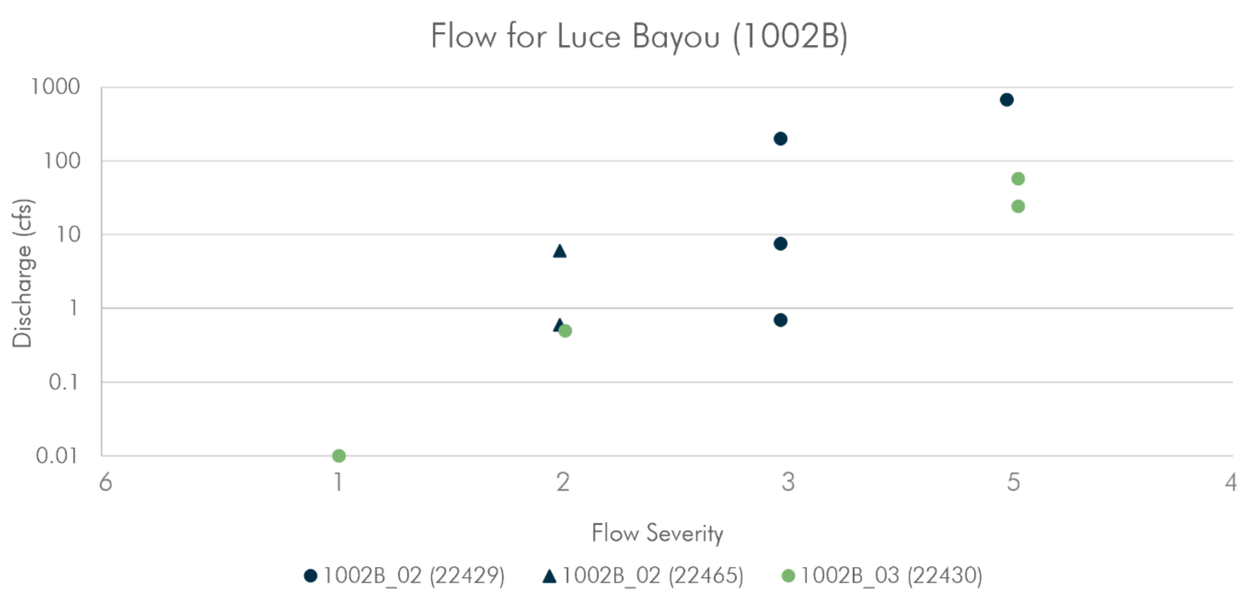


Figure 5. Instantaneous discharge (cfs = cubic feet per second) and flow severity recorded at routine monitoring events (collected between 10/03/2023 and 12/17/2024) by assessment unit (and monitoring station). Flow severity: 6 = dry, 1 = no flow, 2 = low, 3 = normal, 5 = high, 4 = flood.

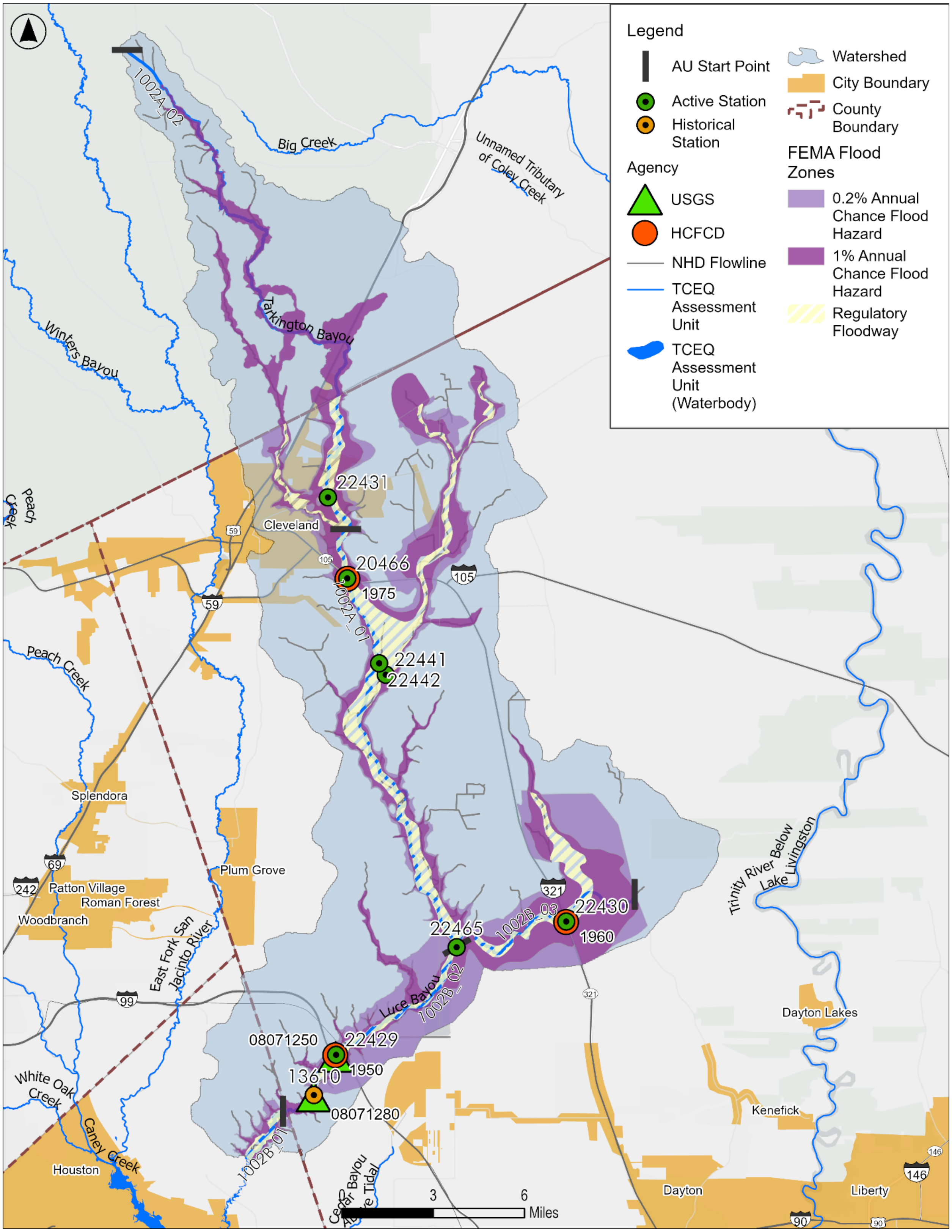


Figure 6. Hydrologic features of the Luce Bayou Watershed including floodplains. Source: FEMA flood plain maps. Flood Data Viewers and Geospatial Data | FEMA.gov (FEMA, 2025).

STREAM FLOW GAGES

There are two U.S. Geological Survey (USGS) and three Harris County Flood Control District (HCFCD) stream gages in this watershed (Table 3 and Figure 6). The USGS site (08071280) at Luce Bayou above Lake Houston near Huffman, TX was discontinued in September, 2022 and a new site (08071250) was installed approximately 2 km (direct line) upstream.

Hydrographs depicting the measured stream elevation and the stream elevation where flooding is likely for each of the HCFCD stations for the past ten years (or the period of record, if less than 10 years is available) are displayed in Figure 7 through Figure 9. Hydrographs depicting the gage height and discharge for each of the USGS stations are displayed in Figure 10 and Figure 11. At the HCFCD site 1975, located near the most upstream extent of AU 1002A_01, in the period of record the stream elevation has averaged 122 feet (ft), ranging between 121 and 130 ft, and has never risen beyond the "flooding likely" elevation of 132.5 ft (Figure 7). The HCFCD site 1960, located in the Luce Bayou AU 10002B_03, had an average stream elevation of 87 ft (ranging between 86 and 96 ft) and has never risen beyond the "flooding likely" elevation of 97 ft in the past four years (Figure 8). Finally, HCFCD site 1950, near the downstream end of the Luce Bayou AU 1002B_02 had an averaged stream elevation of 56 ft (ranging between 53 and 74 ft) and has risen beyond the "flooding likely" elevation of 70.5 ft one time in the past two years (Figure 9).

*Table 3. Gage Stations in the Luce Bayou Watershed. * Period of record differs by parameter.*

Entity	Gage Station ID	Site Description	Period of Record	Parameters
HCFCD	1975	Tarkington Bayou @ SH 105	2/12/2020 - Present	Stream elevation & rainfall
HCFCD	1960	Luce Bayou @ SH 321	2/7/2022 - Present	Stream elevation & rainfall
HCFCD	1950	Luce Bayou @ SH 99	10/27/2009 - Present	Stream elevation & rainfall
USGS	08071280	Luce Bayou above Lake Houston near Huffman, TX	8/1/1996 – 9/21/2022	Discharge & gage height *
USGS	08071250	Luce Bayou at SH-99 near Huffman, TX	9/22/2022 - Present	Discharge & gage height

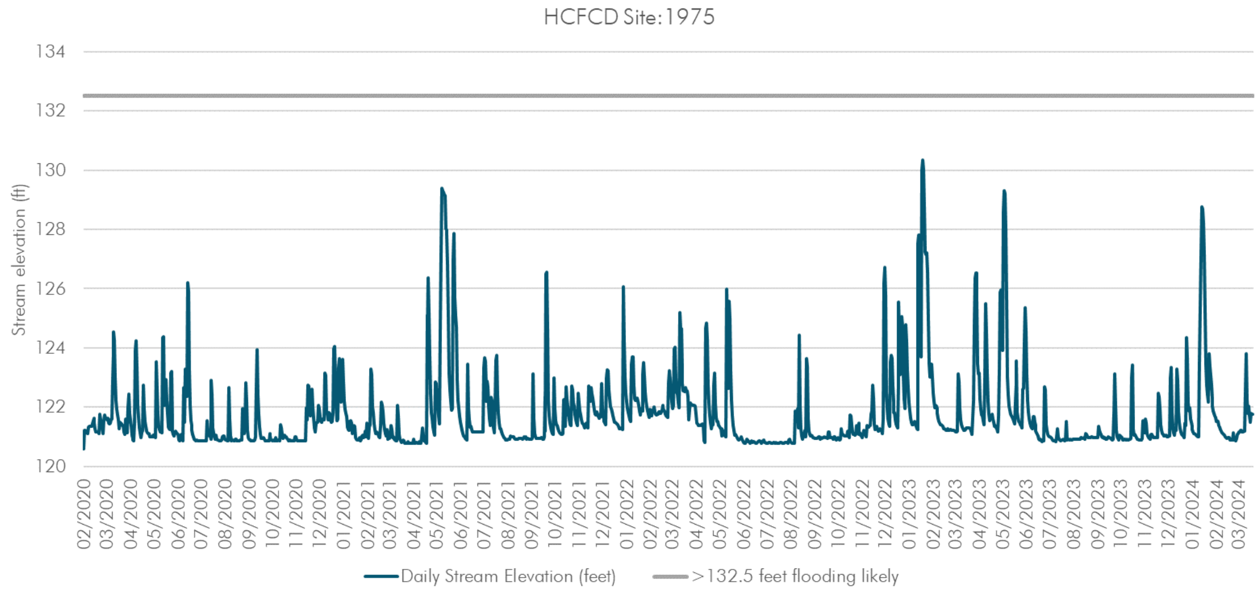


Figure 7. Stream elevation (ft) for HCFCD site 1975 at Tarkington Bayou at SH 105 for the available period of record. The grey line is the stream elevation where flooding is likely for this site (132.5 ft).

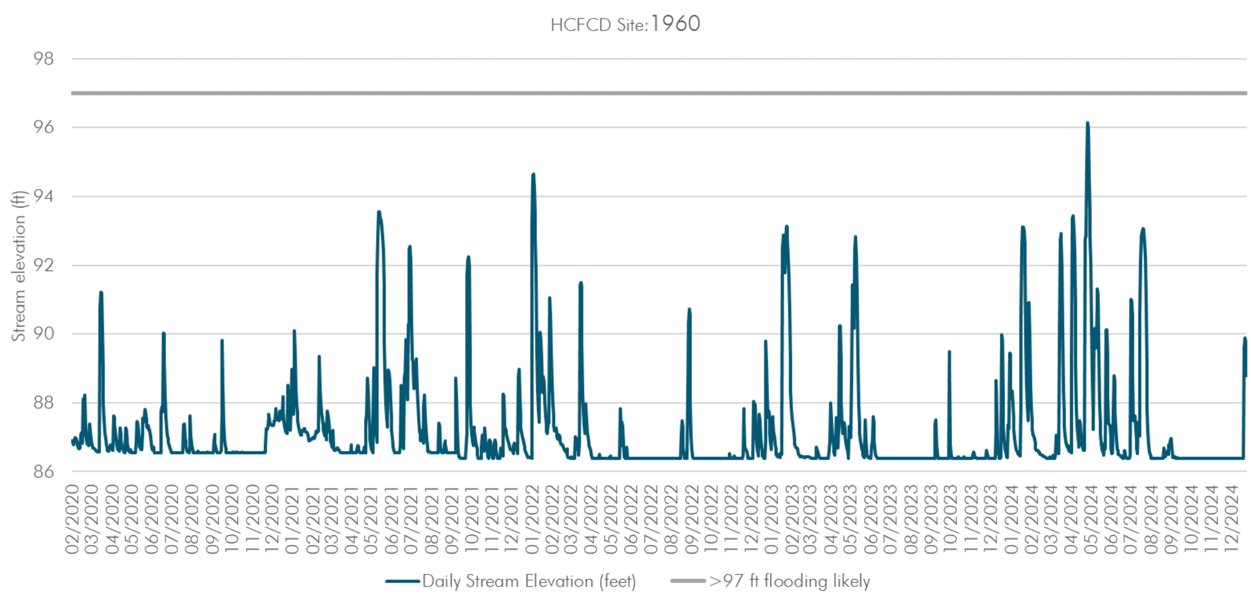


Figure 8. Stream elevation (ft) for HCFCD site 1960 at Luce Bayou at SH321 for the available period of record. Grey line is the stream elevation where flooding is likely for this site (97 ft).

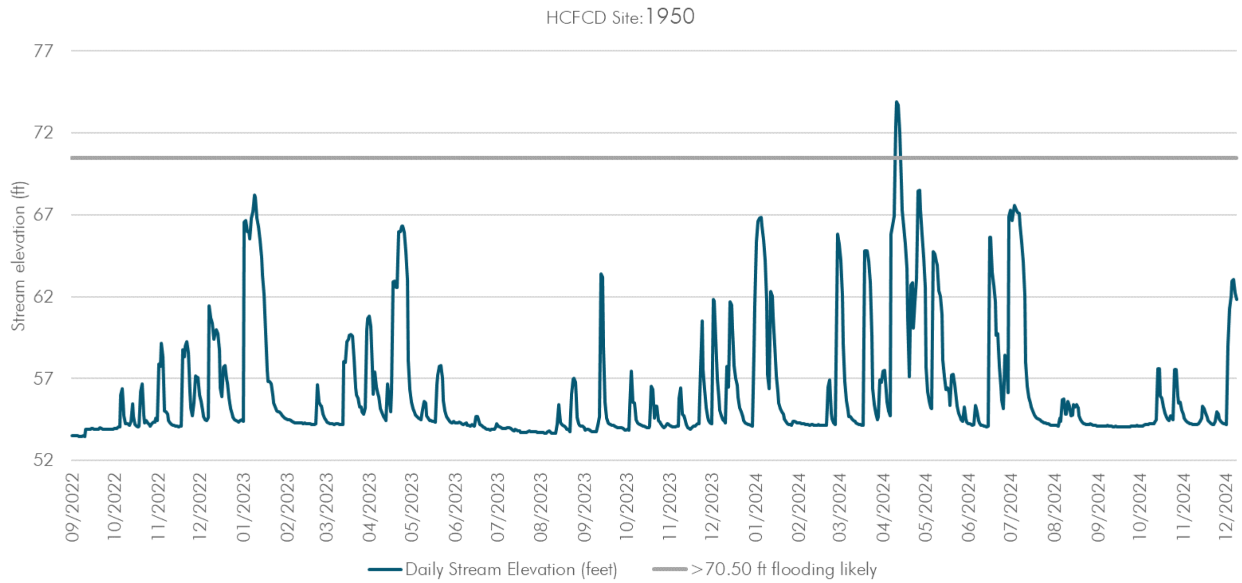


Figure 9. Stream elevation (ft) for HCFCD site 1950 at Luce Bayou at SH 99 for the available period of record. Grey line is the stream elevation where flooding is likely for this site (70.5 ft).

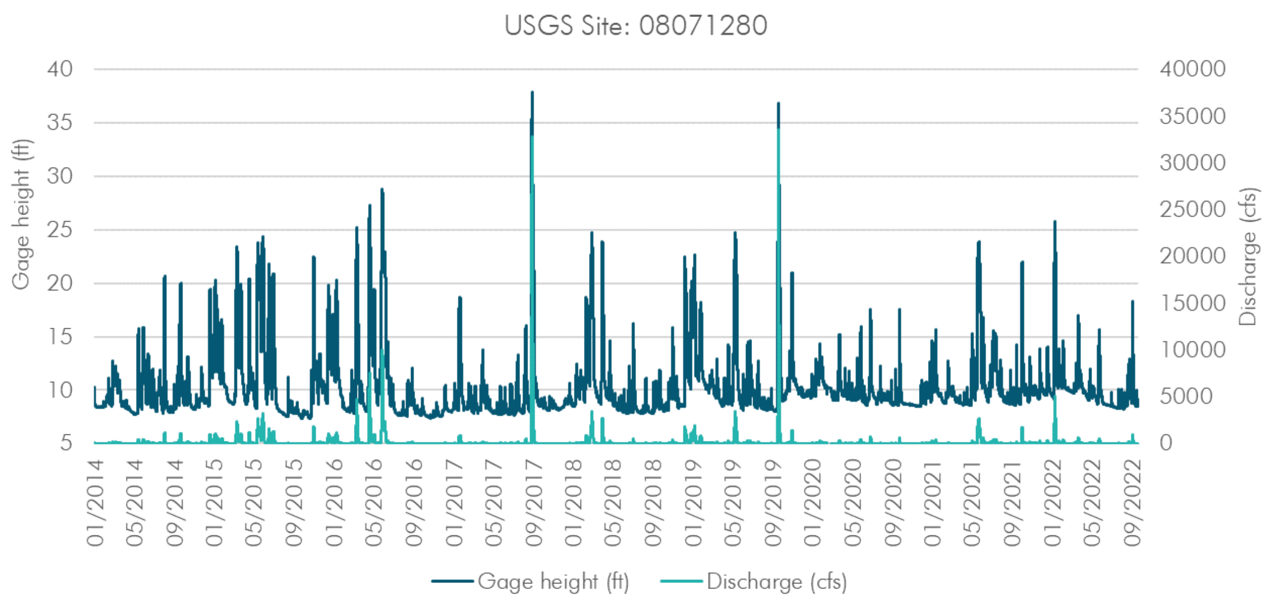


Figure 10. Gage height (ft) and discharge (cfs) for USGS site 08071280 at Luce Bayou above Lake Houston for the period of 01/01/2014 through 09/21/2022.

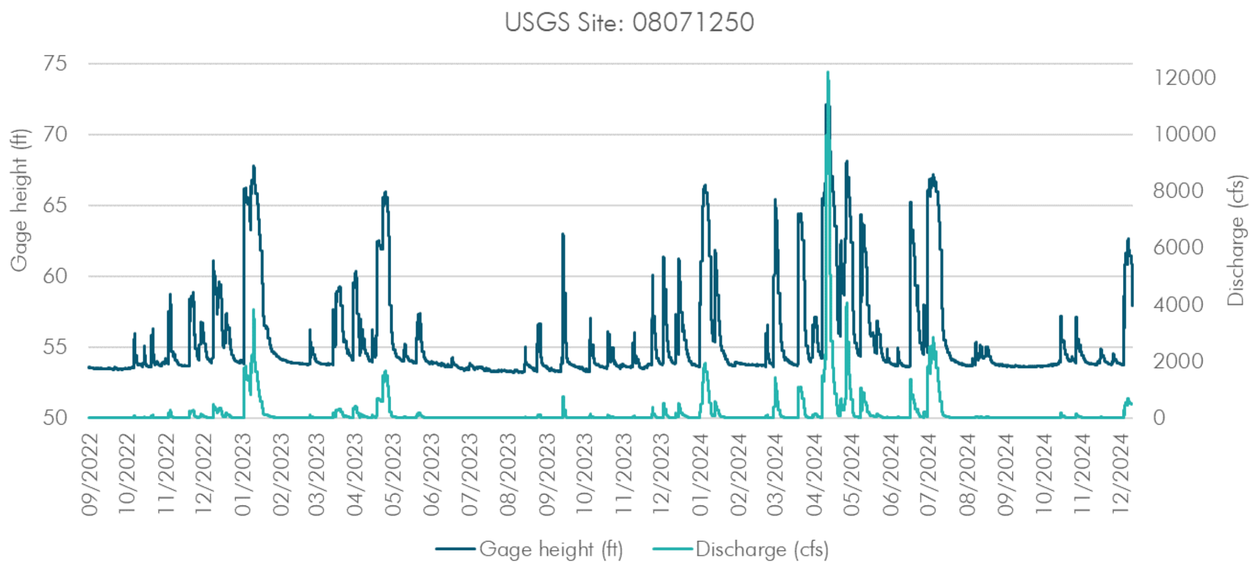


Figure 11. Gage height (ft) and discharge (cfs) for USGS site 08071250 at Luce Bayou at SH 99 for the available period of record (09/22/2022 through 01/01/2025).

PRECIPITATION

Precipitation is one of the primary factors affecting stream flow in the Luce Bayou watershed. During rainfall events, water runoff from the surrounding land flows into the bayou. This runoff results in a rise in the water level and increased flow, which can lead to flooding in low-lying areas adjacent to the bayou. Seasonal changes and the movement of storm systems largely control the amount and timing of precipitation.

There is one National Weather Service weather station located in Cleveland, TX within the Luce Bayou watershed (Table 4, NOAA, 2025). This weather station moved locations in 2014 but between the two locations there is consistent precipitation and temperature data from 2004 through the present. The average annual rainfall recorded in Cleveland, TX over the past 20 years is 63.6 inches/year (Figure 12). The month of May has seen the highest average rainfall of 7.8 inches/month which is elevated because of two years (2015 and 2021) with nearly 20 inches of rain for the month of May.

Table 4. National Weather Service Rain Gage Stations in the Luce Bayou Watershed.

Rain Gage ID	Site Description	Latitude, Longitude	Data Date Range
GHCND:USC00411810	Cleveland, TX	30.3637, -95.0840	6/1/1954-4/5/2018
WBAN:00378	Cleveland (NWS/FAA)	30.3560, -95.0083	7/31/2014-Present

Source: https://www.ncdc.noaa.gov/cdo-web/

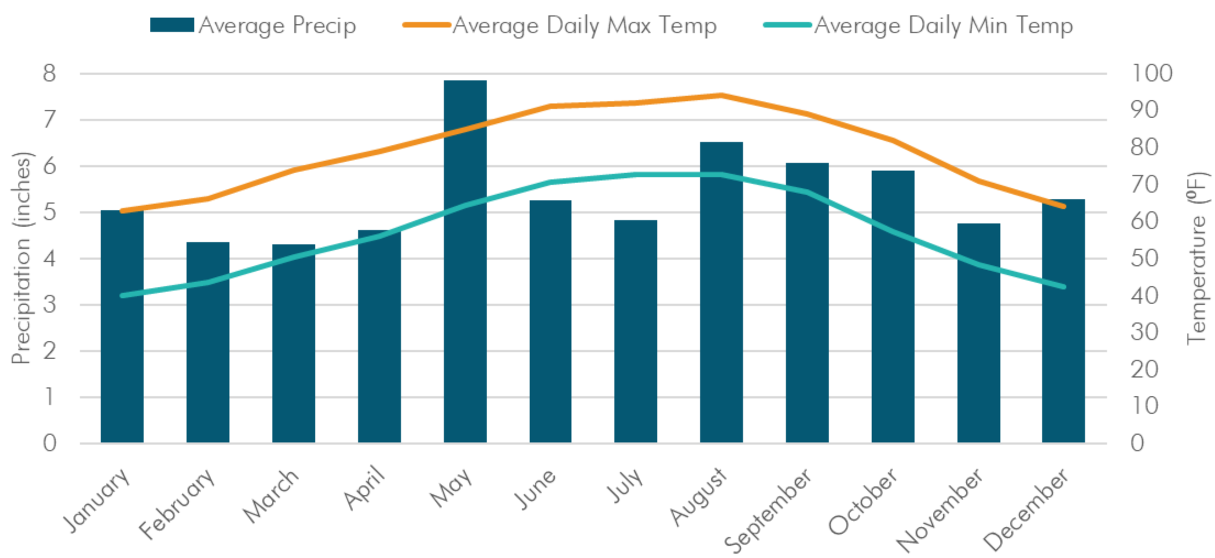


Figure 12. Average precipitation in inches, and average daily minimum and maximum air temperature by month from 2004 – 2024 at Cleveland, TX Weather Stations (corresponds with Table 4). Source: https://www.ncdc.noaa.gov/cdo-web/

HYDROLOGIC SOIL GROUPS

The most prevalent soil types in the Luce Bayou watershed area are clay, sandy loam, and clay loam soils (Table 5). The predominant hydrologic soil groups in the segment are D (31.05%), B/D (27.76%), and C/D (25.86%). All three of these soil groups are characterized as having very slow infiltration rates and high runoff potential. This runoff can contribute to nonpoint sources of bacteria and nutrients entering the waterways. It can also result in more flashy water levels within the bayou following rain events.

Table 5. Hydrologic Soil Groups by Area in the Luce Bayou Watershed. Corresponds with Figure 13.

Hydrologic Soil Group	Soil Texture Class	Typical Soil Composition	Infiltration Rate	Runoff Potential	Area Square Miles	Area %
A	Sand	<10% clay, >90% sand or gravel	High	Low	11.95	5.79
B	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Moderate	Moderately Low	11.52	5.59
C	Clay loam. Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Slow	Moderately High	8.15	3.95
D	Clay, Silty clay, Sandy clay	>40% clay, <50% sand	Very Slow	High	64.03	31.05
A/D	Sand	<10% clay, >90% sand or gravel	Very Slow (High if drained)	High (Low if drained)	–	–
B/D	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Very Slow (Moderate if drained)	High (Moderate if drained)	57.24	27.76
C/D	Clay loam, Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Very Slow (Slow if drained)	High	53.34	25.86
				TOTAL	206	100

Source: Natural Resources Conservation Service at https://www.nrcs.usda.gov/

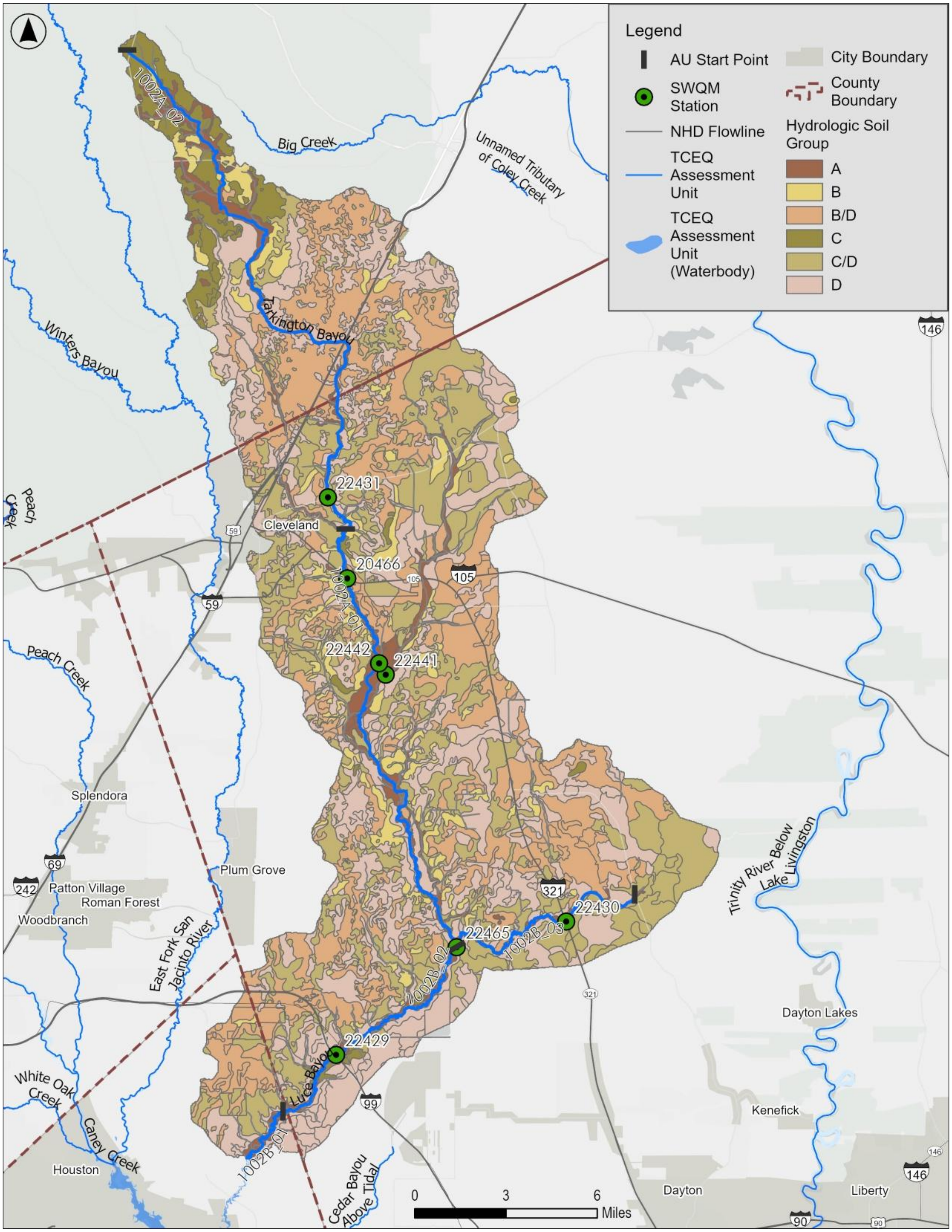


Figure 13. Hydrologic Soil Groups in the Luce Bayou Watershed. Corresponds with Table 5.

LAND COVER AND NATURAL CHARACTERISTICS

H-GAC prepares land cover assessments for the region, with the most recent completed in 2022 from 2022 aerial imagery (H-GAC, 2022a). The Luce Bayou watershed was classified into ten land cover classes. The watershed can be classified as generally rural with only 18.5% of the watershed developed (Table 6). The developed areas can be described as mostly Open Space Intensity at 23.8 square miles (mi^2) or 11.5%. The remaining developed areas in descending order of size are Low Intensity, Medium Intensity, and High Intensity at 5.0%, 1.6% and 0.4%, respectively. Developed areas are predominately found in the western side of the watershed, particularly in Liberty County (Figure 14).

The dominant non-developed land use and largest land cover category is Forest/Shrub at 99.4 mi^2 or 48.2%. Most of the forested areas can be found in San Jacinto County and along the riparian corridor of the streams. The second largest land cover category is Wetlands at 19.3%. Wetlands are found predominantly adjacent to the bayous and their tributaries. Agricultural land area is estimated at 28.0 mi^2 or 13.6% of the watershed between Pasture/Grasslands and Croplands.

Table 6. Land Use and Land Cover for the Luce Bayou Watershed. Corresponds with Figure 14.

Land Cover Class[1]	Land Cover Description	Area mi^2	Area %
Barren Land	Barren lands and unconsolidated shore land areas	0.09	0.04
Cropland	Areas intensely managed to produce annual crops. Crop vegetation accounts for greater than 20% of total vegetation or actively tilled.	0.92	0.45
Developed, High Intensity	Contains significant land area that is covered by concrete, asphalt, and other constructed materials. Vegetation, if present, occupies < 20% of the landscape.	0.83	0.40
Developed, Low Intensity	Contains areas with a mixture of constructed materials and substantial amounts of vegetation or other cover. Constructed materials account for 21% to 49% of total area.	10.30	5.00
Developed, Medium Intensity	Contains area with mixture of constructed materials and vegetation or other cover. Constructed materials account for 50% to 79% of the total area.	3.30	1.60
Developed, Open Space	Contains areas with a mixture of some constructed materials, but mostly managed grasses or low-lying vegetation planted in developed areas for recreation, erosion control, or aesthetic purposes.	23.80	11.54
Forest/Shrub	Composite class that contains all three forest land types (deciduous, evergreen, and mixed forest) and shrub lands.	99.40	48.21
Open Water	Composite class that contains open water and both palustrine and estuarine aquatic beds.	0.63	0.31
Pasture/ Grassland	Composite class that contains both Pasture/Hay lands and Grassland/Herbaceous	27.10	13.14
Wetlands	Composite class that contains all the palustrine and estuarine wetland land types.	39.80	19.30
	TOTAL	**206**	**100**

[1] Source: 2022 15 County 15 Class | H-GAC Regional GIS Data Hub

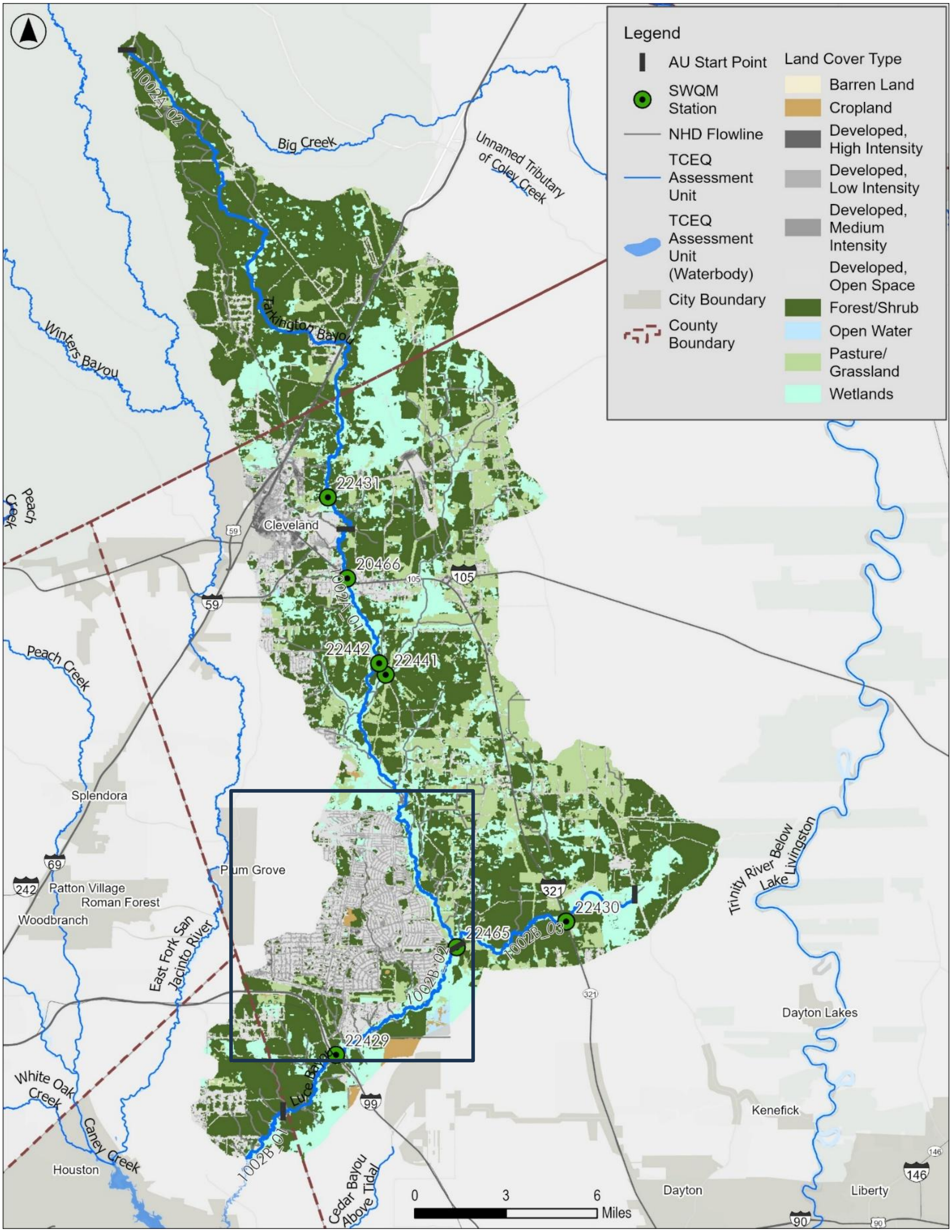


Figure 14. Land Use and Land Cover for the Luce Bayou Watershed. Corresponds with Table 6. Black box indicates portion of watershed that is highlighted in Figure 15 for the development within the watershed.

POPULATION

H-GAC estimated the 2022 population for the Luce Bayou watershed to be 27,284, an increase of 5,402 (125%) since 2010 (Table 7) (H-GAC, 2022b; Texas Demographic Center, 2022). The number of households within the watershed was 11,151 in 2022. The watershed, like most watersheds in the H-GAC region, will likely experience continued growth over the next few decades. By 2050, H-GAC estimates the population will increase to 77,558 for a net growth rate of 184.26% between 2022 and 2050. The percentage of the population in the Luce Bayou watershed that is in poverty as of 2023 is 18.6% which is higher than the national average of 11.1% for the same year (Shrider, 2024). Over 50% of the population in the Luce Bayou watershed are Hispanic minorities with 10.6% having limited English language proficiency.

Table 7. Population for the Luce Bayou Watershed.

Watershed	2010		2022		2050 (projected)		% Projected Population Change (2022-2050)[1]
	Population	Household	Population	Household	Population[1]	Household	
Luce Bayou	21,882	7,803	27,284	11,151	77,558	30,381	184.26%

[1]Sources: H-GAC's Regional Growth Forecast (watershed area except for San Jacinto County) (https://www.h-gac.com/regional-growth-forecast). San Jacinto County's projections are from the Texas Demographic Center's 2022 population datasets (https://demographics.texas.gov/Projections/2022/)

MAJOR WATERSHED EVENTS

DEVELOPMENT

The Luce Bayou watershed, along with watersheds in Southeast Texas, saw a landowner transition in the 1980s from paper mill companies toward passive privately owned retirement investment interests (Kiella, 2020). Much of the acreage in Luce Bayou is still owned by these retirement interests, but with the 2008 recession, many parcels were sold off due to depressed lumber prices and increased development pressure and land speculation. Those timber investment companies that remain have had to optimize production while removing wasteful practices and increasing outputs.

One area within the Luce Bayou watershed has experienced rapid development in the past ten years. Colony Ridge is a collection of subdivisions in unincorporated Liberty County and is located on the western side of the Tarkington and Luce bayous (Figure 14). As observed in aerial images, initial development began in 2013, and within 10 years over 25 square miles was converted from forest/shrub, pasture/grassland, and wetlands to primarily low and medium intensity developed land cover (Figure 15).

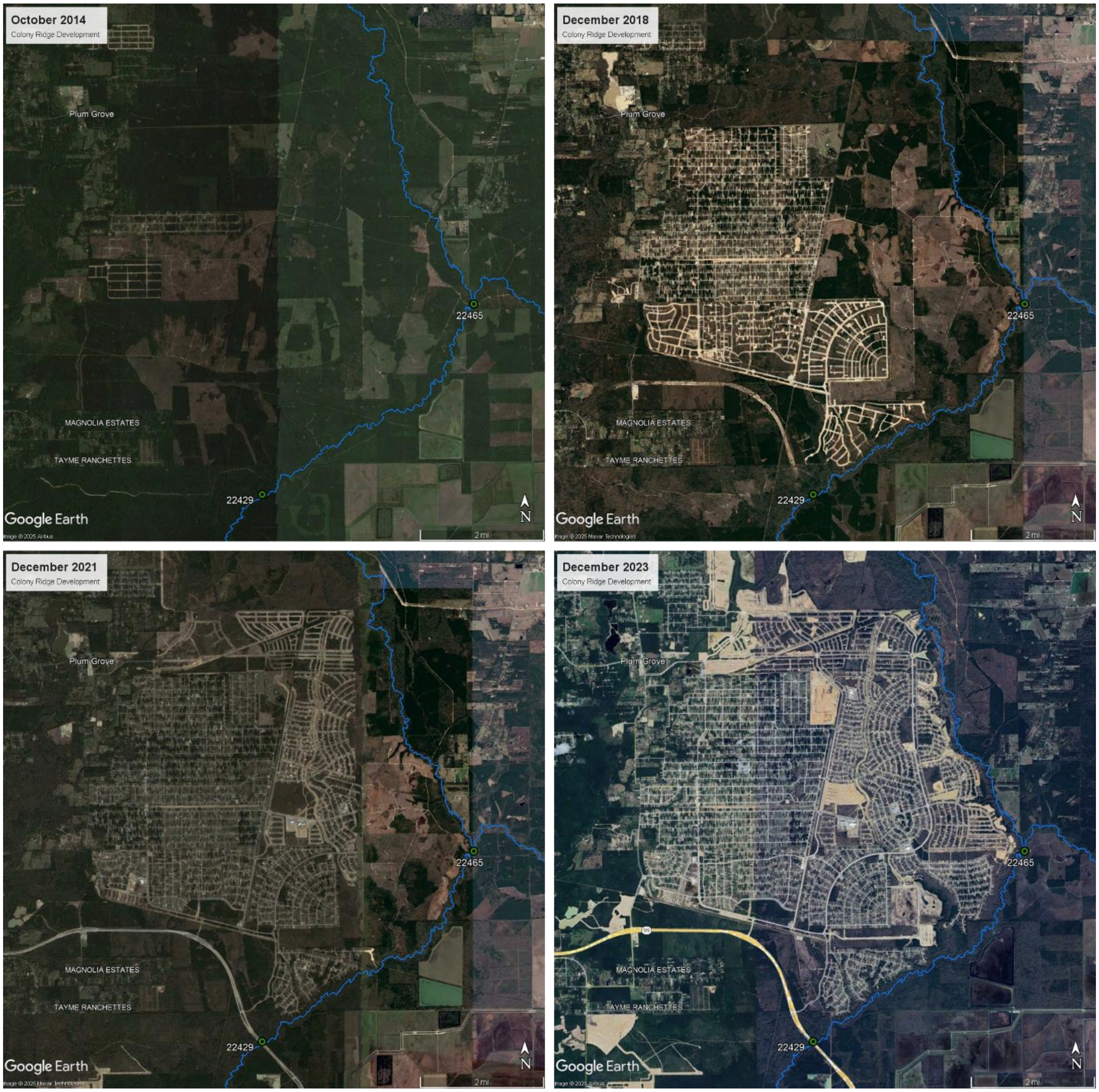


Figure 15. Aerial imagery of the Colony Ridge development from October 2014 to December 2023.

INTERBASIN TRANSFER OF WATER – DRINKING WATER

As the Houston metropolitan area continues its rapid development, the need for clean drinking water also continues to climb. Due to subsidence, over the last several decades, drinking water production has transitioned from water wells pumping groundwater, to utilizing surface water from rivers and streams. The largest sources of surface water for the City of Houston and the surrounding area are Lake Houston, Lake Conroe, and Lake Livingston. These reservoirs store water that the City of Houston is permitted to use to produce drinking water for the region.

As a result of the region's growing need for more drinking water, the City of Houston needed to expand its production capacity. In 2009 the City signed a contract authorizing the Coastal Water Authority to design and construct the infrastructure needed to transfer the City of Houston's permitted water (500 million gallons per day [MGD]) from the Trinity River to Lake Houston. This project is known as the Luce Bayou Interbasin Transfer Project. The project is funded through a consortium of partners that supply water to the greater Houston Region and include the City of Houston, Coastal Water Authority, North Harris Regional Water Authority, Central Harris Regional Water Authority, West Harris County Regional Water Authority and the North Fort Bend Water Authority. The project begins at the Trinity River and flows southwest and empties into the area where Luce Bayou and Lake Houston meet, below the Luce Bayou Watershed as covered by this basin highlights report (Figure 16). This $381 million water supply project is the largest built in in Southeast Texas in the last 50 years. It consists of a 500 MGD pump station that pulls water from the Trinity River and transfers it to Lake Houston through three miles of dual 96" pipe and over 23 miles of earthen canal. The canal system includes a sedimentation basin, water level control gates, 12 bridges, and 22 inverted siphons.

SEGMENT CHARACTERIZATION:1002A – TARKINGTON BAYOU AND 1002B – LUCE BAYOU

The CRP, until recently, maintained only one active monitoring station within the Luce Bayou watershed. This has limited past assessments of the watershed to only Tarkington Bayou AU 1002A_01. Since 2022, the TCEQ and CRP have increased the number of monitoring sites within the watershed to increase temporal and spatial data availability and to better understand the extent of any impairments or concerns. We are presenting information for both segments herein and summarizing available historic and recent data for all Luce and Tarkington AUs. It should be noted that in some instances the data may not be ready for public release through SWQMIS but it is anticipated that all presented data will be accessible by the time of this report's publication or shortly thereafter. These data are provisional and may be subject to revision or exclusion from SWQMIS. This expanded data set is presented in the sections below to provide a greater sense of the water quality for the entire watershed. Any limitations to the data, such as size of the data set, will be explored, specifically in relation to any result summations or conclusions presented.

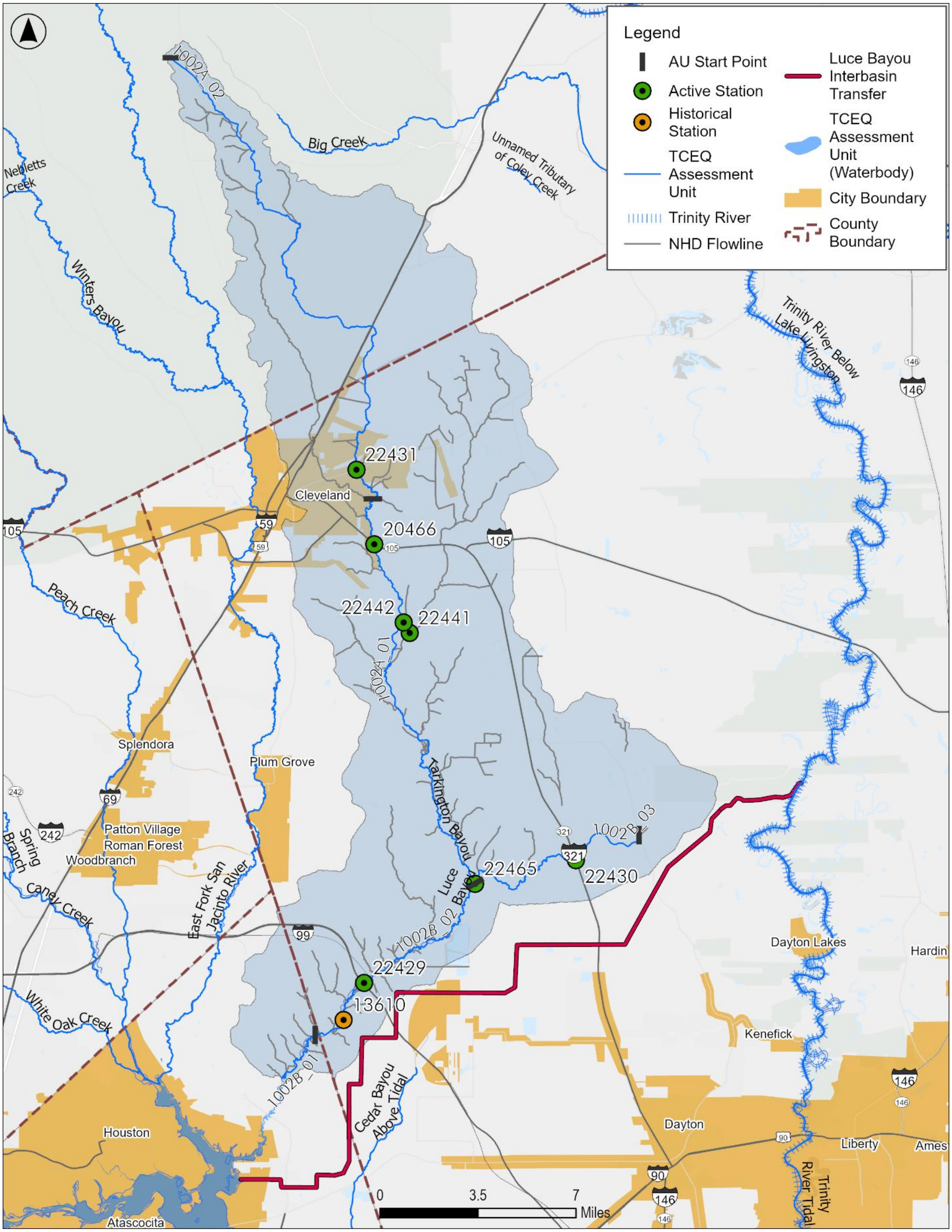


Figure 16. Map indicating the path of the interbasin transfer of water and the drinking water source (Lake Houston).

SEGMENT DESCRIPTIONS

Tarkington Bayou (Segment 1002A) is approximately 40.5 miles long and flows into Luce Bayou (Segment 1002B) which is approximately 22 miles long. There are a total of two AUs with active monitoring stations on the Tarkington Bayou segment. There are three AUs, two of which have active monitoring stations, on the Luce Bayou segment (Table 8, Table 9, and Figure 17). Figure 18 through Figure 24 are photos of each of the monitoring stations.

Table 8. Assessment Unit Descriptions for Segment 1002A – Tarkington Bayou and 1002B – Luce Bayou.

Segment ID	Segment Name	AU ID	AU Description	AU Length (mi)
1002A	Tarkington Bayou	1002A_01	From the Luce Bayou confluence upstream to the Little Tarkington Bayou confluence near the City of Cleveland	17.9
		1002A_02	From the Little Tarkington Bayou confluence to just upstream of FM 2025	22.6
1002B	Luce Bayou	1002B_01	From the Lake Houston confluence upstream to the Key Gully confluence	2.89
		1002B_02	From the Key Gully confluence upstream to the Tarkington Bayou confluence	10.0
		1002B_03	From the Tarkington Bayou confluence upstream to FM 1008	8.54

There are a total of four active monitoring stations in the FY 2025 Coordinated Monitoring Schedule for the Luce Bayou watershed. The submitting and collecting entities, the monitoring type (i.e., routine, biased, etc.), the number of monitoring events per year, and the parameter groups collected are presented in Table 9. In addition, there are three monitoring stations associated with an active total maximum daily load (TMDL) study occurring in the watershed. Two of the active CRP stations, 20466 and 22431, are also being visited as part of the TMDL study to increase the number of temporal data available in conjunction with the bacteria impairment for 1002A_01. Data collection in association with the study is expected to end in 2026.

Table 9. FY 2025 active monitoring stations in the Luce Bayou Watershed. Sites sampled by the Clean Rivers Program (CRP) or Total Maximum Daily Load (TMDL).

Monitoring Type	Segment ID	Assessment Unit (AU)	Station ID	Station Description	SE[2]	CE[3]	MT[4]	Scheduled Monitoring Events Per Year			
								Field	Conv.	Bact.	Flow
CRP[1]/TMDL	1002A	1002A_02	22431	TARKINGTON BAYOU AT FM 787 APPROXIMATELY 1.9 KM EAST OF CAMPBELL ST IN CLEVELAND TX	HG	TF	RT	4/8	4/8	4/8	4/8
CRP/TMDL	1002A	1002A_01	20466	TARKINGTON BAYOU AT SH 105/SH 321 SOUTHEAST OF CLEVELAND	HG	TF	RT	4/8	4/8	4/8	4/8
TMDL	1002A	1002A_01	22442	TARKINGTON BAYOU AT CR 331 4.1 KM SOUTH AND 4.0 KM EAST OF CLEVELAND	HG	TF	RT	12	12	12	12
TMDL	1002A	N/A	22441	MARSH BRANCH STREAM AT CR 331 4.6 KM SOUTH AND 4.3 KM EAST OF CLEVELAND	HG	TF	RT	12	12	12	12
CRP	1002B	1002B_03	22430	LUCE BAYOU AT SH 321 APPROXIMATELY 1.1 KM SOUTH OF COUNTY ROAD 2232	HG	HG	RT	4	4	4	4
TMDL	1002B	1002B_02	22465	LUCE BAYOU 20 M UPSTREAM OF THE WOODEN BRIDGE AT AN UNNAMED COUNTY ROAD 0.54 KM EAST OF ROAD 3540 AND 0.3 KM DOWNSTREAM OF THE CONFLUENCE OF TARKINGTON BAYOU AND LUCE BAYOU	HG	TF	RT	12	12	12	12
CRP	1002B	1002B_02	22429	LUCE BAYOU AT GRAND PARKWAY/SH-99 NORTHEAST OF LAKE HOUSTON	HG	HG	RT	4	4	4	4

[1] The Clean Rivers Program coordinated monitoring schedule for current and previous fiscal years can be located at cms.lcra.org

[2] Submitting Entity – The entity submitting monitoring data to TCEQ's Surface Water Quality Information System

[3] Collecting Entity – The entity collecting monitoring data. HG = Houston-Galveston Area Council, TF = Texas Research Institute for Environmental Studies

[4]Monitoring Types – RT = Routine

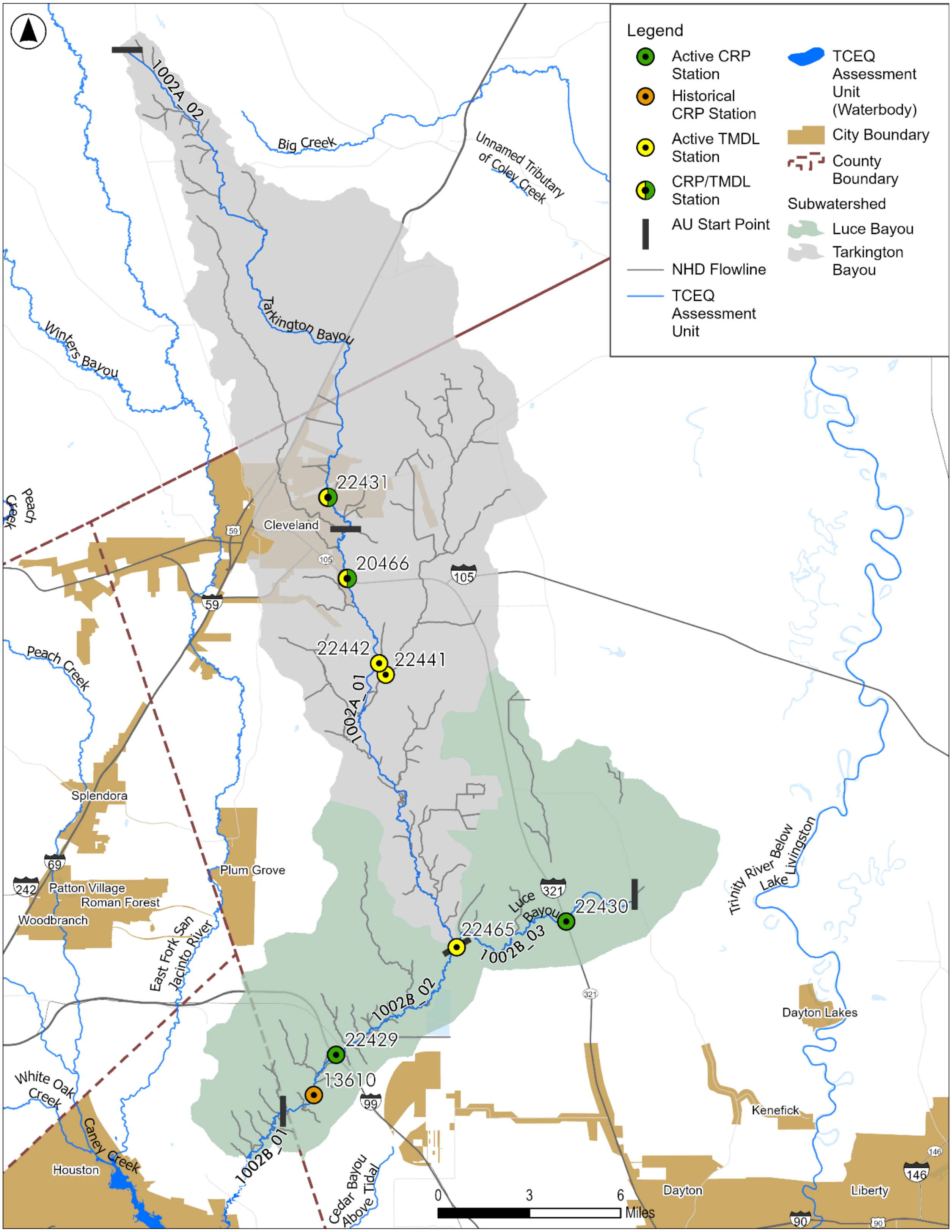


Figure 17. Map of Luce Bayou Watershed with TCEQ recognized segments and subsequent assessment units with all current and historic monitoring stations.

SEGMENT PHOTOS

Figure 18. Photo of Tarkington Bayou (1002A_02) at site 22431 (Tarkington Bayou at FM 787) facing upstream. Photo by S. Johnston.

Figure 19. Photo of Tarkington Bayou (1002A_01) at site 20466 (Tarkington Bayou at SH 105/SH 321) facing downstream on 05/23/2023. Photo by K. Guidroz.

Figure 20. Photo of Tarkington Bayou (1002A_01) at site 22442 (Tarkington Bayou at CR 331) facing the upstream, right bank on 06/16/2023. Photo by K. Guidroz.

Figure 21. Photo of Marsh Branch at site 22441 (Marsh Branch Stream at CR 331) facing downstream. Photo by S. Johnston.

Figure 22. Photo of Luce Bayou (1002B_03) at site 22430 (Luce Bayou at SH 321) facing downstream on 06/16/2023. Photo by K. Guidroz

Figure 23. Photo of Luce Bayou (1002B_02) at site 22465 (Luce Bayou 20 m upstream of the wooden bridge at an unnamed county road) facing upstream from the wooden bridge. Texas Research Institute for Environmental Studies (TRIES) field staff are pictured, conducting a discharge measurement. Photo by S. Johnston.

Figure 24. Photo of Luce Bayou (1002B_02) at site 22429 (Luce Bayou at Grand Parkway/SH 99) facing upstream on 06/16/2023. Photo by K. Guidroz..

DESCRIPTION OF WATER QUALITY ISSUES

WATER QUALITY STANDARDS AND CRITERIA

Segment 1002A (Tarkington Bayou) and 1002B (Luce Bayou) are unclassified segments that are assessed based on the statewide criteria of freshwater streams. Both segments are designated as primary contact recreation 1 (Table 10). Assessment unit (AU) 1002A_01, Tarkington Bayou, has been assigned an aquatic life use (ALU) of intermediate (Table 11). All other AUs have a default ALU designated use of high.

Table 10. Designated Uses for Recreation and Associated Numeric Criteria and Nutrient Screening Levels for Segments 1002A and 1002B. PCR1 = primary contract recreation 1.

SEGMENT		DESIGNATED USE	CRITERIA[1]		NUTRIENT SCREENING LEVELS[2]			
Segment ID	Segment Name	Recreation	Indicator Bacteria[3] Geomean (MPN/100 mL)	Indicator Bacteria [3] Grab Maximum[1] (MPN/100mL)	Total Phosphorus (mg/L)	Nitrate-Nitrogen (mg/L)	Ammonia-Nitrogen (mg/L)	Chlorophyll-a (μg/L)
1002A	Tarkington Bayou	PCR1	126	399	0.69	1.95	0.33	14.1
1002B	Luce Bayou	PCR1	126	399	0.69	1.95	0.33	14.1

[1] *Source: 2022 Texas Surface Water Quality Standards (https://www.tceq.texas.gov/waterquality/standards/2022-texas-surface-water-quality-standards), Page 55. (TCEQ, 2022)*

[2] *Source: 2024 Guidance for Assessing and Reporting Surface Water Quality in Texas (https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024/2024-guidance.pdf/view), Table 3.11.*

[3] *The indicator bacteria for freshwater is E. coli.*

Table 11. Designated Uses for Aquatic Life Use and Associated Numeric Criteria[1] for Assessment Units in Segments 1002A and 1002B

SEGMENT			DESIGNATED USE[1]	CRITERIA[2]	
Segment ID	Segment Name	Assessment Unit	Aquatic Life Use[3]	Dissolved Oxygen Grab Minimum (mg/L)	Dissolved Oxygen Grab Screening Level (mg/L)
1002A	Tarkington Bayou	1002A_01	I	3.0	4.0
		1002A_02	H	3.0	5.0
1002B	Luce Bayou	1002B_01	H	3.0	5.0
		1002B_02	H	3.0	5.0
		1002B_03	H	3.0	5.0

[1] *Source: 2022 Texas Surface Water Quality Standards (https://www.tceq.texas.gov/waterquality/standards/2022-texas-surface-water-quality-standards), Appendix D, Page 198. (TCEQ, 2022)*

[2] *Source: 2024 Guidance for Assessing and Reporting Surface Water Quality in Texas (https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024/2024-guidance.pdf/view), Chapter 3, Table 3.2.*

[3] *Aquatic Life Use is categorized as either E = Exceptional, H = High, I = Intermediate, L = Limited, or M = Minimal.*

Because the Tarkington Bayou (1002A) and Luce Bayou (1002B) are unclassified segments, there are no defined criteria for other general use parameters, however the receiving water body, Lake Houston

(1002), does have defined criteria (Table 12). These Lake Houston general use criteria were used to conduct preliminary data review and visualizations.

Table 12. Numeric criteria for general use parameters by segment. Because 1002A and 1002B are unclassified segments, there are no designated numeric criteria. Segment 1002 is the receiving waterbody for the Luce Bayou Watershed.

SEGMENT		CRITERIA			
Segment ID	Segment Name	Chloride (mg/L) maximum annual average	Sulfate (mg/L) maximum annual average	pH Range (s.u.)	Temperature (°F)
1002A	Tarkington Bayou	–	–	–	–
1002B	Luce Bayou	–	–	–	–
1002	Lake Houston	100	50	6.5 - 9.0	90

SUMMARY OF 2024 ASSESSMENT RESULTS

The 2024 Texas Integrated Report (IR) (TCEQ, 2024) describes the status of the water body based on historical data and the extent to which it attains the Texas Surface Water Quality Standards. The seven-year assessment period for the 2024 IR was 12/1/15 – 11/30/22.

For the 2024 Integrated Report, only Tarkington Bayou, AU 1002A_01, was assessed (Table 13). All AUs within the Luce Bayou Segment, 1002B, as well as Tarkington Bayou AU 1002A_02 were not assessed in the 2024 IR due to insufficient data. Monitoring is currently on-going in these assessment units to support assessments in a future Integrated Report.

Table 13. Integrated Level of Support for Assessment Units in Segment 1002A – Tarkington Bayou. Date of record included in the 2024 Integrated Report (12/01/15 – 11/30/22) FS = Fully Supporting, NS = Non-Supporting, NC = No Concern, CN = Use Concern, CS = Screening Level Concern, and NA = Not Assessed.

Designated Use	Method	Parameter	Tarkington Bayou 1002A_01
Recreation Use	Bacteria Geomean	*E. coli*	NS
Aquatic Life Use	Dissolved Oxygen Grab Minimum	Dissolved Oxygen Grab	FS
	Dissolved Oxygen Grab Screening Level	Dissolved Oxygen Grab	CS
General Use	Dissolved Solids	Total Dissolved Solids	NA
		Sulfate	NA
		Chloride	NA
	High pH	pH	NA
	Low pH	pH	NA
	Nutrient Screening Levels	Total Phosphorus	CS
		Nitrate	CS
		Ammonia	NC
		Chlorophyll-a	NA
	Water Temperature	Water Temperature	NA

RECREATIONAL USE

Pathogen Indicator Bacteria (E. coli)

According to the 2024 IR, there is one contact recreation impairment for Tarkington Bayou, AU 1002A_01, due to elevated concentrations of pathogen indicator bacteria, *E. coli* (Table 14 and Figure 25). The category for the integrated level of support for the impairment on AU 1002A_01 is 5c meaning additional data and information will be collected or evaluated before a management strategy is selected. The TCEQ did not assess the other AUs for this period due to insufficient data. Pathogen indicator bacteria, *E. coli*, can naturally be highly variable in both space and time. As a result, a minimum of 20 data points over two seasons and two years are used to assess if a waterbody is meeting recreational use standards. In AU 1002A_01, the *E. coli* geometric mean was 167.28 MPN/100 mL, which is above the contact recreation standard of 126 MPN/100 mL for PCR1.

H-GAC completed a review including data collected since the end of the IR date range (which ended on 11/30/2022), some of which are preliminary and have not undergone complete Quality Assurance/Quality Control procedures (Table 14). Geomean analyses were not completed for AUs lacking sufficient data points (<20 results). While the TCEQ does not use the single grab criteria of 399 MPN/100mL for assessments, it can be helpful for data visualization and comparative purposes (TCEQ, 2022). Preliminary data visualization suggests that elevated pathogen indicator bacteria, *E. coli*, may be a concern for the AUs not previously assessed in the Luce Bayou Watershed (Figure 26 and Figure 27).

Table 14. Bacteria E. coli results for Tarkington Bayou, Segment 1002A and Luce Bayou, Segment 1002B. Only assessment units with ≥20 data points were evaluated. Category: 5c = Additional data and information will be collected or evaluated before a management strategy is selected. Assessed Level of Support: *FS = Fully Supporting, NS = Non-Supporting, and NA = Not Assessed. Mean exceedances = mean of the samples that exceeded criteria.*

	2024 Integrated Report (12/01/15 – 11/30/22)			H-GAC Data Review			
AU ID	Assessed Level of Support	Category	Geometric Mean[1] (MPN/100mL)	Date Range	n	Geometric Mean[1] (MPN/100mL)	Mean Exceedances (Samples Exceeding grab maximum[2]/n)
1002A_01	NS	5c	167.28	2/9/2017 - 12/17/2024	46	168.39	1,692.9 (7/45)
1002A_02	NA	-	-	10/9/2023 - 12/18/2024	12	-	785.8 (5/12)
1002B_01	NA	-	-	-	-	-	-
1002B_02	NA	-	-	10/03/2023 - 12/17/2024	6	-	8,290.0 (3/6)
1002B_03	NA	-	-	10/03/2023 - 08/29/2024	4	-	10,230.0 (2/4)

[1]The criteria for recreational use for non-tidal streams if not otherwise determined is assumed to be Primary Contact Recreation I (PCR1) with a geometric mean criterion for E. colli of 126 MPN/100mL.
[2]The single sample criterion for PCR1 is 399 MPN/100mL.

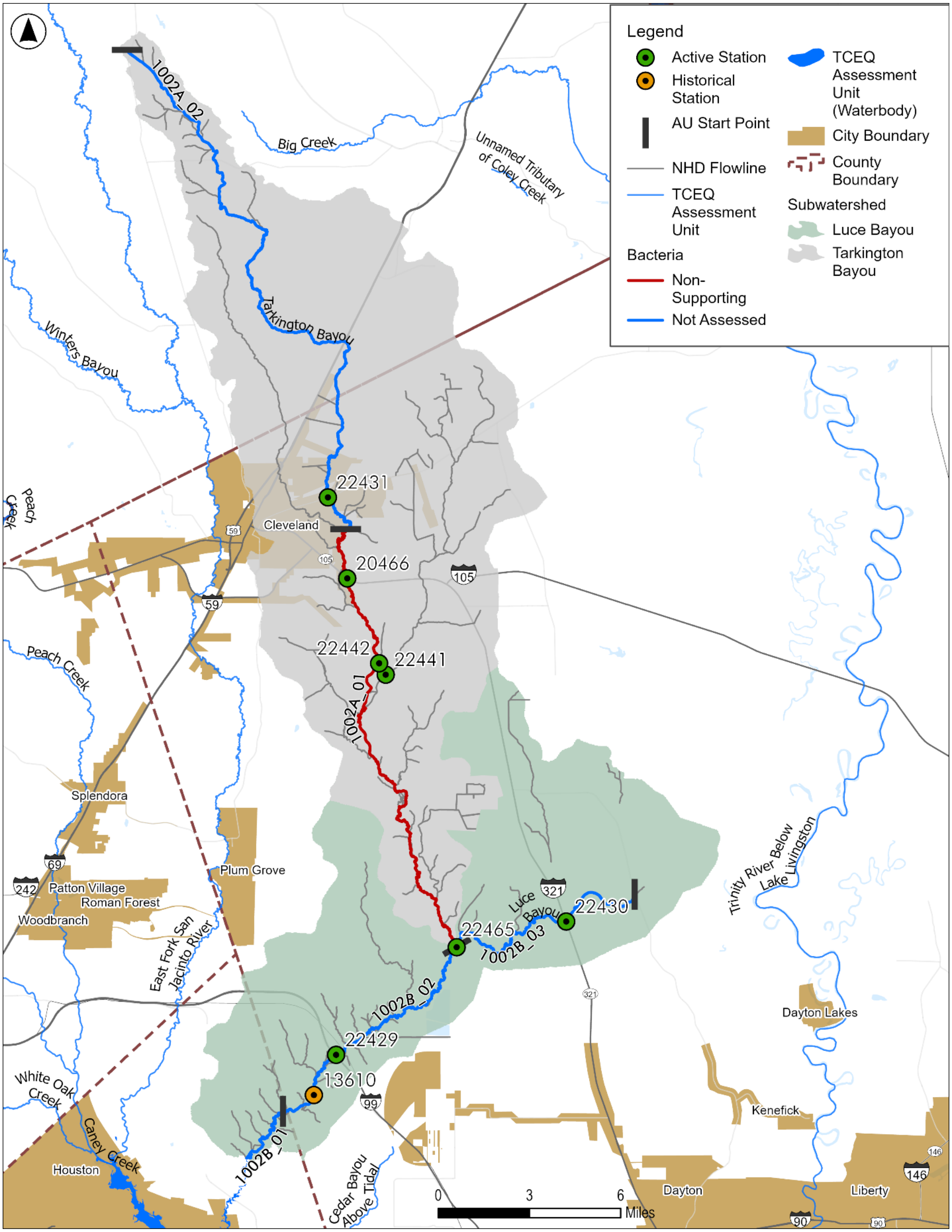


Figure 25. Map of Luce Bayou watershed's assessment for pathogen indicator bacteria (2024 IR).

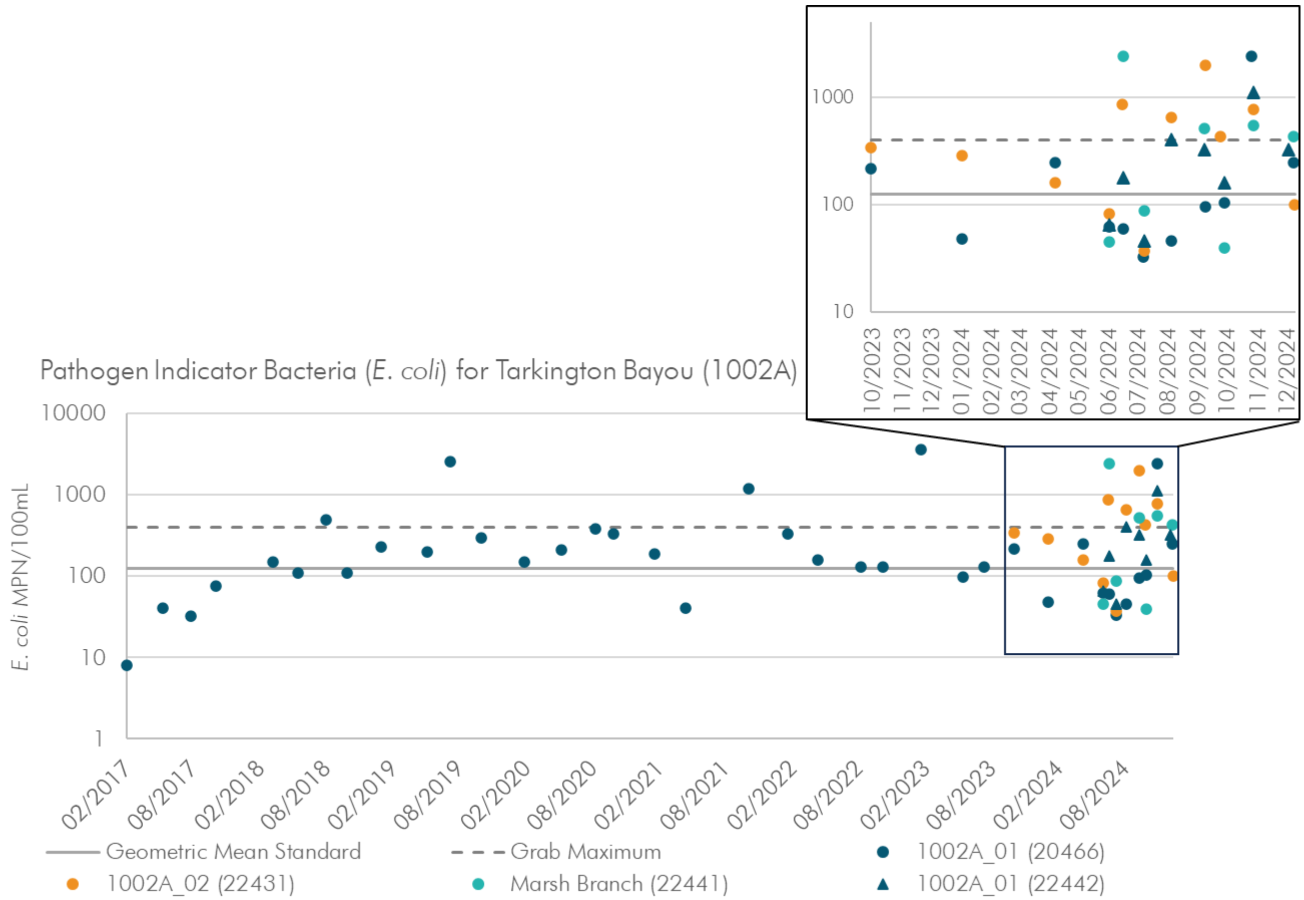


Figure 26. Pathogen indicator bacteria E. coli grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The geometric mean standard of 126 is plotted in the solid grey line and the single grab standard of 399 is plotted in the dashed gray line. Note: y-axis as log scale.

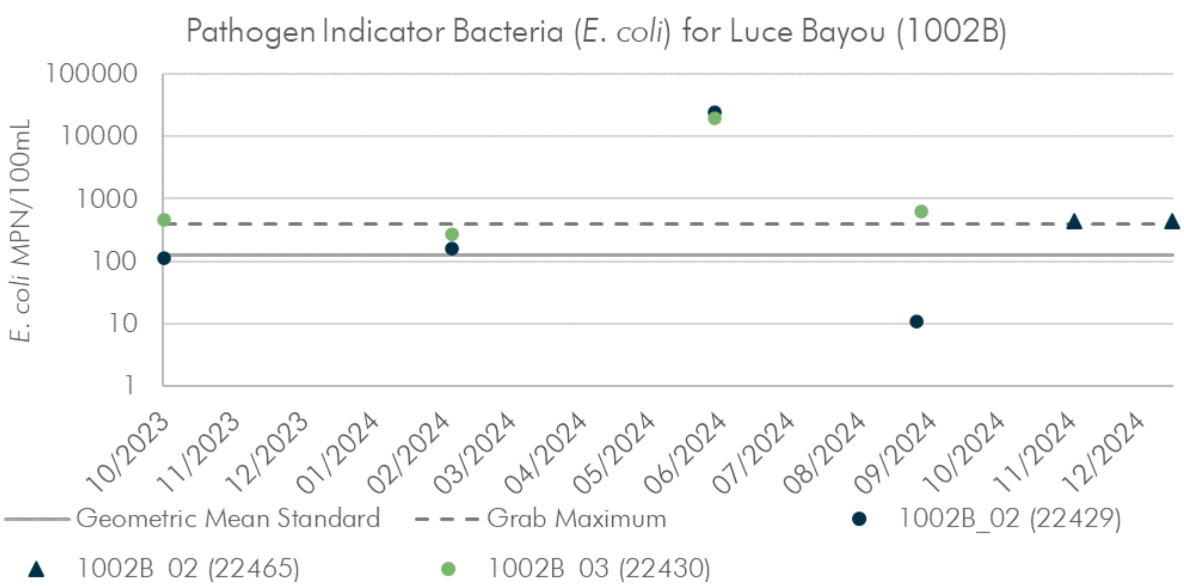


Figure 27. Pathogen indicator bacteria E. coli grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The geometric mean standard of 126 is plotted in grey line and the single grab standard of 399 is plotted in the dashed gray line. Note: y-axis as log scale.

AQUATIC LIFE USE

Dissolved Oxygen (D0)

Reported in the 2024 IR, an aquatic life use concern for low dissolved oxygen (DO) grab screening level was present for AU 1002A_01. Due to insufficient data in the other AUs, this was the only AU assessed. In AU 1002A_01, 18.52% of the samples assessed (5 of 27) for the 2024 IR were below the dissolved oxygen grab screening level of 4 mg/L established for this segment's designated aquatic life use of intermediate (Table 15 and Figure 28). The use-attainment assessment method for aquatic life use also evaluates the dissolved oxygen grab minimum. In the 2024 IR, AU 1002A_01 was found to be fully supporting; 0.0% of the 27 samples assessed were below the grab minimum level of 3 mg/L.

H-GAC completed a data review including data collected since the end of the IR date range (which ended on 11/30/2022), some of which are preliminary and have not undergone complete Quality Assurance/Quality Control procedures. Preliminary review of these more recent data collected support the assessment results for 1002A_01 in the 2024 IR (Figure 29). Some of the recent DO grab data from AU 1002A_02 fell below the DO grab minimum of 3 mg/L (5/11 or 45% of samples) (Figure 30). Additionally, preliminary data from all AUs suggest that results frequently fall below the DO grab screening levels.

Table 15. Dissolved oxygen (DO) impairments and trends for Tarkington Bayou, Segment 1002A and Luce Bayou, Segment 1002B. Assessed Level of Support: FS = Fully Supporting, CS = Screening Level Concern, NS = Non-Supporting, and NA = Not Assessed. Mean exceedances = mean of the samples that exceeded criteria.

		2024 Integrated Report (12/01/15 – 11/30/22)			H-GAC Data Review (02/09/2017 – 12/18/2024)	
Parameter	Criteria	AU ID	Current Assessed Level of Support	Mean Exceedances (Samples Exceeding Standard/n)	Date Range	Mean Exceedances (Samples Exceeding Standard/n)
Dissolved Oxygen Grab Minimum (mg/L)	3.0	1002A_01	FS	- (0/27)	02/09/2017 – 12/12/2024	2.6 (4/45)
		1002A_02	NA	-	10/09/2023 – 12/18/2024	2.3 (5/11)
		1002B_01	NA	-	-	-
		1002B_02	NA	-	10/03/2023 – 12/17/2024	- (0/6)
		1002B_03	NA	-	10/03/2023 – 08/29/2024	0.9 (1/4)
Dissolved Oxygen Grab Screening Level (mg/L)	4.0	1002A_01	CS	3.54 (5/27)	02/09/2017 – 12/12/2024	3.0 (11/45)
	5.0	1002A_02	NA	-	10/09/2023 – 12/18/2024	2.7 (7/11)
		1002B_01	NA	-	-	
		1002B_02	NA	-	10/03/2023 – 12/17/2024	4.5 (2/6)
		1002B_03	NA	-	10/03/2023 – 08/29/2024	2.1 (2/4)

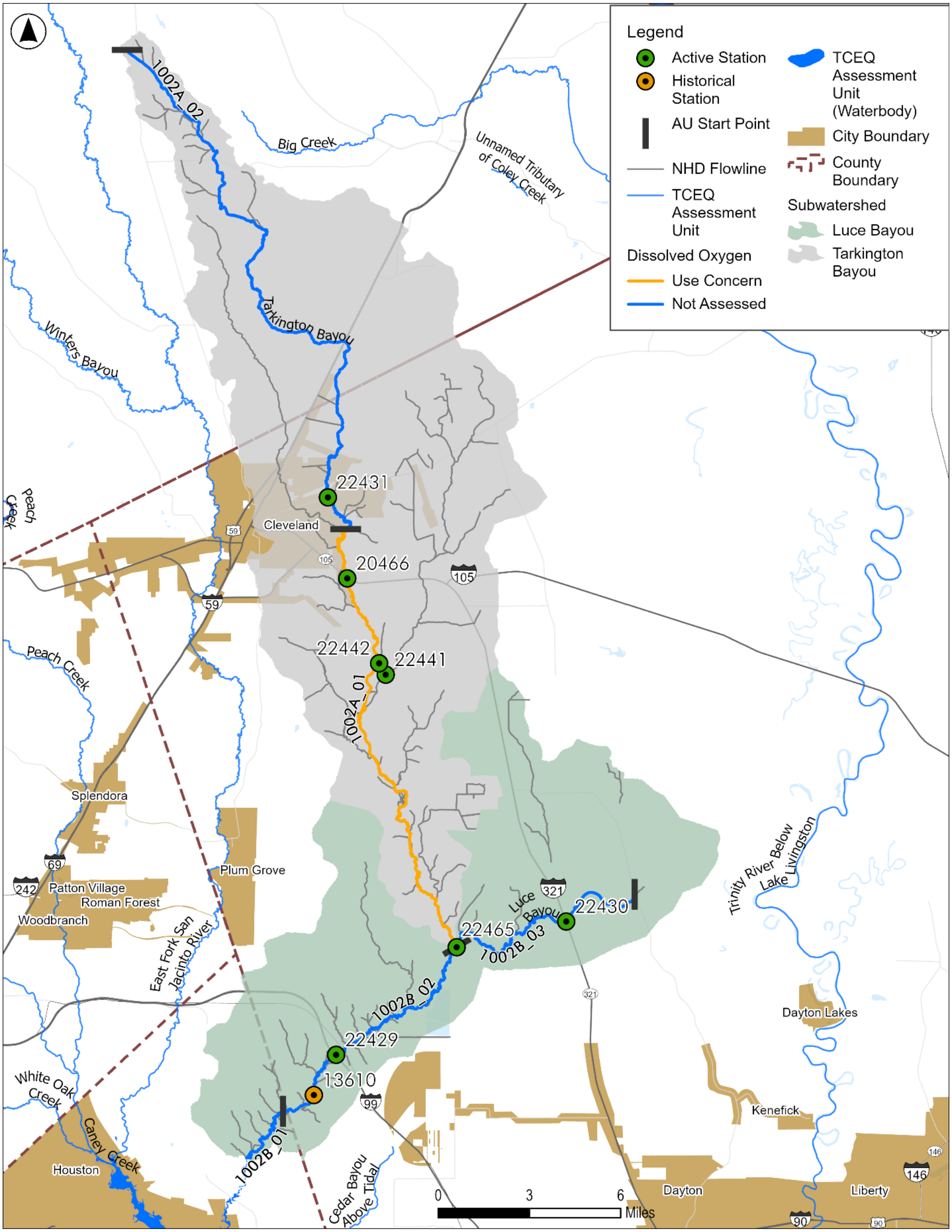


Figure 28: Luce Bayou watershed's assessment for dissolved oxygen concerns (TCEQ, 2024).

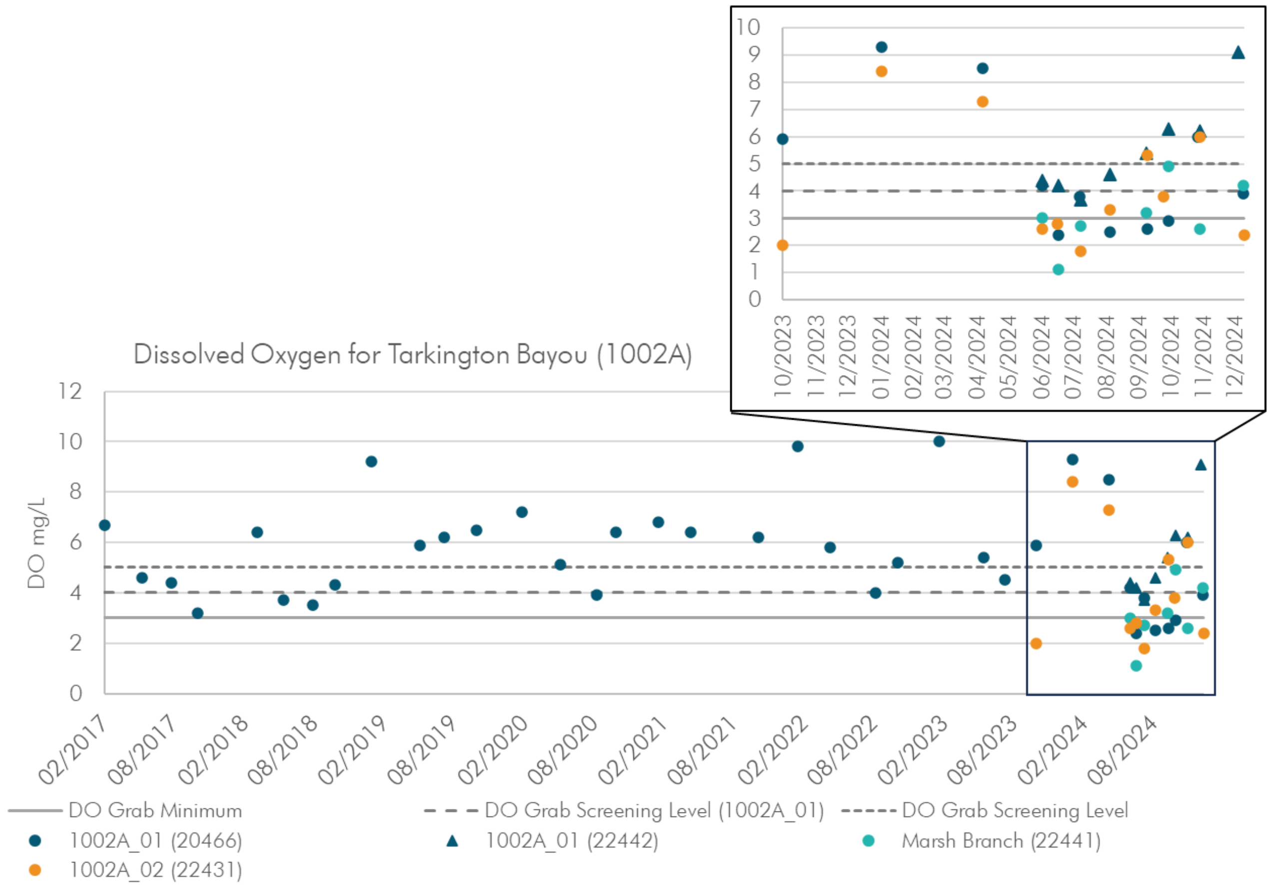


Figure 29. Dissolved oxygen (DO) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The DO grab minimum of 3 mg/L is plotted in grey line and the DO grab screening levels (by AU) are plotted in the dashed lines.

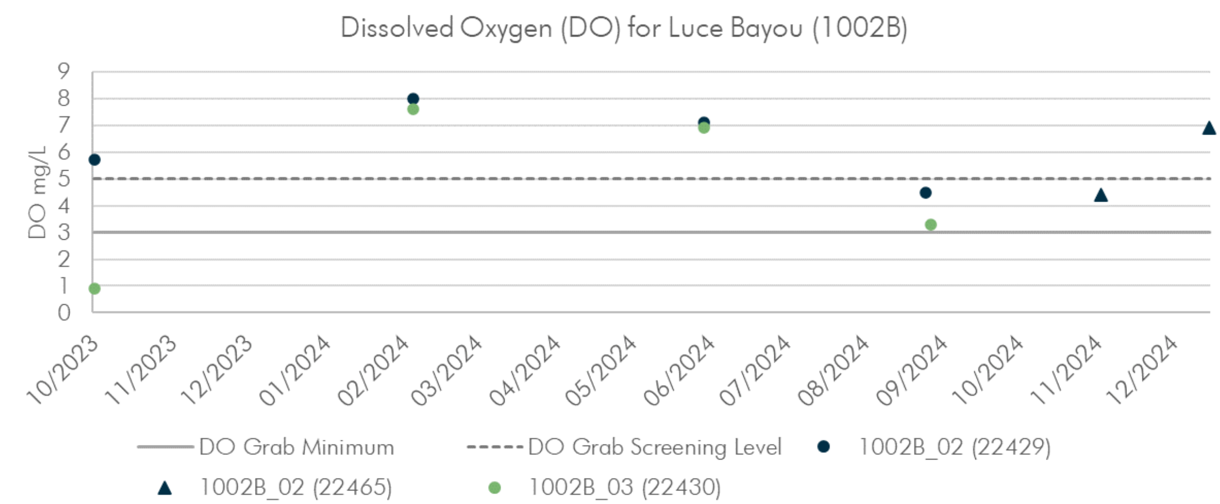


Figure 30. Dissolved oxygen (DO) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The DO grab minimum of 3 mg/L is plotted in grey line and the DO grab screening level of 5 mg/L is plotted in the dashed line.

GENERAL USE

Nutrient Concerns

Two General Use nutrient screening level concerns were found within AU 1002A_01 in the 2024 IR: total phosphorus and nitrate. Total phosphorus exceeded the criteria of 0.69 mg/L for 15 of 27 samples. Nitrates found in the water exceeded the criteria of 1.95 mg/L for 17 of 27 samples. There was no concern for ammonia, as only 1 of 27 samples exceeded the criteria of 0.33 mg/L.

H-GAC completed a data review including data collected since the end of the IR date range (which ended on 11/30/2022), some of which are preliminary and have not undergone complete Quality Assurance/Quality Control procedures. Preliminary review of these more recent data support the 2024 IR assessment results for AU 1002A_01 for total phosphorus, nitrate-nitrogen, and ammonia-nitrogen (Table 16 and Figure 31). The available data for the other AUs suggest that there are few exceedances for the three nutrient parameters monitored on the other AUs. Note there are no chlorophyll-a data available for these segments. All data included in the H-GAC data review are presented in Figure 32 through Figure 35 for total phosphorus and nitrate-nitrogen, and Appendix E for ammonia-nitrogen.

Table 16. Nutrient impairments and trends for Tarkington Bayou, Segment 1002A and Luce Bayou, Segment 1002B. Integrated Level of Support: NC = No Concern, CS = Screening Level Concern, and NA = Not Assessed. Mean exceedances = mean of the samples that exceeded criteria.

		2024 Integrated Report (12/01/15 – 11/30/22)			H-GAC Data Review (02/07/2017 – 12/18/2024)	
Parameter	Criteria	AU ID	Current Assessed Level of Support	Mean Exceedances (Samples Exceeding Standard/n)	Date Range	Mean Exceedances (Samples Exceeding Standard/n)
Total Phosphorus	0.69	1002A_01	CS	2.12 (15/27)	02/09/2017 – 12/12/2024	1.96 (18/41)
		1002A_02	NA	-	10/09/2023 – 10/03/2024	- (0/7)
		1002B_01	NA	-	-	-
		1002B_02	NA	-	10/03/2023 – 12/17/2024	1.24 (1/6)
		1002B_03	NA	-	10/03/2023 – 08/29/2024	- (0/4)
Nitrate-Nitrogen	1.95	1002A_01	CS	11.95 (17/27)	02/09/2017 – 12/12/2024	11.28 (21/41)
		1002A_02	NA	-	10/09/2023 – 10/03/2024	- (0/7)
		1002B_01	NA	-	-	-
		1002B_02	NA	-	10/03/2023 – 12/17/2024	5.54 (2/6)
		1002B_03	NA	-	10/03/2023 – 08/29/2024	- (0/4)
Ammonia-Nitrogen	0.33	1002A_01	NC	11.30 (1/27)	02/09/2017 – 12/12/2024	0.81 (1/39)
		1002A_02	NA	-	10/09/2023 – 10/03/2024	1.37 (2/5)
		1002B_01	NA	-	-	-
		1002B_02	NA	-	10/03/2023 – 12/17/2024	- (0/6)
		1002B_03	NA	-	10/03/2023 – 05/31/2024	- (0/3)

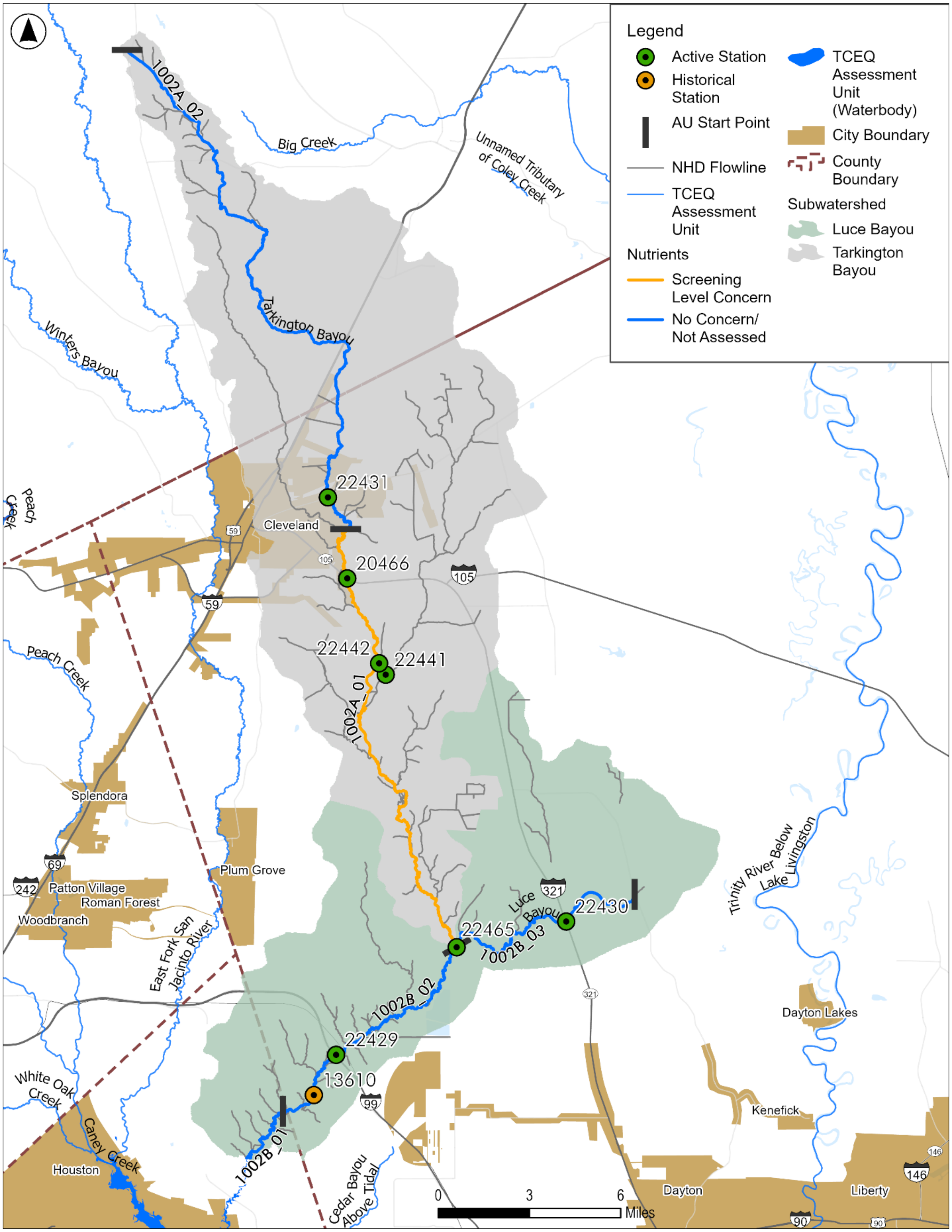


Figure 31. Luce Bayou watershed's assessment for nutrient concerns (TCEQ, 2024).

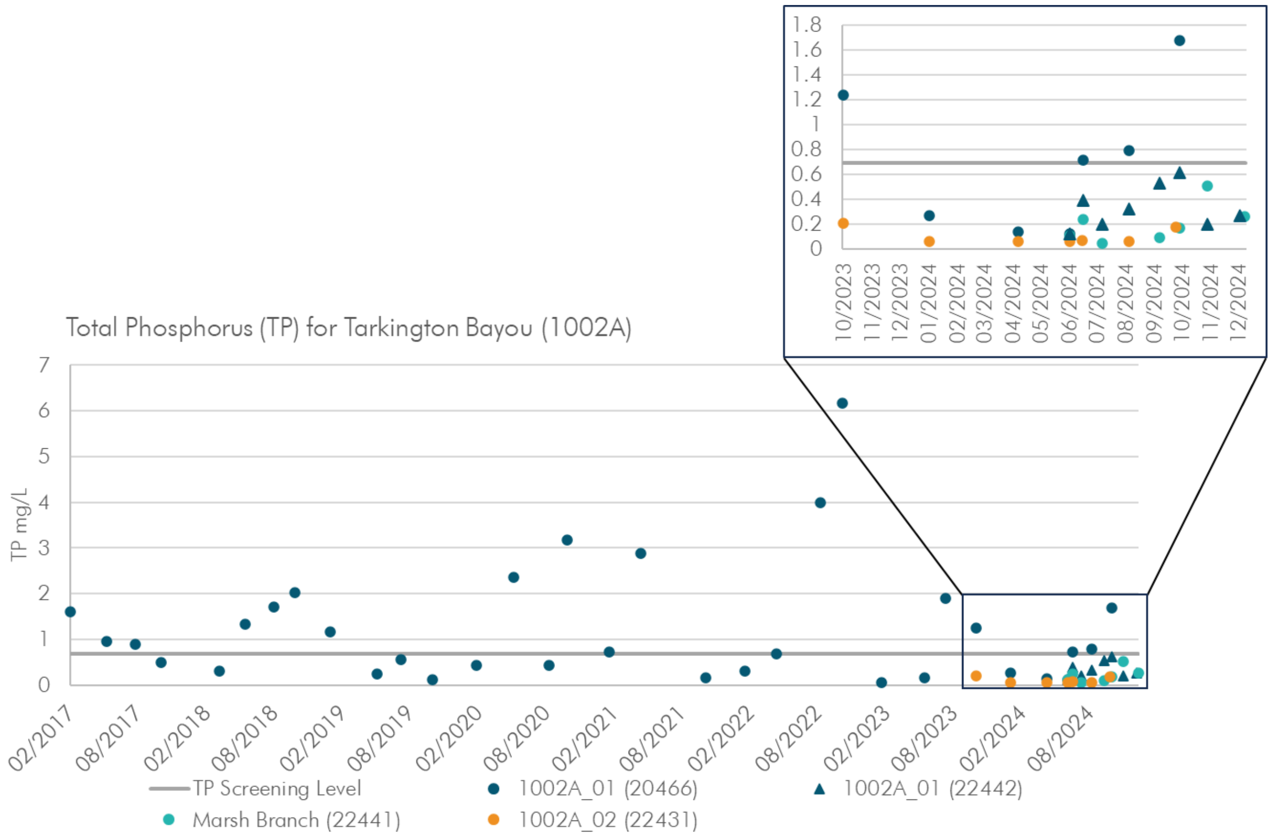


Figure 32. Total phosphorus (TP) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The TP screening level of 0.69 mg/L is plotted in grey line.

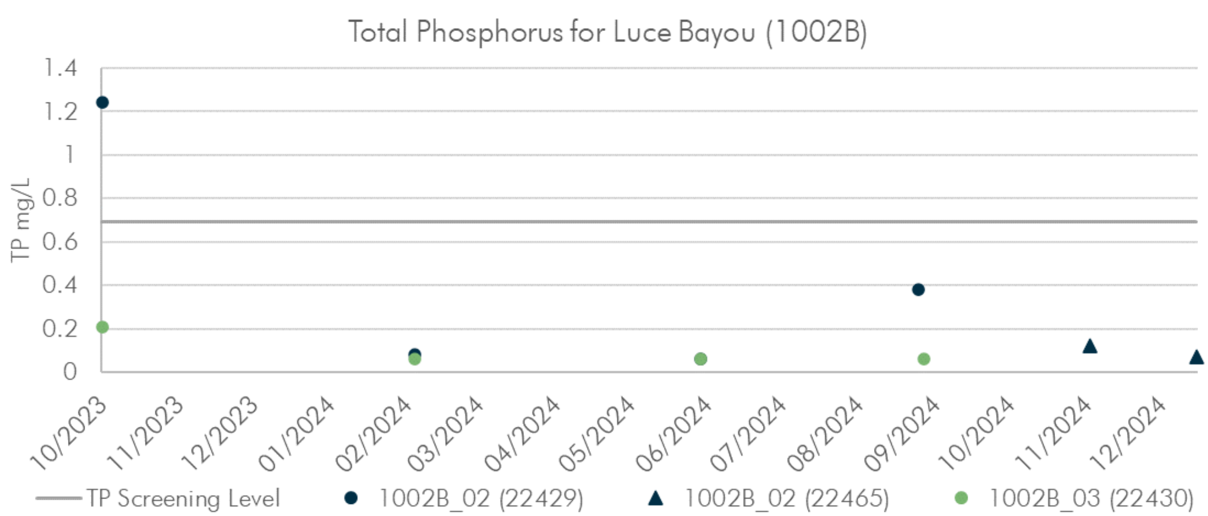


Figure 33. Total phosphorus (TP) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The TP screening level of 0.69 mg/L is plotted in grey line.

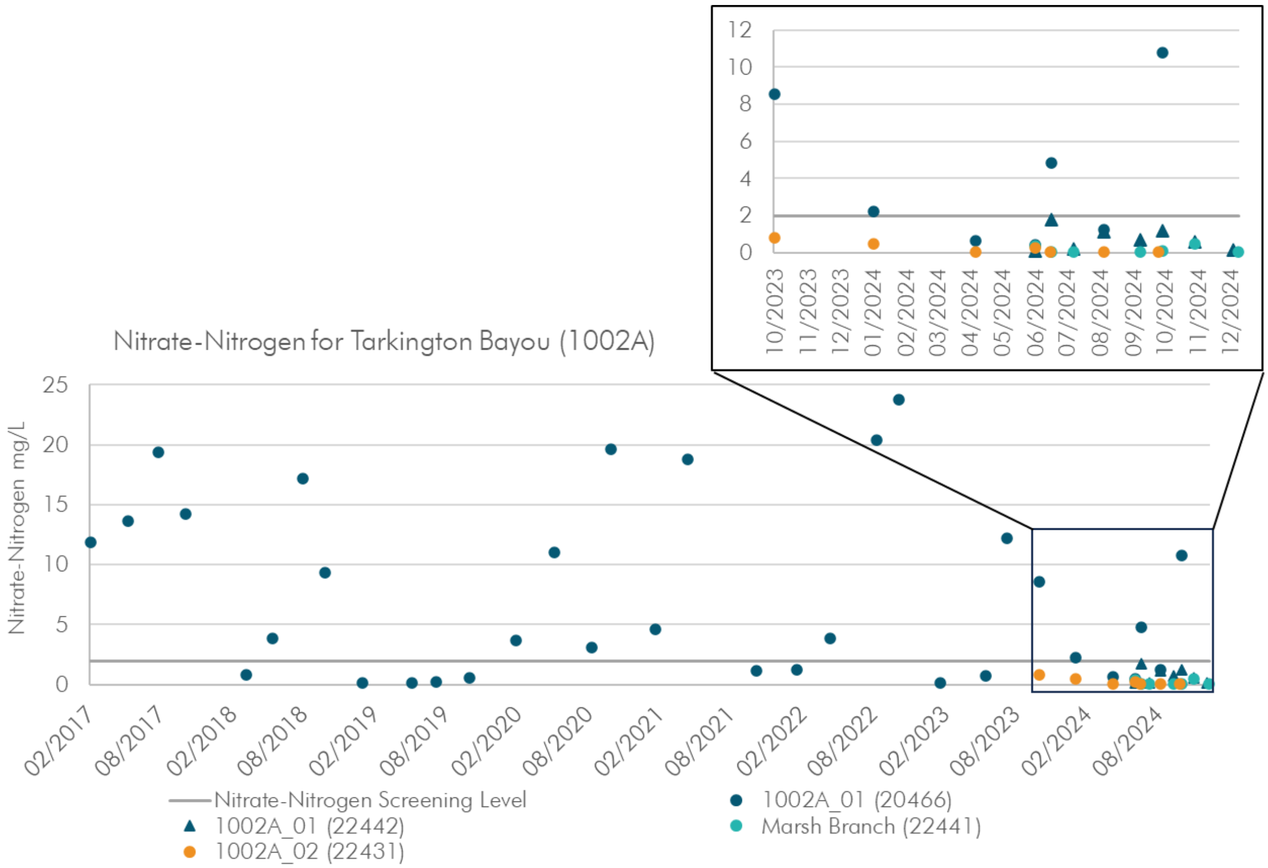


Figure 34. Nitrate-nitrogen (NO_3) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The NO_3 screening level of 1.95 mg/L is plotted in grey line.

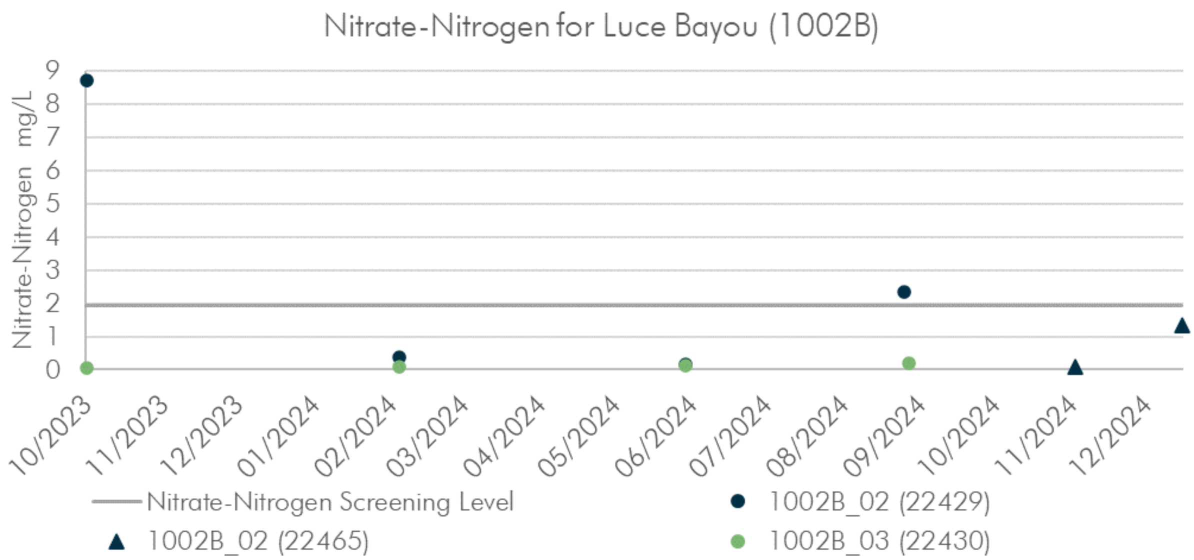


Figure 35. Nitrate-nitrogen (NO_3) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The NO_3 screening level of 1.95 mg/L is plotted in grey line

Other Parameters
Available data for other general use parameters were compared to the Lake Houston criteria for visualization purposes. All data in the period of record reviewed for this report (2/9/2017 – 12/18/2024) for chloride, sulfate, and temperature were below the numeric criteria for the receiving water body, Lake Houston (1002) (Appendix E). There are several instances of pH values below the minimum numeric criteria of 6.5 standard units (s.u.) (Figure 36 and Figure 37). If low pH issues arise in the Lake Houston segment, further investigation into the pH values within the contributing Luce Bayou watershed may be warranted.

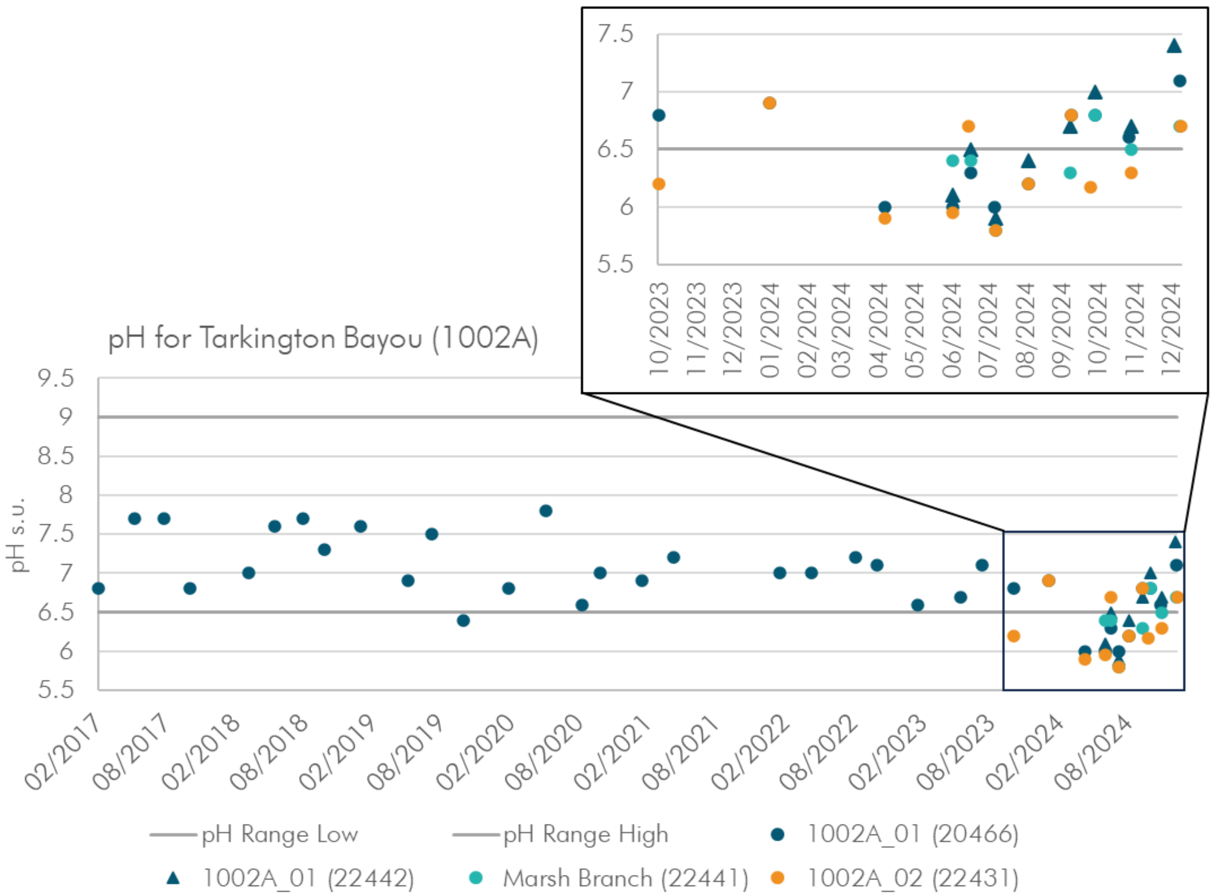


Figure 36. pH grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The pH minimum and maximum numeric criteria for the receiving water body Lake Houston (1002) of 6.5 – 9.0 s.u. is plotted in grey lines.

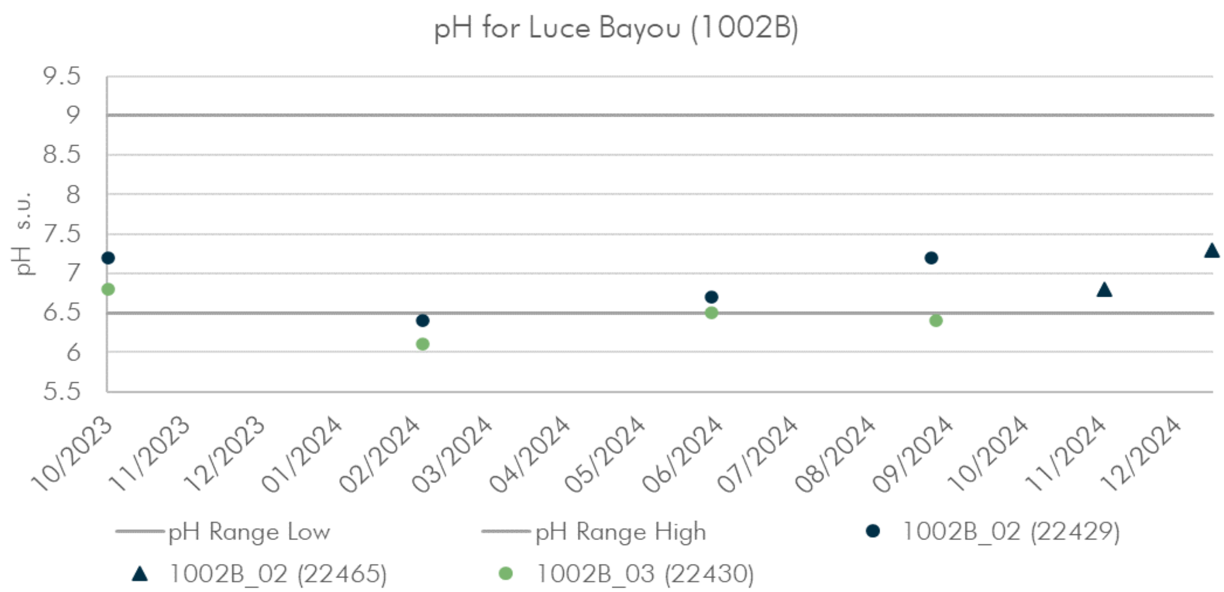


Figure 37. pH grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The pH minimum and maximum numeric criteria for the receiving water body Lake Houston (1002) of 6.5 – 9.0 s.u. is plotted in grey lines.

POTENTIAL SOURCES OF WATER QUALITY ISSUES

Potential sources of fecal indicator bacteria and nutrients in the Luce Bayou watershed include both point and nonpoint sources. These sources include wastewater treatment facilities, sanitary sewer overflows, failing on-site sewage facilities, stormwater runoff, and animal waste.

PERMITTED WASTEWATER DISCHARGES

Centralized wastewater accounts for 18.59 square miles or 9.01% of the Luce Bayou watershed. There are 10 permitted outfalls within the Luce Bayou watershed (Table 17 and Figure 38). Of these outfalls, 9 are classified as domestic (D) sewage dischargers that are currently permitted to discharge <1 MGD. The final permittee is a wastewater (W) discharger that is permitted to discharge <1 MGD. The cumulative permitted discharge to the watershed is slightly over 5 MGD (TCEQ, 2025a). In general, well maintained wastewater treatment facilities have been found to meet state pollutant discharge permit requirements (H-GAC, 2024).

Table 17. Permitted Wastewater Discharges in the Luce Bayou Watershed. W = wastewater, D = domestic

Assessment Unit	NPDES1 ID	TCEQ Permit Number	Permittee Name	WWTF Name	Average Permitted Daily Flow (MGD)	Type
1002A_02	TX0137791	WQ0015581001	United Front Shepard, LLC	Shepard Travel Center	0.02	W
1002A_01	TX0053481	WQ0010766002	City of Cleveland	Cleveland East WWTP	0.95	D
NA[1]	TX0133817	WQ0015061001	Quadvest, LP	Bella Vista	NA	W
1002A_01	TX0142662	WQ0016137001	Liberty County Utilities, LLC	Liberty County Utilities WWTP No 2	0.65	D
1002B_02	TX0144339	WQ0016319001	Liberty County Utilities, LLC	Liberty County Utilities WWTP No 3	0.65	D
1002B_02	TX0141062	WQ0015967001	Liberty County Utilities, LLC	Liberty County Utilities WWTP No 1	0.65	D
1002B_02	TX0140422	WQ0015897001	Utilities Investment Company, Inc.	Santa Fe 2 WWTP	0.65	D
1002B_02	TX0138207	WQ0015646001	Utilities Investment Company, Inc.	Santa Fe WWTP	0.65	D
1002B_02	TX0145025	WQ0016399001	Texas Water Utilities, L.P.	Kingland Central WWTP	0.28	D
1002B_01	TX0142913	WQ0016164001	Saint-Tropez Laguna Azure, LLC	ST Tropez WWTP	0.40	D
1002B_01	TX0139653	WQ0015830001	Texas Water Utilities, L.P.	Los Pinos WWTP	0.12	D

[1]*Outfall not in the watershed, a portion of the collection system is within the watershed.*

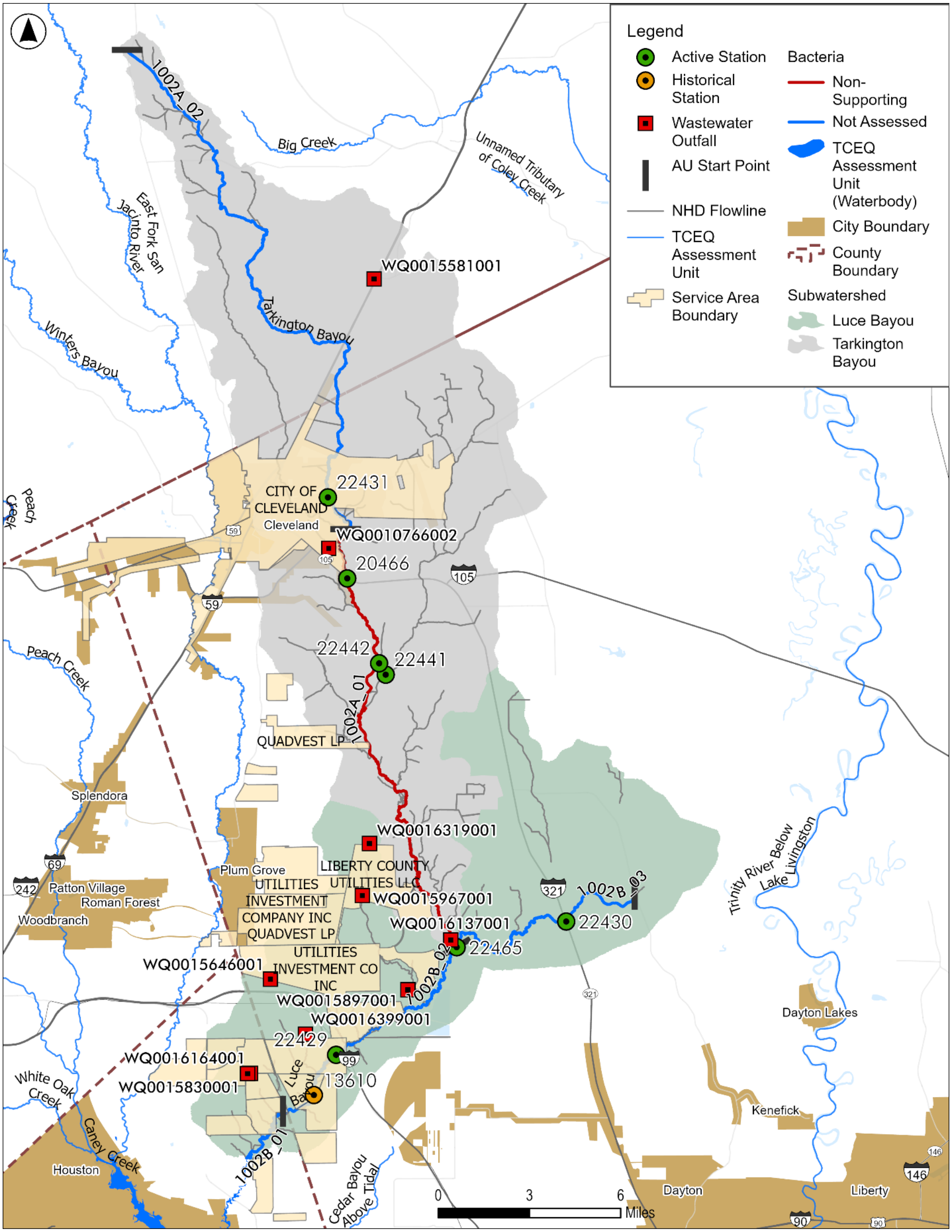


Figure 38. Permitted Effluent Discharges for the Luce Bayou Watershed (Segment 1002) (Data Source: H-GAC 2024).

SANITARY SEWER OVERFLOWS

Wastewater collection systems that transport wastewater to the treatment plant can be a source of bacteria. The service area boundaries, Figure 38, for the wastewater treatment plants contain the collection systems for twelve treatment plants, eleven of which were discussed previously concerning direct outfalls to the watershed. The Bella Vista Plant, TPDES No. WQ0015061001 (Figure 38), discharges outside of the watershed, however a portion of the collection system is found within the watershed and should be considered a possible source of bacteria should the collection system fail.

For the period of 2019 – 2023, only one permittee, the City of Cleveland, reported SSOs to the TCEQ (TCEQ, 2025b). The city reported a total of 10 SSOs in the Luce Bayou watershed. The total reported volume of these discharges was 3,751 gallons (Table 18). While this number and volume of SSOs may not necessarily cause chronically high bacteria levels within this waterway, each discrete event may cause acute conditions that could affect public health.

Sources of SSOs often include aging wastewater infrastructure, mechanical failure, inflow and infiltration, and improper disposal of fats, oils, and grease. The major cause of SSOs reported in the Luce Bayou watershed were due to infiltration and inflow from high rainfall events that overwhelmed the collection system.

Table 18. Sanitary sewer overflows reported between January 1, 2019 and December 31, 2023 in the Luce Bayou watershed

Cause	Cause Description	Number	Total gallons
Infiltration and Inflow	High stormwater inflow overwhelming the collection system	8	2,451
Mechanical and maintenance	Bar screen failure and cleaning during rain events	1	800
Other	No cause given	1	500
	Total	10	3,751

ON-SITE SEWAGE FACILITIES

Most of the watershed, 90.99%, is not serviced by centralized wastewater. Some on-site sewage facilities (OSSFs) in the watershed are operated under permit; however, some units are unregistered or not consistently reported. For the purposes of this report, all OSSFs will be treated as potential unregulated sources of fecal waste due to the nature of their permits, lack of reported data, and diffuse nature.

H-GAC, in coordination with authorized agents in H-GAC's service region, compiled the number of permitted and registered OSSFs in the project watershed (H-GAC, 2025a). Liberty and Harris counties are local authorized agents who have accepted responsibility from TCEQ to permit OSSFs and enforce laws and rules governing OSSFs on behalf of the State. There are 881 registered OSSFs in the Luce Bayou watershed (Figure 39). H-GAC does not have permitted OSSF data from San Jacinto County.

In addition to permitted systems, there are OSSFs that are not registered. Non-registered OSSF locations were estimated using H-GAC's geographic information database of potential OSSF locations (H-GAC, 2025b) in the Houston-Galveston area using known OSSF locations, 911 addresses, and WWTF service boundaries. Using H-GAC's estimate of non-registered OSSFs, there are likely another 2,119 non-registered OSSFs within the project watershed (Figure 39).

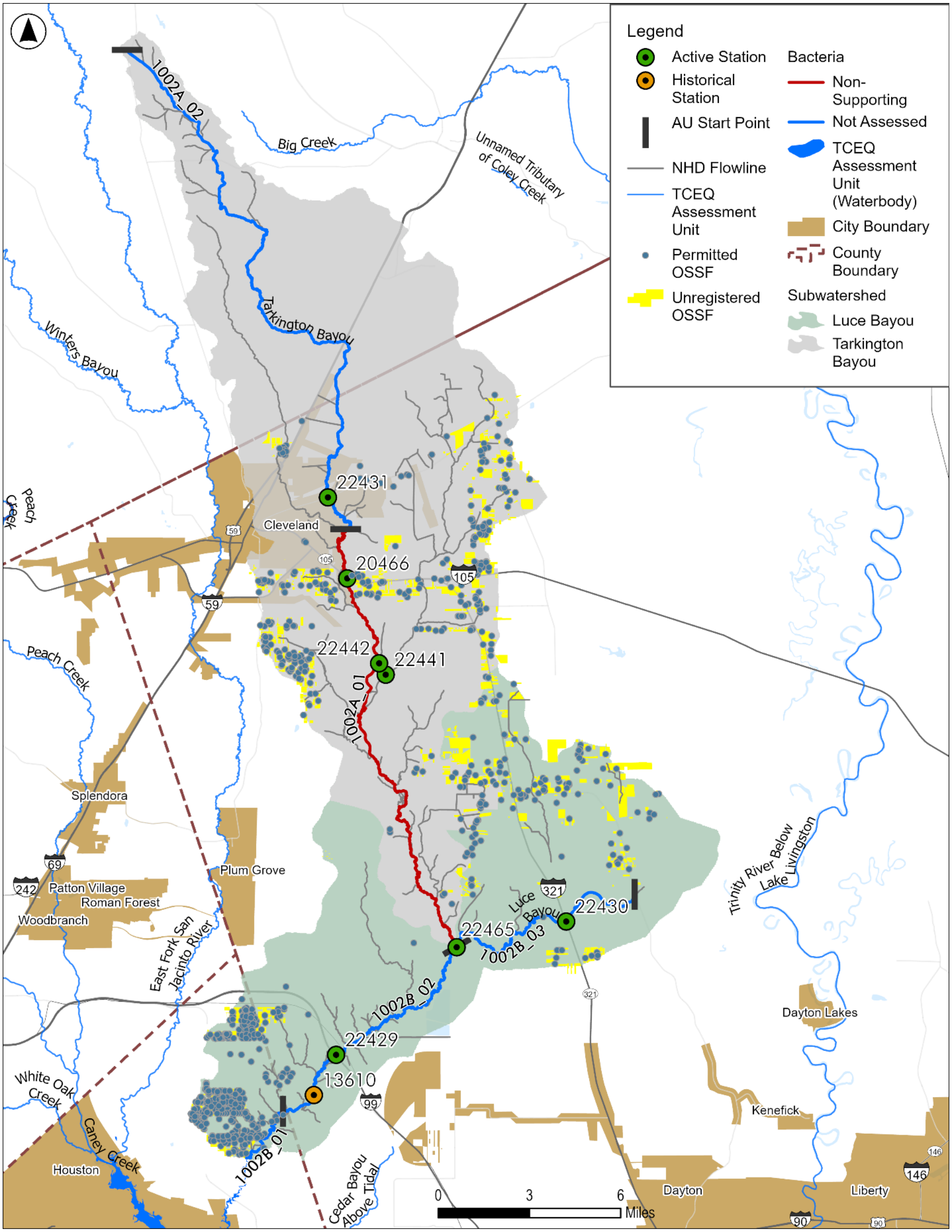


Figure 39. On-Site Sewage Facilities for the Luce Bayou Watershed.

NON-POINT SOURCES AND STORM SEWERS

Stormwater runoff can contribute to nutrient and bacteria contamination of waterways. All warm-blooded animals can increase these loadings within rural and urban settings.

RURAL STORMWATER

The Luce Bayou watershed is composed predominantly of rural land cover types (81.46%), including natural areas and agricultural producing lands. Wildlife, feral hogs and domesticated animals within these areas can contribute to nutrient and bacteria loadings (Table 19).

Table 19. Estimated populations for rural non-point sources of fecal waste by wildlife and livestock within the Luce Bayou watershed.

	Estimated Population						
Watershed	Deer	Feral Hogs	Cattle and Calves	Hogs and Pigs	Sheep and Goats	Equine	Poultry
Luce Bayou	1,219	3,218	4,953	60	244	227	1,257

Deer

Most avian and mammalian wildlife, including invasive species, are difficult to estimate, as long-term monitoring data or literature values indicating historical baselines are lacking. However, the White-Tailed Deer Program of the Texas Parks and Wildlife Department (TPWD, 2020) estimates deer populations within Deer Management Units (DMU). In the Pineywoods ecoregion, the Luce Bayou watershed falls into the DMUs 13 and 14. For the period of 2005 – 2019, the average TPWD deer population for DMU 13 and 14 were estimated at 3.8016 and 13.45231 per square mile, respectively, regardless of land cover type. By applying these averages to the area of each DMU within the Luce Bayou watershed (161.07 square mile and 45.1 square mile, respectively), the white-tailed deer population can be estimated at 1,219 (Table 19).

Feral Hogs

Feral hogs are a non-native, invasive species, which likely impact the watershed with fecal waste contamination. Like deer, factors for estimating feral hog populations based on land area are available. These factors vary depending on land cover types and range between 8.9 and 16.4 hogs per square mile (Timmons, et al., 2012). Feral hog population estimates may be weighted more heavily in riparian areas where animals are protected from the stresses associated with development and have more direct access to available food and water resources. The 8.9 hogs per square mile is applied to Barren, Cropland, and Developed Low Intensity land cover types. The 16.4 hogs per square mile is applied to Open Space Development, Forest/Shrub, Pasture/Grassland and Wetland land cover types. Feral hogs were estimated to have a total population of 3,218 within the Luce watershed (Table 19).

Livestock

Several agricultural activities that do not require permits can be potential sources of fecal bacteria loading. Fecal waste from livestock such as cattle, pigs/hogs, sheep, goats, horses, and poultry can be introduced through direct deposition and as runoff from manure used in crop fertilization.

In Table 19, estimates of livestock in the Luce Bayou watershed are shown. These estimates were calculated by applying a ratio of watershed's pasture/grassland land cover area compared to county land area times the livestock numbers from the 2022 Census of Agriculture for Harris, Liberty and San Jacinto Counties performed by the USDA (USDA, 2024). This calculation assumes equal distribution of livestock and farm operations throughout the three counties.

URBAN STORMWATER

While the major land cover types are considered rural, the watershed contains urban and suburban development. Development will continue to grow with the influx of population to the watershed. All land cover development types currently make up approximately 18.54% of the watershed. Development with high and medium intensity make up just 2%. This latter type of development brings increased impervious land cover that along with slow-draining soils can increase the amount of untreated runoff and influence flooding events to the Luce Bayou watershed.

Dogs and Cats

One common urban source of bacterial contamination are domesticated pets. Stray animals are of particular concern as they congregate in packs and their waste can impact the watershed. Additionally, pet parks and walking trails can increase the impact if their wastes are not packed out appropriately. Table 20 summarizes the estimated number of dogs and cats in the Luce Bayou watershed. Pet population estimates were calculated as the estimated number of dogs (0.614) and cats (0.457) per household according to data from the American Veterinary Medical Association 2017-2018 U.S. Pet Statistics (AVMA, 2018). H-GAC estimated the number of households in the Luce Bayou watershed at 11,151 in 2022. The actual contribution and significance of bacteria loads from pets reaching the water bodies of the watershed is unknown.

Table 20. Estimated populations for urban non-point sources of fecal waste by dogs and cats in the Luce Bayou watershed.

Watershed	Estimated Population	
	Dogs	Cats
Luce Bayou	6,847	5,096

Stormwater

The Luce Bayou watershed contains one area that is categorized as an "urbanized area," which can lead to a future stormwater permit. The City of Cleveland was considered by the U.S. Census as a designated urbanized area (USCB, 2021). The TCEQ has often considered this designation for inclusion in the stormwater permit program. Currently this area makes up 10.8 square miles or 5.3% of the Luce Bayou watershed (Figure 40). The state's stormwater permitting program describes the minimum requirements each entity must meet to ensure water quality protection and address identified impairments. Permit holders can be important to address urban pollution sources. To search for more information on a general permit (including stormwater), please visit TCEQ's Water Quality General Permits Search tool.

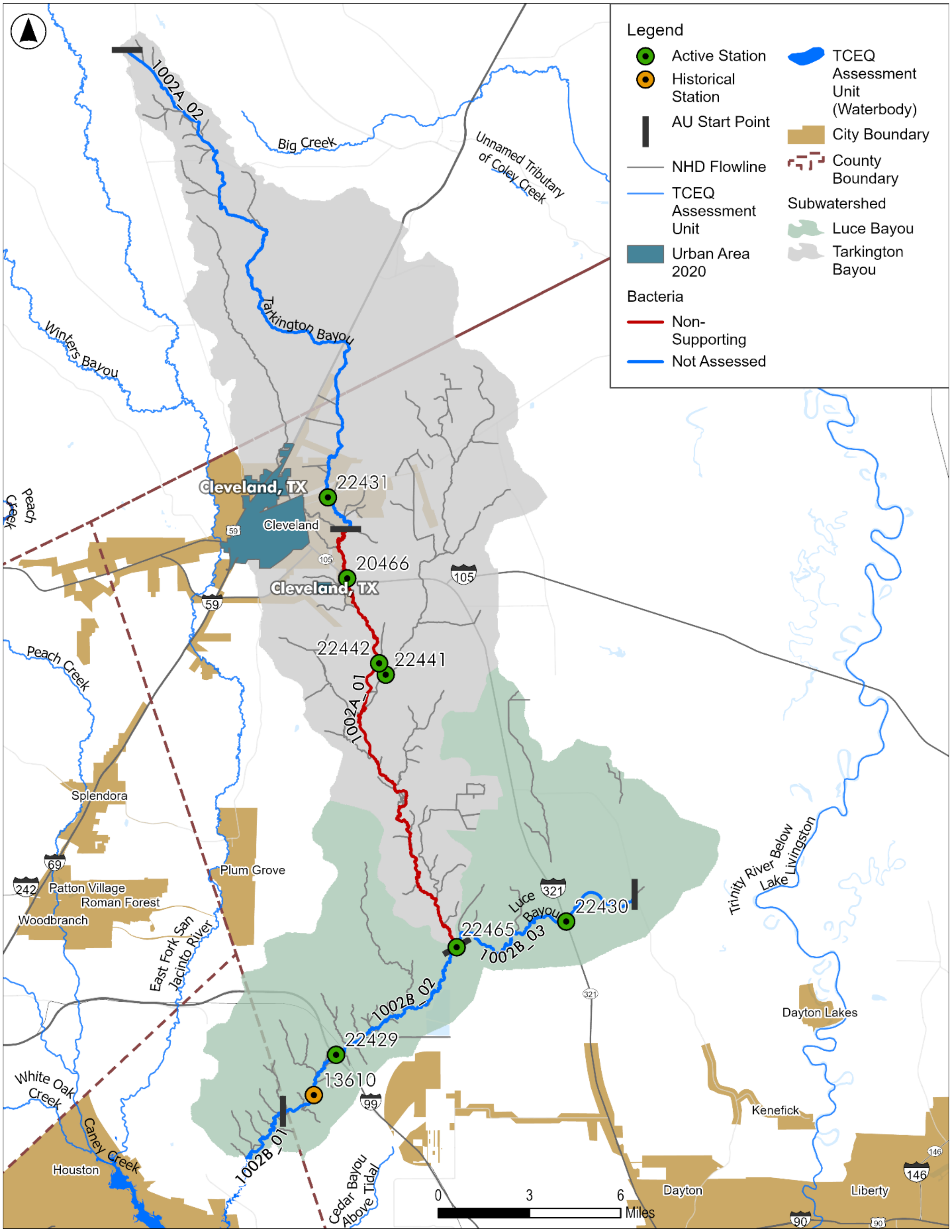


Figure 40. MS4 Permitted Areas (Urban Area 2020) for the Luce Bayou watershed.

ONGOING PROJECTS

The TCEQ's Total Maximum Daily Load (TMDL) Program is funding H-GAC to collect additional bacteria and flow data in Luce Bayou watershed. This monitoring is expected to continue into 2026. These data will be used to develop a bacteria TMDL for Tarkington Bayou's impaired AU, 1002A_01. The TMDL document will be prepared in 2026. The work will be coordinated and shared with stakeholders within the watershed. Once completed, the watershed is anticipated to be incorporated into the Bacteria Implementation Group's project area (Figure 41) and stakeholders will be invited to participate in implementing the Group's implementation plan, https://www.h-gac.com/bacteria-implementation-group. The stakeholders will be asked to deliberate on this decision and determine if this is the correct path forward. The thirty-three-member Group has amended the implementation plan in the past to expand the project area, including a watershed, the East Fork of the San Jacinto River in 2016, adjacent to Tarkington Bayou. The bacteria reduction strategies included in the Group's implementation plan or those, should the watershed stakeholders decide to create their own plan, are voluntary. Implementation success relies on the participation and actions taken by those that live, work, and/or play in the watershed to see results.

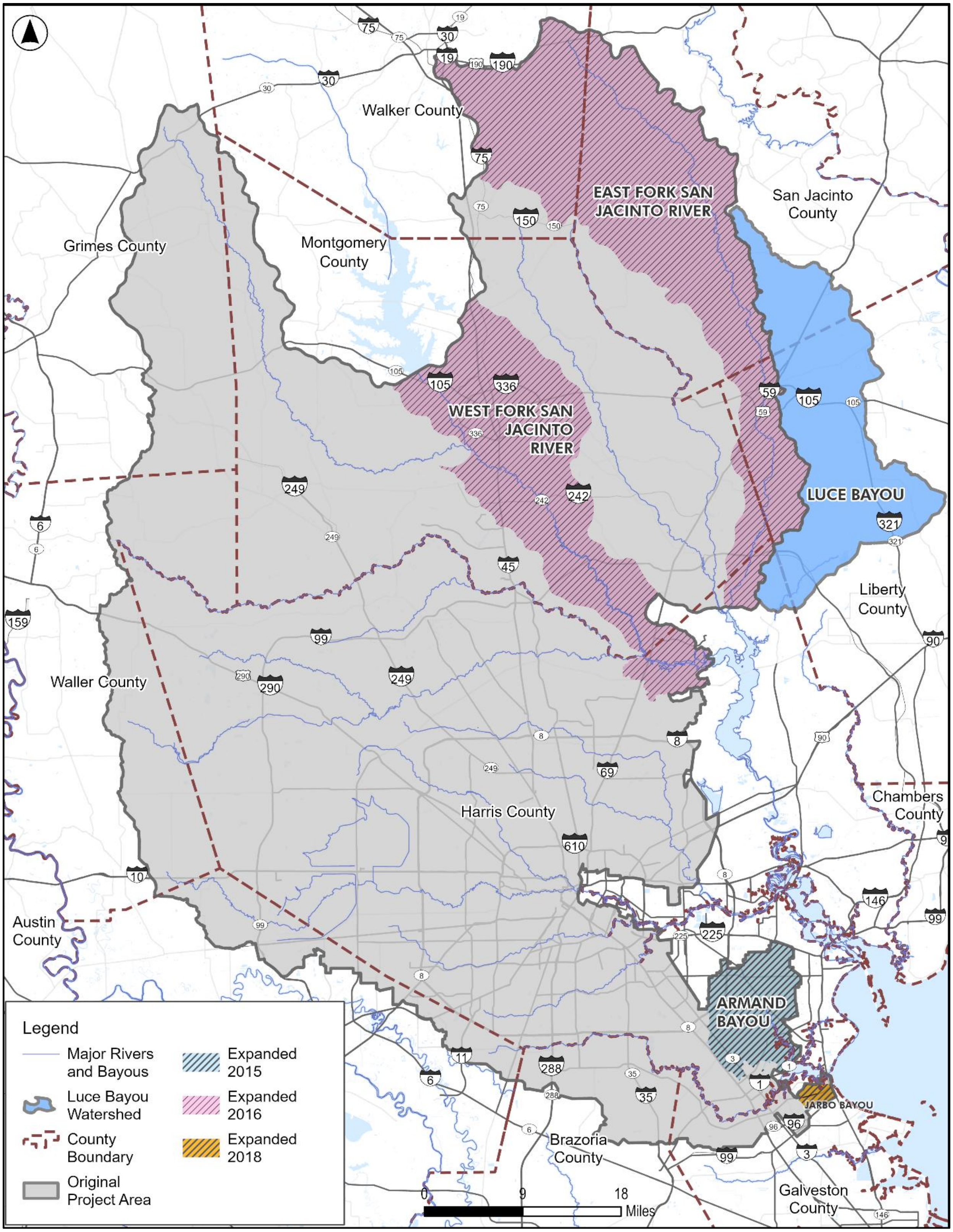


Figure 41. Bacteria Implementation Group (BIG) Project Area

POTENTIAL STAKEHOLDERS

Potential stakeholders in the Luce Bayou watershed include but are not limited to:

- Bacteria Implementation Group (BIG)
- City of Houston
- City of Cleveland
- Colony Ridge Land, LLC.
- Harris County
- Harris County Flood Control District (HCFCD)
- Houston Audubon
- Houston Canoe Club
- Galveston Bay Foundation (GBF)
- Liberty County
- Natural Resource Conservation Service, U.S. Department of Agriculture (USDA)
- National Parks Service
- NextEra Energy – Tarkington Bayou Mitigation Bank
- Sam Houston National Forest (USDA)
- San Jacinto County
- Tarkington Bayou Hunting Club, Inc.
- Tarkington Independent School District
- Texas A&M Forest Service
- Texas Commission for Environmental Quality (TCEQ)
- Texas Parks and Wildlife (TPWD)
- Texas Research Institute for Environmental Studies, Sam Houston State University
- Texas State Soil and Water Conservation Service (TSSWCB)
- The Earth Partners – Tarkington Mitigation Bank
- U.S. Army Corps of Engineers (USACE) Galveston District
- United States Geological Survey (USGS)
- Utility Districts

RECOMMENDATIONS FOR IMPROVING WATER QUALITY

Ways that potential stakeholders can take action to improve water quality in the Luce Bayou watershed include but are not limited to:

1) Participate in the development and implementation of Watershed-based Plans.
   - A Total Maximum Daily Load (TMDL) development process is about to begin for the Luce and Tarkington Bayou watersheds. The TMDL will focus on bacteria levels in the waterways and will culminate in an Implementation Plan (I-Plan) that will identify potential ways to address bacteria levels and sources. The participation of local governments, organizations, and residents in the process is critical to the success of the effort.
   - A Watershed Protection Plan (WPPs) is a voluntary effort to identify sources and pollution and measures to reduce them. A WPP can address multiple types of pollution and may be of interest to watershed stakeholders in the future.

2) Gather more information on water quality and potential pollution sources.
   - Continue collecting water quality data and expand monitoring efforts either through the Clean Rivers Program or in support of actions associated with the development of watershed-based plans.
   - Implement or expand volunteer monitoring with the Texas Stream Team. Community Scientists with the Texas Stream Team can provide water quality data in areas without professional monitoring or provide more frequent monitoring where professional monitoring is present.
   - Conduct a use attainability analysis for the waterway.

3) Identify and address point sources of pollution. Point sources of pollution can be tracked back to a specific source such as sanitary sewer overflows, wastewater treatment facility discharges, or discharges from illicit connections. These sources may be regulated or permitted.

   - Analyze Discharge Monitoring Report data and present results to TCEQ, wastewater permittees, local governments/utility districts, and stakeholders through updates to the Regional Water Quality Management Plan.
   - Analyze sanitary sewer overflow data from regulated dischargers and present results to TCEQ, wastewater permittees, local governments/utility districts, and stakeholders through updates to the Regional Water Quality Management Plan.
   - Improve compliance and enforcement of existing stormwater quality permits and improve stormwater controls in new developments.
   - Conduct targeted bacteria monitoring to identify potential infrastructure issues or illicit discharges.

4) Identify and address nonpoint sources of pollution. Nonpoint sources of pollution can stem from the actions of individuals across the watershed and combine to create issues for our waterways. Many nonpoint sources can be carried into waterways by runoff from rain events but may not be

traceable back to an origin point. However, because individual actions add to the pollution, individual actions can also help to reduce the sources of pollution.

- Support programs and resources to educate residents on the importance of proper pet waste disposal. Pet waste is identified in most watershed-based plans as a key source of bacteria in local waterways. Pet waste should always be picked up and disposed of in a waste receptacle. Specific pet waste stations can also be installed in apartment complexes or public areas like parks or trails.
- Support public education programs to inform businesses, residents, and apartment complexes on appropriate disposal of fats, oils, grease, and wipes. Fats, oils, and grease from cooking, as well as wipes that are flushed down toilets, create clogs in residential and city pipes that can lead to residential sewer backups or sanitary sewer overflows. This can bring bacteria into contact with our waterways, but more importantly into contact with residents which is a public health concern. Fats, oils, and grease should be poured into a container, cooled, and then disposed of in the trash, and wipes should be thrown away in the trash not flushed in the toilet. Individuals and businesses alike can participate in programs like Cease the Grease and Protect our Pipes.
- Support homeowner education regarding proper maintenance of on-site sewage facilities, as well as programs that assist with repairing or replacing failing systems or connect homeowners with centralized sewer collection systems where practical.
- Expand the use of low impact development and green infrastructure practices. These practices can help reduce stormwater runoff.
- Identify illegal dumping sites and improve signage and enforcement to reduce the instances of illegal dumping. When illegal dumping or floatable debris has accumulated in areas, work to clean up the site(s) utilizing existing programs such as Rivers Lakes Bays 'N Bayous Trash Bash, Stopping Plastics and Litter Along Shorelines (SPLASh), or by creating new local cleanup programs
- Support or participate in programs such as the Texas State Soil and Water Conservation Districts (SWCDs) that educate landowners on best management practices for livestock or provide resources to assist with implementing these practices.

REFERENCES

Anderson, B. 2024. Burton B. Tarkington Historical Marker. Historical Marker Database. Accessed January 08, 2025. https://www.hmdb.org/m.asp?m=179151. Last updated on Dec. 1, 2024.

AVMA (American Veterinary Medical Association). 2018. 2017-2018 U.S. Pet Ownership Statistics. Retrieved June 24, 2020, from: www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics.

H-GAC (Houston-Galveston Area Council). 2022a, 2022 15 Class Land Cover Data Set. Land Use & Land Cover Data | Houston-Galveston Area Council (H-GAC).

H-GAC (Houston-Galveston Area Council). 2022b. H-GAC Regional Growth Forecast. Accessible at: https://www.h-gac.com/regional-growth-forecast.

H-GAC (Houston-Galveston Area Council). 2024. 2024 Water Quality Management Plan Update. Accessible at: https://www.h-gac.com/water-quality-management-planning. H-GAC. August 2024.

H-GAC (Houston-Galveston Area Council). 2025a. OSSF Information System. Permitted OSSF within the H-GAC planning area. datalab.h-gac.com/ossf/

H-GAC (Houston-Galveston Area Council). 2025b. OSSF Information System-Non-Registered. Non-registered OSSF within the H-GAC planning area, non-published data 2024.

Erin M. Kiella. 2020. Knock on Wood, Overhauling East Texas Lumber Production. Texas A&M University - Real Estate Center. Publication 2264. March 16, 2020.

NOAA (National Oceanic and Atmospheric Administration). 2025 National Climate Data Center Climate Data Online. Retrieved January 22, 2025, from: www.ncdc.noaa.gov/cdo-web.

Emily A. Shrider. 2024. Poverty in the United States: 2023. U.S. Census Bureau, Current Population Reports, P60-283, U.S. Government Publishing Office, Washington, DC.

TCEQ (Texas Commission on Environmental Quality). 2022. 2022 Texas Surface Water Quality Standards. Retrieved April 15, 2025, from: 2022 Texas Surface Water Quality Standards - Texas Commission on Environmental Quality - www.tceq.texas.gov

TCEQ (Texas Commission on Environmental Quality). 2024. 2024 Integrated Report. Accessed April 15, 2025, from: https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024?b_start:int=0

TCEQ (Texas Commission on Environmental Quality). 2025a. TCEQ Central Registry. Retrieved February 5, 2025, from: www2.tceq.texas.gov/wq_dpa/index.cfm.

TCEQ (Texas Commission on Environmental Quality). 2025b. Personal written communication with Nicole Reed regarding sanitary sewer overflows within the H-GAC region. Jan. 16, 2025.

Texas Demographics Center. 2022. Texas Population Projections Program. Accessed January 28, 2025, from: https://demographics.texas.gov/Projections/2022/.

Timmons, J.B., B. Higginbotham, R. Lopez, J.C. Cathey, J. Millish, J. Griffin, A. Sumrall, and K. Skow. 2012. Feral Hog Population Growth, Density, and Harvest in Texas. August 2012. Online:agrilife.org/feralhogs/files/2010/04/FeralHogPopulationGrwothDensityandHervestinTexasedited.pdf.

TPWD (Texas Parks and Wildlife Department). 2025. Texas Ecoregions. Texas Parks and Wildlife Department. Accessed January 8, 2025. https://tpwd.texas.gov/education/hunter-education/online-course/wildlife-conservation/texas-ecoregions

TSHA (Texas State Historical Association). 1995. Anonymous, "Tarkington Bayou," *Handbook of Texas Online*, accessed January 08, 2025, https://www.tshaonline.org/handbook/entries/tarkington-bayou

TSHA (Texas State Historical Association). 1995. Anonymous, "Luce Bayou," *Handbook of Texas Online*, accessed January 08, 2025, https://www.tshaonline.org/handbook/entries/luce-bayou.

FEMA (Federal Emergency Management Agency). 2025. Flood Data Viewers and Geospatial Data, National Flood Hazard Layer, accessed February 14, 2025. Flood Data Viewers and Geospatial Data | FEMA.gov

USCB (United States Census Bureau). 2021. 2020 Census Urban and Rural Classification and Urban Area Criteria. U.S. Department of Commerce Economics and Statistics Administration. https://gis.h-gac.com/arcgis/rest/services/Census/Census_Urban_2020/MapServer

USDA (United States Department of Agriculture). 2024. US Department of Agriculture Census of Agriculture 2022. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/. Accessed February 5, 2025.

APPENDICES

APPENDIX A: ACRONYMS & ABBREVIATIONS

ALU	Aquatic Life Use
AU	Assessment Unit
BIG	Bacteria Implementation Group
BMP	Best Management Practices
CE	Collecting Entity
CFS	Cubic feet per second
CFU	Colony-Forming Unit
CMS	Coordinated Monitoring Schedule
CN	Concern for near nonattainment
CRP	Clean Rivers Program
CS	Concern for screening levels
CWA	Clean Water Act
DMU	Deer Management Units
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DSHS	Department of State Health Services
E. coli	*Escherichia coli*
EIH	Environmental Institute of Houston, University of Houston-Clear Lake
EJSCREEN	Environmental Justice Screening and Mapping Tool
EPA	U.S. Environmental Protection Agency
FO	Field Operations
FROG	Fats, rags, oils, and grease
FS	Fully Supporting designated use
FY	Fiscal Year
H-GAC	Houston-Galveston Area Council
HCFCD	Harris County Flood Control District
HH	Houston Health Department
I-Plan	Implementation Plan
IR	Texas Integrated Report for Clean Water Act Sections 305(b) & 303(d)
km	kilometer
L	liter
LDC	Load Duration Curve
LOESS	Locally Weighted Least Squares Plot
LOQ	Limit of Quantitation
mg	milligram
mg/L	milligram per liter
MGD	Millions of Gallons per Day
mi	mile
mg	milligram
mL	milliliter
MPN	Most Probably Number
MS4	Municipal Separate Storm Sewer System
MT	Monitoring Type
NC	No Concern
NCR	Noncontact Recreation
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NS	Nonsupport for designated use
OSSF	On-Site Sewage Facility
PCB	Polychlorinated biphenyl
PCR1	Primary Contact Recreation 1
PCR2	Primary Contact Recreation 2
QAPP	Quality Assurance Project Plan
RUAA	Recreational use attainment analysis
SAS	Statistical Analysis System
SCR1	Secondary Contact Recreation 1
SCR2	Secondary Contact Recreation 2
SHNF	Sam Houston National Forest
SE	Submitting Entity
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SEP	Supplemental Environmental Project
SJRA	San Jacinto River Authority
SSO	Sanitary Sewer Overflow
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TRIES	Texas Research Institute for Environmental Studies
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
UAA	Use Attainability Analysis
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WPP	Watershed Protection Plan
WWTF	Wastewater treatment facility

APPENDIX B: GLOSSARY OF WATER QUALITY TERMS

A

Algae - Plants that lack true roots, stems and leaves. Algae consist of non-vascular plants that attach to rocks and debris or float freely in the water. Such plants may be green, blue-green, or olive-green and slimy to the touch. They usually have a coarse filamentous structure.

Ambient - The existing water quality in a particular water body (beyond the immediate influence of a discharge pipe).

Ammonia-Nitrogen (NH_3) - Ammonia, naturally occurring in surface and wastewaters, is produced by the breakdown of compounds containing organic nitrogen.

Aquatic Community - An association of interacting populations of aquatic organisms in a given water body or habitat.

Aquatic Life Use (ALU) - A designation assigned to an individual water body segment based upon the potential to support aquatic life.

Assessment Unit (AU) - The smallest geographic areas of a water body that can support a designated or site-specific use.

Attainable Use - A use that can be reasonably achieved by a water body in accordance with its physical, biological, and chemical characteristics whether it is currently meeting that use or not. Guidelines for the determination and review of attainable uses are provided in the standards implementation procedures. The designated use, existing use, or presumed use of a water body may not necessarily be the attainable use.

Assessed Waters - Water bodies for which the State is able to make use-support decisions based on actual information.

B

Basin - Large geographic areas generally containing one or more watersheds.

Benthos - Aquatic organisms that live on, in, or near the bottom of a water body, including worms, leeches, snails, flatworms, burrowing mayflies and clams.

Best Management Practices (BMPs) - Schedules of activities, maintenance procedures, and other management practices to prevent or reduce the pollution of water to the maximum extent practicable. Best management practices include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bloom - The accelerated growth of algae and/or higher aquatic plants in a body of water. Bloom is often related to pollutants that increase the rate of growth.

C

Channelization - Straightening and deepening
streams so water will move faster. A method of flood control that disturbs fish and wildlife habitats and can interfere with a water body's ability to assimilate waste.

Chloride (Cl^-) - One of the major inorganic ions in water and wastewater. Concentrations can be increased by industrial processes. High chloride concentrations can affect metallic objects and growing plants.

Chlorophyll-*a* - A photosynthetic pigment found in all green plants. The concentration of chlorophyll a is used to estimate phytoplankton biomass (all of the phytoplankton in a given area) in surface water.

Classified - Refers to a water body that is listed and described in Appendix A or Appendix C of the Texas Surface Water Quality Standards.

Coastal Basin - A collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by major river basins and a bay or other outlet to the ocean.

Concentration - The amount or mass of a substance present in a given volume or mass of samples.

Conductivity - A measure of the carrying capacity for electrical current, in mhos/cm, of 1 cm^3 of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Conductivity is a measure of how salty the water is. Salty water has high conductivity.

Confluence - The flowing together of two or more streams, including where a tributary joins another, usually larger, stream segment.

Contact Recreation - Recreational activities involving a significant risk of ingestion of water; including wading by children, swimming, water skiing, diving, and surfing. See also noncontact recreation.

Contamination - Degradation of water quality due to human activity (as compared to the original or natural conditions).

Conventional Parameters - A list of basic parameters that require laboratory analyses. The parameters frequently include, but are not limited to, solids (TSS and TDS), nutrients (nitrogen and phosphorus compounds), chlorides, and sulfates.

Criteria - Water-quality conditions that are to be met in order to support and protect desired uses.

D

Designated Use - A use that is assigned to specific
water bodies in Appendix A or in Appendix D of the Texas Surface Water Quality Standards. Typical uses that may be designated for specific water bodies include domestic water supply, categories of aquatic- life use, kinds of recreation, and aquifer protection.

Dioxin - A family of polychlorinated chemicals found in waste from the paper bleaching processes and the combustion of chlorinated compounds. It is considered carcinogenic and can disrupt the reproductive and immune systems in humans.

Discharge - The rate of fluid flowing past a given point at a given time.

Dissolved Oxygen (DO) - The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.

Dissolved Oxygen (DO) Measurements, 24- hour - The measurement of dissolved oxygen over a 24-hour period using deployed, unattended, automated equipment preset to record and store field measurements over one 24-hour period.

These measurements are used to assess Aquatic Life Use.

Drought - A time of less-than-normal or less-than-expected rainfall.

E

E. coli - *Escherichia coli*, a member of the total
coliform group of bacteria found in feces. It indicates fecal contamination and the possible presence of enteric pathogens (viral, protozoan, and bacterial pathogens of the gastrointestinal route).

Effluent - Wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source) prior to entering a water body.

Enterococci - A subgroup of fecal streptococcal bacteria (mainly *Streptococcus faecalis* and *Streptococcus faecium*) found in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens.

Estuary - Regions of interaction between rivers and near shore ocean waters, where tidal action and river flow create a mixing of fresh and salt water.

Eutrophication - The process by which water becomes enriched with nutrients (particularly phosphorus and nitrogen).

F

Fecal Coliform - A subset of the coliform bacteria
group that is found in the intestinal tracts and feces of warm-blooded animals. Heat-tolerant bacteria from other sources can sometimes be included. It is used as an indicator of the potential presence of pathogens.

Field Parameters - A list of basic tests generally collected in the field using equipment and meters. The list also includes visual observations.

Flood - A relatively high streamflow that overtops the banks of a stream.

Flood Stage - The gage height (or stage) at which overflow of the natural banks of a stream begins to cause damage in the local area from flooding.

Flood Plain - The relatively level area of land bordering a stream channel that is inundated during a flood event.

Fully Supporting (FS) - The water body meets TSWQS or supports its designated uses.

G

Gage Station - A particular site on a stream segment where systematic observations or hydrologic data are obtained.

Gage Datum - A uniquely selected reference point for each gage site.

Gage Height - The distance (or height) of the stream (or lake) water surface above the gage datum (reference point). Gage height is also called stage, river height, river level, river stage, stream height, stream stage, and water height.

Geographic Information Systems (GIS) - A computerized system for combining, displaying, and analyzing geographic data.

H

Habitat - The area in which an organism lives.

Headwaters - The source and upper part of a stream.

Hydrograph - A graph of the water level or rate of flow of a body of water over time, showing the temporal or seasonal change.

I

Impaired - A designation for an associated use (aquatic life, contact recreation, etc.) where a water quality standard is not attained.

Impairment - A detrimental effect on the integrity of a water body caused by a change in the chemical, physical, or biological quality or condition of a water body that prevents attainment of the designated use.

Implementation Plan (I-Plan) - A formalized written plan developed by stakeholders to address specific concerns (e.g., bacteria) and contain policy recommendations to bring water bodies back into compliance.

Impoundment - A body of water confined by a dam, dike, floodgate, or other barrier.

Indicator Organism - An organism, species or community that indicates the presence of a certain environmental condition or conditions.

Intermittent Stream - A stream that has a period of zero flow for at least one week during most years.

L

Limit of Quantitation (LOQ) - The lowest concentration of a substance that can be accurately measured under specific conditions.

LOESS Plot - a graph that shows the relationship of two variables (measurements or parameter values) made using a technique that calculates the slope of the plotted line at different time periods (locally weighted least-squares regression), producing a line that usually shows inflections (change points) rather than a straight line that best fits all points. LOESS is not really an acronym but can be thought of as "Local regression."

M

Macrobenthic Invertebrate - Aquatic bottom- dwelling fauna. Common types are flat worms, leeches, snails, and various insect species.

Monitoring - The process of sampling and analyzing water quality parameters over time.

Municipal Separate Storm Sewer System (MS4)
- A conveyance (or system of conveyances) that is owned by a state, city, town, village, or other public entity that discharges to waters of the U.S., is designed to collect or convey stormwater (e.g., storm drains, pipes, ditches), is not a combined sewer, and is not part of a sewage treatment plant or publicly owned treatment works.

N

National Pollutant Discharge Elimination System (NPDES) - A permit program under Clean Water Act Section 402 that imposes discharge limitations on point sources based upon the effluent limitation capabilities of a control technology or on local water quality standards.

Nekton - The aggregate of actively-swimming aquatic organisms in a body of water able to move independently of water currents.

Nitrate-Nitrogen (NO_3-N) - A compound containing nitrogen that can exist as a dissolved solid in water. Excessive amounts can have harmful effects on humans and animals (>10 mg/L).

Nitrite-Nitrogen (NO_2-N) - An intermediate oxidation state in the nitrification process (ammonia, nitrite, and nitrate).

Noncontact Recreation - Aquatic recreational pursuits not involving a significant risk of water ingestion and limited body contact incidental to shoreline activity; including fishing, and commercial and recreational boating. See also contact recreation.

Nonpoint Source (NPS) Pollution - A pollution source that is not subject to regulation, that is diffuse and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

Nutrient - Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater but is also applied to other essential and trace elements.

O

Outfall - A designated point of effluent discharge.

Oyster Waters - Waters producing edible species of clams, oysters, or mussels.

P

Perennial Stream - A stream that has a continuous flow of surface water throughout the year in at least parts of its catchment area during seasons of normal flow.

Permit - A legally binding document issued by a State or Federal permitting authority to the owner or manager of a point source discharge. The permit document contains a schedule of compliance and specifies monitoring and reporting requirements.

pH - The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

Phosphorus - A nutrient that is essential to the growth of organisms. It can be the nutrient that limits the primary productivity of water. In excessive amounts from wastewater, agricultural drainage, and certain industrial waste it also contributes to the eutrophication (the natural aging progression) of lakes and other water bodies.

Pollution - The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water that renders it harmful, detrimental, or injurious to humans, animal life, vegetation, property, or the public health, safety, or welfare. Pollution may impair the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

Point Source Pollution - Any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

Polychlorinated Biphenyls (PCBs) - A class of organic compounds used in dielectric fluids in transformers, capacitors, and coolants. PCBs are highly toxic and are associated with endocrine disruption and neural toxicity in humans.

Pool - A small part of a stream reach with little-to-no velocity. Pools commonly contain water deeper than surrounding areas.

Precipitation - Any or all forms of water particles that fall from the atmosphere (such as rain, snow, hail, etc.).

Public Water Supply (PWS) Use - A water body designated to provide water to a public water system.

Q

Quality Assurance Project Plan (QAPP) - A written document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements.

R

Reach - A continuous part of a stream between two specified points.

Receiving Waters - Waters that receive treated or untreated wastewaters.

Recreational Use Attainment Analysis (RUAA) - A Use Attainment Analysis that is designed to determine if contact recreation is an appropriate use of a water body.

Reservoir - Any natural or artificial holding area used to store, regulate, or control water.

Riparian - Areas adjacent to streams or rivers with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

River Basin - A collection of watersheds drained by a major river and its tributaries.

Routine Monitoring - Monitoring that is scheduled in advance without intentionally trying to target a certain environmental condition. Routine monitoring typically consists of field measurements, conventional chemical parameters, bacteria, and flow measurements.

Runoff - The part of precipitation or irrigation water that runs off land into streams and other surface water.

S

Screening Level - Established targets (instream concentrations) for parameters that establish targets that can be directly compared to monitoring data. Screening levels are derived from long-term monitoring data or published levels of concern.

Sediment - Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water and deposited in reservoirs and slow-moving areas of streams and rivers.

Segment - A water body or portion of a water body that is individually defined and classified in the Texas Surface Water Quality Standards. A segment is intended to have relatively homogeneous chemical, physical, and hydrological characteristics. A segment provides a basic unit for assigning site-specific standards and for applying water quality management programs. Classified segments may include streams, rivers, bays, estuaries, wetlands, lakes, and reservoirs.

Sonde - A multi-parameter water quality monitoring device that calculates and records field parameters.

Specific Conductance - A measure of the ability of a liquid to conduct an electrical current.

Standards - The designation of water bodies for desirable uses and the narrative and numerical criteria deemed necessary to protect those uses.

Stormwater - Rainfall runoff, snow-melt runoff, surface runoff, and drainage.

Stream Mile - A distance of one mile along a line connecting the midpoints of the channel of a stream.

Stream Order - A ranking of the relative sizes of streams within a watershed based on the nature of their tributaries. The smallest unbranched tributary is called first order, the stream receiving the tributary is second order, and so on.

Subwatershed - Any of several drainage areas that flow to a specific location and collectively form a watershed.

Sulfate (SO_4^{2-}) - An ion derived from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Sulfates are widely distributed in nature.

Surface Water - An open body of water, such as a lake, river, or stream.

Surface Water Quality Monitoring Information System (SWQMIS) - A database that serves as a repository for surface water quality monitoring data for the state of Texas. SWQMIS also provides data validation and reporting tools, a mapping interface, and modules for tracking information about projects and quality assurance documents.

T

Texas Surface Water Quality Standards (TSWQS) - Standards that establish explicit goals for the water quality of streams, rivers, lakes, and bays throughout the state. The Standards are developed to maintain the quality of surface waters in Texas so that it supports public health and enjoyment and protects aquatic life, consistent with the sustainable economic development of the state. Water quality standards identify appropriate uses for the state's surface waters,
including aquatic life, recreation, and sources of public water supply. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code.

Tidal - Descriptive of coastal waters subject to the ebb and flow of tides. For purposes of standards applicability, tidal waters are saltwater. Classified tidal waters include all bays and estuaries with a segment number that begins with 24xx, all streams with the word tidal in the segment name, and the Gulf of America (Gulf of Mexico in the 2024 IR).

Total Dissolved Solids (TDS) - The amount of material (inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of milligrams per liter.

Total Maximum Daily Load (TMDL) - The total amount of a substance that a water body can assimilate and still meet the Texas Surface Water Quality Standards.

Total Suspended Solids (TSS) - The amount of organic and inorganic suspended particles in water.

Toxic Pollutants - Materials contaminating the environment that cause death, disease, and/or birth defects in organisms that ingest or absorb them.

Tributary - A stream or river that flows into a larger one.

U

Use Attainability Analysis (UAA) - A structured scientific assessment of the factors affecting a water body's attainment of specified uses.

W

Water body - Refers to any mass of water (lake, bay, river, creek, bayou, etc.).

Water Quality - The chemical, physical, and biological characteristics of water.

Watershed - The area of land from which precipitation drains to a single point. Watersheds are sometimes referred to as drainage basins or drainage areas.

Watershed Protection Plan (WPP) - A voluntary, locally led approach to address state water quality standard impairments along with other water-related concerns.

APPENDIX C: WATER QUALITY TECHNICAL PRIMER

The Water Quality Technical Primer is provided as an overview of general water quality terminology. In combination with the Glossary, the Technical Primer provides background and defines terminologies and methodologies used to acquire, analyze, and report the data that is presented in the Basin Highlights Report.

THE FEDERAL CLEAN WATER ACT

The Clean Water Act establishes the basic structure for regulating pollutant discharges, pollutant loadings in water, and regulating surface water quality standards. The goal of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. §1251(a)). Amendments to The Clean Water Act in 1977:

- Established the basic structure for regulating pollutant discharges into the waters of the United States;
- Gave the US Environmental Protection Agency (EPA) the authority to implement pollution control programs such as setting wastewater standards for industry;
- Maintained existing requirements to set water quality standards for all contaminants in surface waters;
- Made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions;
- Funded the construction of sewage treatment plants under the construction grants program; and
- Recognized the need for planning to address the critical problems posed by nonpoint source pollution.

POLLUTION

The Texas Administrative Code defines pollution as "the alteration of the physical, thermal, chemical, or biological quantity of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose."

There are two categories of pollution: Point Source and Nonpoint Source Pollution.

<u>Point Source pollution</u> is any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

<u>Nonpoint Source (NPS) pollution</u> is any source that is not subject to regulation, that is diffuse and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

TEXAS SURFACE WATER QUALITY STANDARDS

The Texas Surface Water Quality Standards (TSWQS) establish numerical and narrative goals to maintain the quality of streams, rivers, lakes, and bays throughout the state. Appendix A and Appendix D of the TSWQS establish the geographic boundaries and the appropriate standards for each body of water. The standards are developed to maintain the quality of surface waters. Standards ensure public health and enjoyment, protect aquatic life, and remain consistent with the sustainable economic development of the state. The Texas Commission on Environmental Quality (TCEQ) develops the TSWQS under the authorization of the U.S. Clean Water Act and Texas Water Code. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code. The standards are approved by the EPA.

The TSWQS are designed to:

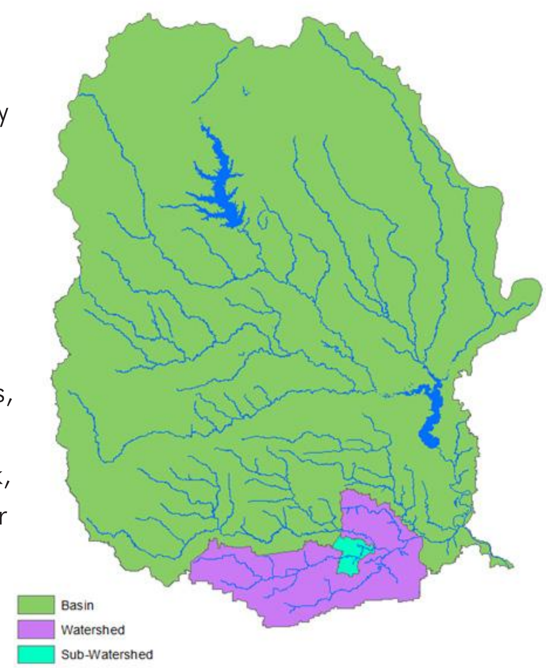
- Designate the uses, or purposes, for which the state's water bodies should be suitable;
- Establish numerical and narrative goals for water quality throughout the state; and
- Provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals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

The criteria adopted and incorporated into the standards are the allowable concentrations of pollutants in State, Territory, and authorized Tribal waters and are developed for the protection of aquatic life and human health. Impairments occur when water quality conditions do not meet the assigned uses or criteria as defined in the TSWQS.

DRAINAGE AREAS — BASINS, WATERSHEDS, AND SUB-WATERSHEDS

A watershed is a defined geographic area that waterways flow through on the way to a common body of water. Basins are larger geographic areas generally containing one or more watersheds. A river basin is a collection of watersheds drained by a major river and tributaries. A coastal basin is a collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by two major river basins and a bay or other outlet to the ocean.

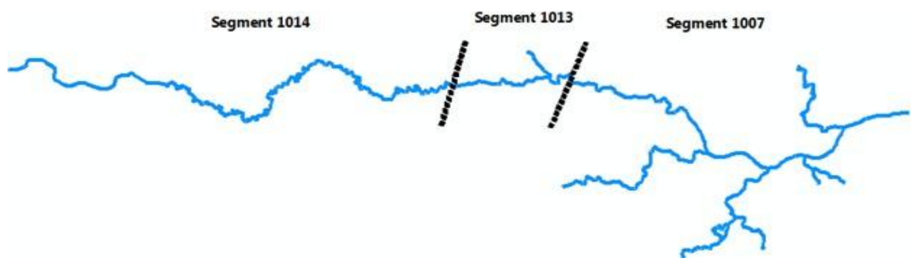
Watersheds can be broken down into even smaller drainage areas, which are referred to as sub-watersheds For example, a sub-watershed could be defined as the drainage area of a small creek, stream, or portion of a stream that is part of the drainage area for a tributary, which is part of a major river drainage basin.



WATER BODIES, SEGMENTS, AND ASSESSMENT UNITS

The term water body is used to refer to any mass of water. A water body can be contained in a lake or a bay, or flow, such as a river, creek, or bayou. The TCEQ divides water bodies in the state into distinct segments that generally represent natural watersheds and are intended to have similar chemical, physical, and hydrological characteristics. Each segment is assigned a four-digit code. The first two digits identify the river basin, and the last two digits identify the segment. Segments can be either classified or unclassified.

Classified Segments

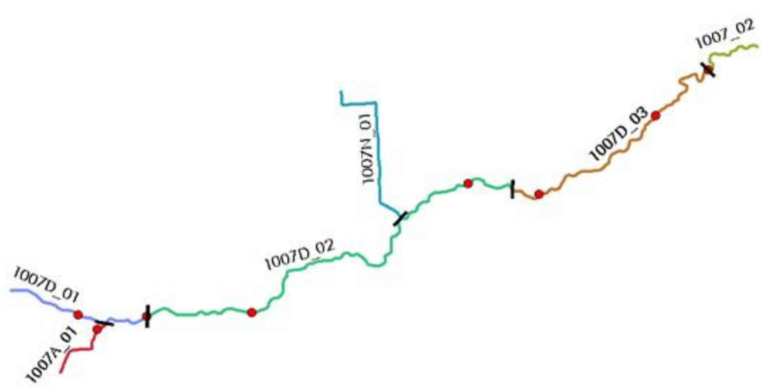


A classified segment is a water body (or portion of a water body) that is individually defined in the TSWQS. Typically, classified segments are major waterways. Site specific numerical criteria are developed to evaluate the uses and overall water quality of a classified segment. The parameters evaluated include bacteria, nutrients, and dissolved oxygen. Site-specific numerical criteria are developed to evaluate the uses and water quality of classified segments. These uses include aquatic life use and recreational use (discussed later in the primer).

Unclassified Segments

Unclassified segments are often tributaries of classified segments. These segments are usually assessed based on the criteria of the classified segment into which they flow. However, some unclassified segments have been assigned specific water quality standards in the TSWQS. Unclassified segments are assigned the same four-digit code as the classified segment and a letter that is specific to that waterway.

Assessment Units (AUs)



For assessment purposes, each segment is subdivided into hydrologically distinct units, or assessment units (AUs). AUs are the smallest geographic areas of a water body that can support a designated or site-specific use. A segment may have one or multiple AUs, depending on water quality conditions or flow in different sections of the water body. Each AU has the same four or five-digit code as the segment followed by an AU identifier (e.g., _01, _02, etc.). If there are multiple AUs, the assessment units will generally be in sequential order (e.g., 1007D_01, 1007D_02, etc.). Each AU is evaluated separately as part of the assessment.

For example, Sims Bayou Above Tidal (1007D) is divided into three AUs. The red dots represent monitoring stations. Monitoring stations have been placed on the downstream and upstream ends of each AU in 1007D. Tributary 1007A has one monitoring station close to the confluence with the parent stream 1007D.

WATER QUALITY AND DESIGNATED USES

As defined in the TSWQS, a water body can be assigned specific uses including aquatic life, public water supply, and contact recreation use. Designated uses typically have corresponding numeric criteria listed in the TSWQS. General criteria apply across the entire state, but if sufficient information is available for a specific water body, the site-specific standards may be developed.

Aquatic Life Use

Aquatic life use (ALU) is determined by the amount of dissolved oxygen and the abundance and diversity of species. Aquatic life use consists of five categories: minimal, limited, intermediate, high, and exceptional. In Texas, water bodies not specifically listed in Appendix A or D of the TSWQS are presumed to have a high aquatic life use and corresponding dissolved oxygen criteria. This use is assessed using 24-hour dissolved oxygen data along with nekton and macrobenthic invertebrate community evaluations.

Public Water Supply Use

Public water supply (PWS) use includes an evaluation of chloride, sulfates, and total dissolved solids in the water body. Criteria for these parameters are set so that public water supplies are capable of treating and delivering water of acceptable quality.

Recreational Use

Recreational use refers to how safely a water body can support activities that involve the possibility of ingesting or coming into contact with water. If activities are likely to result in ingestion of water (swimming, diving, tubing, surfing, wading by children), bacteria concentrations need to be lower. The TSWQS protects human health by setting numeric criteria in a water body relative to the types of recreational activity occurring on that water body. Fecal indicator bacteria levels are measured to determine risk. Criteria are expressed as the number of bacteria per 100 milliliters (mL) of water [in terms of colony-forming units (CFU), most probable number (MPN), or other applicable reporting measures]. The presence of fecal indicator bacteria in waters suggests that human and animal wastes may be reaching the assessed waters. In freshwater, the indicator organism is *Escherichia coli* (*E. coli*). Enterococci bacteria are the indicator for tidal water bodies.

There are five categories of recreational use, which are based on the type and frequency of recreation.

- Primary Contact Recreation 1 (PCR1) – Activities that are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and the following whitewater activities: kayaking, canoeing, and rafting).

- Primary Contact Recreation 2 (PCR2) – Water recreation activities, such as wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and whitewater kayaking, canoeing, and rafting, that involve a significant risk of ingestion of water but that occur less frequently than for PCR1 due to physical characteristics of the water body or limited public access.

- Secondary Contact Recreation 1 (SCR1) – Activities that commonly occur but have limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating). These activities are presumed to pose a less significant risk of water ingestion than PCR1 or PCR2 but more than secondary contact recreation 2.

- Secondary Contact Recreation 2 (SCR2) – Activities with limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating) that are presumed to pose a less significant risk of water ingestion than SCR1. These activities occur less frequently than SCR1 due to physical characteristics of the water body or limited public access.

- Noncontact Recreation (NCR) – Activities that do not involve a significant risk of water ingestion, such as those with limited body contact incidental to shoreline activity, including birding, hiking, and biking. NCR use may also be assigned where primary and secondary contact recreation activities should not occur because of unsafe conditions, such as ship and barge traffic.

Primary contact recreation is the presumed recreational use in Texas water bodies unless there is evidence to show that the water body is not used for primary contact recreation. A Recreational Use Attainability Analysis (RUAA) is necessary to change the presumed use of a water body.

WATER QUALITY MONITORING

Surface Water Quality Monitoring (SWQM) Program

TCEQ's Surface Water Quality Monitoring Program evaluates the physical, chemical, and biological characteristics to ensure that it is suitable for general or designated uses. Water quality is monitored and evaluated in relation to human health concerns, ecological conditions, and designated uses. Data collected under the SWQM program is utilized by the TCEQ to provide a basis for effective policies that promote the protection, restoration, and wise use of the state's surface water.

Surface water samples are collected for assessment purposes following the methodologies outlined in TCEQ's *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods* (TCEQ Publication RG-415) (colloquially referred to as "SWQM Procedures"). The guidelines outlined in the SWQM

Procedures manual document the methods and the quality assurance procedures that must be used to demonstrate that data collected by monitoring personnel across the state are of a known and adequate quality. All data collected by H-GAC and its partners are collected following SWQM procedures.

Water quality data, including data collected under SWQM and the Clean Rivers Program, are stored in the Surface Water Quality Monitoring Information System (SWQMIS). This database is used to enter, manage, track, and report on water quality-related data.

Coordinated Monitoring Schedule (CMS)

The Coordinated Monitoring Schedule (CMS) is the combined schedule for all surface water quality monitoring in Texas. Monitoring entities within a basin or region meet annually to establish and coordinate monitoring schedules as a way to ensure appropriate coverage, reduce duplication of effort, and better utilize available resources.

The CMS lists:

- Monitoring stations
- Collecting Entities (CE)
- Submitting Entities (SE)
- Monitoring Type (MT)
- Parameters
- Monitoring frequency

The Coordinated Monitoring Schedule is available online at cms.lcra.org

Quality Assurance Project Plan (QAPP)

H-GAC's Clean Rivers Program Quality Assurance Project Plan (QAPP) describes H-GAC's quality assurance policies, management structure, and procedures used to implement the quality assurance requirements for the Clean Rivers Program. These policies and procedures are necessary to verify and validate data collected for the Clean Rivers Program. The QAPP is reviewed and approved by TCEQ to help ensure that all data generated are of known and documented quality, deemed acceptable for their intended use and that the data have been collected and managed in such a way as to guarantee its reliability. Only quality-assured data may be used for water quality assessments or other regulatory purposes. H-GAC's current and previous QAPP documents are available on H-GAC's website at h-gac.com.

Monitoring Types

Monitoring activities may be divided into the following categories:

- Routine Monitoring
- Special-Study Monitoring
- Permit-Support Monitoring
- Systematic Monitoring

The type of monitoring conducted by the Clean Rivers Program is usually routine, meaning it is monitoring that is scheduled in advance without intentionally trying to target any certain environmental condition, with samples being collected regardless of the conditions encountered. Routine monitoring, at a minimum, includes field measurements [DO, pH, specific conductance, temperature], conventional chemical parameters (nutrients, chloride, sulfate), bacterial measurements (*E. coli* or enterococci), and flow measurements (if applicable for that water body). Please see Appendix C: Water Quality Parameters for a detailed description of each parameter.

Another monitoring type conducted by the Clean Rivers Program is biased monitoring (monitoring targeted to a season, time, or condition) measurements, such as 24- hour DO. In this procedure a data sonde (a water quality monitoring device that calculates and records field parameters) is deployed to measure DO every 15 minutes for 24 hours. After the deployment period, the data is analyzed, and the 24-hour average and absolute minimum are calculated. The DO average and absolute minimum are used to assign an ALU category to a water body. For example, exceptional aquatic life use has a 24-hour average of 6.0 mg/L and an absolute minimum of 4.0 mg/L.

ASSESSMENT OF WATER QUALITY DATA

The provisions of Sections 305(b) and 303(d) of the Clean Waters Act require the TCEQ to provide the *Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)* (Integrated Report) to the EPA every two years. The report contains a list of water bodies evaluated, water bodies assessed by basin, impaired water bodies (303(d) List), water bodies of concern, water bodies either newly listed or removed from the 303(d) List, and other supporting information.

For the assessment, TCEQ evaluates data collected during a seven-year period. The time frame is extended to 10 years (if needed) to attain the minimum number of data points needed for the assessment. Each assessed water body is identified as:

- <u>Fully Supporting</u> – At least 10 data points (20 for bacteria) are available for an assessment, and the water body meets TSWQS or supports designated uses

- <u>Of Concern</u> – There are two levels of concern, CN and CS. CN means there is concern for near nonattainment of the TSWQS based on numeric criteria. A concern status of CN indicates that standards are not being met, but there is insufficient data to fully assess the water body. CS means that there is a concern for water quality based on screening levels. Screening levels are used when there is not a defined standard (as with nutrients) and are derived from statistical distributions of statewide water quality monitoring data, with the 85th percentile for each applicable parameter is used as the screening level criteria.

- <u>Impaired</u> – Data indicates that the water body does not meet standards. Impaired water bodies are placed on the 303(d) List.

When a water body is determined to be impaired, several things must happen:

- The water body must be listed on the 303(d) List;

- An evaluation must be undertaken to determine what is preventing the water body from supporting its designated use(s) or if the use(s) are appropriate.

- Steps must be taken to either remedy the problem, collect additional data, or evaluate which uses are appropriate for the water body. These steps may include additional monitoring, development of a Total Maximum Daily Load (TMDL) or Watershed Protection Plan (WPP), or a review of the water quality standards.

After assessment, water bodies are placed into one of five categories (with subcategories). These categories indicate the water quality status of the water body. These categories (as well as subcategories), and their descriptions, are:

1. Attaining all water quality standards and no use is threatened.
2. Attaining some water quality standards and no use is threatened; and insufficient data and information are available to determine if the remaining uses are attained or threatened.
3. Insufficient data and information are available to determine if any water quality standard is attained.
4. Water quality standard is not supported or is threatened for one or more designated uses but does not require the development of a TMDL.
   4a TMDL has been completed and approved by EPA.
   4b Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.
   4c Nonsupport of the water quality standard is not caused by a pollutant.
5. The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.
   5a A TMDL is underway, scheduled, or will be scheduled.
   5b A review of the water quality standards for the water body will be conducted before a TMDL is scheduled.
   5c Additional data and information will be collected before a TMDL is scheduled.
   5n Water body does not meet its applicable chlorophyll-*a* criterion, but additional study is needed to verify whether exceedance is associated with causal nutrient parameters or impacts to response variables.
   5r A WPP is under development or accepted by EPA for this parameter.

If a previously assessed AU has insufficient data available during the assessment period for the most recent Integrated Report, this results in a carry-forward of the impairment listing from the previous report.

MANAGEMENT MEASURES FOR IMPAIRED WATER BODIES

If sufficient data is available to determine that a water body is impaired and does not meet standards, a management measure can be utilized to address the impairment.

- A Total Maximum Daily Load (TMDL) is a method used to determine the amount (load) of a pollutant an impaired water body can receive daily and still meet water quality standards and designated uses. After a load is calculated for the pollutant sources, an implementation plan (I-Plan) is drafted by the water body's stakeholders outlining management measures to be used to return the target pollutant to the calculated load. An I-Plan's management measures are usually voluntary actions but can, if recommended by stakeholders, include regulatory actions.

- A Watershed Protection Plan (WPP) is a community and stakeholder driven framework that uses a holistic/watershed approach to address potential sources of impaired waterways. The plan is developed with community involvement, and the measures to reduce pollutants are voluntary.

- A Use Attainability Analysis (UAA) determines if the natural characteristics of a water body cannot attain the currently designated uses and/or criteria. Natural characteristics include temperature, pH, DO, diversity of aquatic organisms, amount of streamflow, and physical conditions such as depth. If there is a consensus among stakeholders and resource agencies that a presumed or designated use may not be appropriate for a water body, a UAA may be conducted to determine the most appropriate use(s).

- A Recreational Use Attainment Analysis (RUAA) is used to determines if contact recreation use occurs in a water body. A waterway may have physical characteristics or limited public access that would not warrant a contact recreation use designation.

APPENDIX D: STATISTICAL METHODOLOGY

The identification of long- and short-term trends is important to many stakeholders, and these trends are important components of H-GAC's work, particularly in relation to the evaluation and revision of regional monitoring efforts and priorities. H-GAC staff used several methods of analyses to characterize surface water quality in the H-GAC region. Trend analysis can identify cases where the value of a water quality parameter is changing over time. Statistical tests are performed to distinguish statistically significant trends from random and seasonal variation. While it might seem reasonable to use all the data available for these analyses, as the amount of data increases the likelihood of finding a statistically significant but unimportant trend also increases. To minimize this, H-GAC performed trend analysis on the most recent 7 years (January 1, 2017 – Aug 31, 2024) of TCEQ-validated data to highlight recent trends in water quality in the region.

All data management and statistical analysis were performed using Statistical Analysis System (SAS). Complete details of data selection, preparation, and analysis can be found in the SAS code, which is available upon request.

Data Selection and Processing

For analyses in this report, H-GAC staff selected water quality data collected between 01/01/2017 and 08/31/2024 from data downloaded from SWQMIS. All data used for these analyses were collected under a TCEQ-approved QAPP. Qualified data (data added to SWQMIS with qualifier codes that identify quality, sampling, or other problems that may render the data unsuitable) were excluded from the download.

Variables in each dataset were transformed as appropriate, and new variables were created to facilitate analysis and graphical display of results. In some cases, data from two or more STORET (method) codes (Table 21) were combined because the results obtained from each method can be considered equivalent. Any data collected at a depth greater than 0.3 meters, or not collected under a routine ambient monitoring program, were deleted.

Censored data (data reported as < [parameter limit of quantitation (LOQ)]) were transformed to a value of one-half the parameter LOQ associated with the data, with some important exceptions. Because nutrient LOQs have been lowered over time, the presence of data censored at many different LOQs in the same dataset poses several problems. If the data for a given parameter are censored at values well above a later, lower LOQ value, trend analysis could suggest a trend where no real water quality trend is present. There is no ideal solution to this problem. Editing the censored data alone would limit, but not eliminate, false trends. In cases where some of the data reflected use of a lower LOQ than the current H-GAC Clean Rivers Program LOQ, values were transformed to one-half of the H-GAC Clean Rivers Program's LOQ to minimize the identification of trends caused by changing analytical methods. H-GAC does not believe the impact from this transformation is significant. The impact of this analysis would be most pronounced for parameter trends typically found at concentrations at or near the LOQ in that specific water body.

Table 21. STORET Codes and Parameters for Trend Analysis

STORET Code	Parameter	Units
00061	Instantaneous Flow	cfs
00094	Specific Conductance	µmhos/cm @ 25°C
00010	Temperature	°C
00300	Dissolved Oxygen	mg/L
00078	Secchi Transparency	Meters
00400	pH	S.U.
31699	*E. coli*	MPN/100mL
31701	Enterococci	MPN/100mL
32211	Chlorophyll-*a* (Spectrophotometric)	µg/L
70953	Chlorophyll-*a* (Fluorometric)	µg/L
00665	Total Phosphorus	mg/L as P
00610	Ammonia-Nitrogen Total	mg/L as N
00630	Nitrite+Nitrate*	mg/L as N
00620	Nitrate Nitrogen, Total	mg/L as N
00625	Total Kjeldahl Nitrogen	mg/L as N
00530	Total Suspended Solids	mg/L
00940	Chloride	mg/L as Cl
00945	Sulfate	mg/L as SO_4

*Nitrate+Nitrite was selected when available, but some labs have reported nitrate rather than Nitrate+Nitrite. These two parameters were considered equivalent for the purpose of analysis.

Trend Analysis for the Regional Water Quality Summary ("Frog Chart")

The "Frog Chart" is an index constructed by H-GAC to capture the degree of impairment/concerns for selected parameters (Dissolved Oxygen, Bacteria, Chlorophyll-a, Nutrients, PCBs/Dioxin, and a category for Other impairments) in each segment. H-GAC's assessment of the health of these water bodies is a stream length-weighted summary of the impairments/concerns in each segment and is weighted based upon the percentage of the segment exhibiting the impairment or concern. This index is the basis for assigning a frog count to each segment. Segments are assigned from zero to five frogs, with the higher frog count indicating fewer impairments and concerns and better overall water quality.

In 2015, H-GAC staff compiled a subset of stations in classified segments believed to be most representative of segment water quality by selecting one to three stations that were statistically representative of a given parameter in a given segment. Means and standard deviations of parameter values are calculated for each station, and those stations with means and standard deviations closest to the overall mean and standard deviation for the segment and parameter combination were selected. Preference was given to stations where stream flow was measured, and final selections were reviewed for reasonableness. In most cases, the station, or stations at the most downstream location of the segment was the most statistically representative. Selection relied on SAS procedures PROC MEANS and PROC RANK. The same subset of stations has been used since 2015 to allow consistent comparisons across regional water quality summaries created for different years.

A conservative trend analysis was performed using seven years of recent data (01/01/2017 – 08/31/2024) at the selected representative monitoring stations in the classified portion of each watershed to detect trends at the watershed level for the H-GAC Regional Water Quality Summary ("Frog Chart"). Trends were identified by nonparametric correlation analysis and simple linear regression. Because nonparametric methods are less sensitive to extreme values in the data than parametric techniques like linear regression, trends that were suggested by linear regression analysis alone were not included in the chart.

Trends for the "Frog Chart" analysis were considered statistically significant if the p-value was below 0.05, which is the standard significance level used in most applications.

Some adjustments to the final frog count were made by H-GAC staff based on best professional judgment, in order to capture attributes not fully revealed by the SAS data analysis. Waterbodies where no monitoring data were collected, except for assessment based on oyster waters, trend and frog analyses were omitted.

APPENDIX E: GENERAL USE DATA VISUALIZATIONS

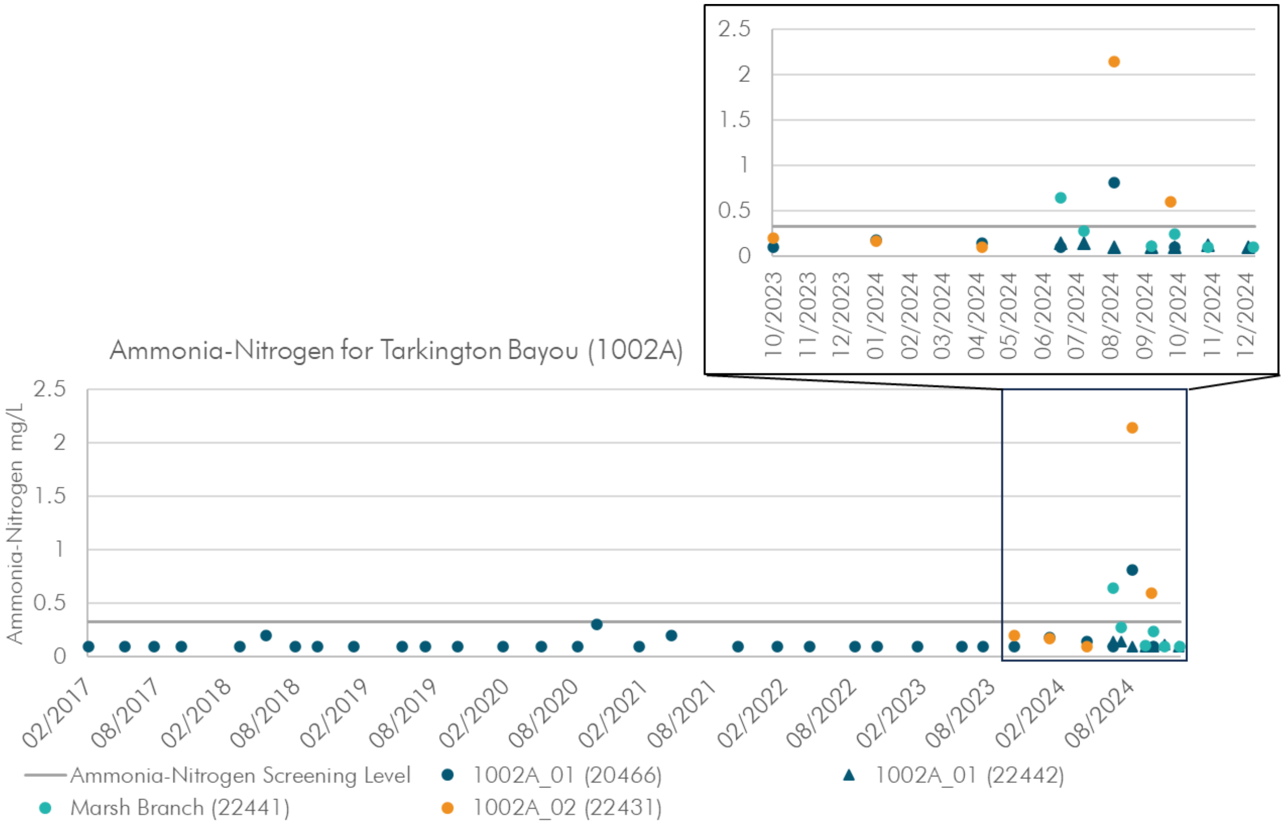


Figure 42. Ammonia-nitrogen (NH_3) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The NH_3 screening level of 0.33 mg/L is plotted in grey line.

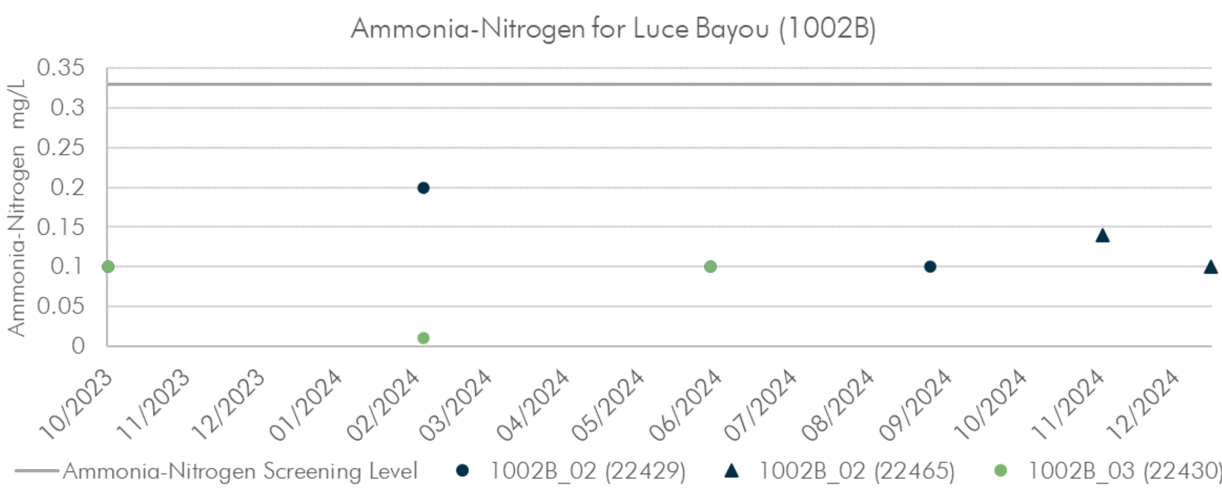


Figure 43. Ammonia-nitrogen (NH_3) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The NH_3 screening level of 0.33 mg/L is plotted in grey line

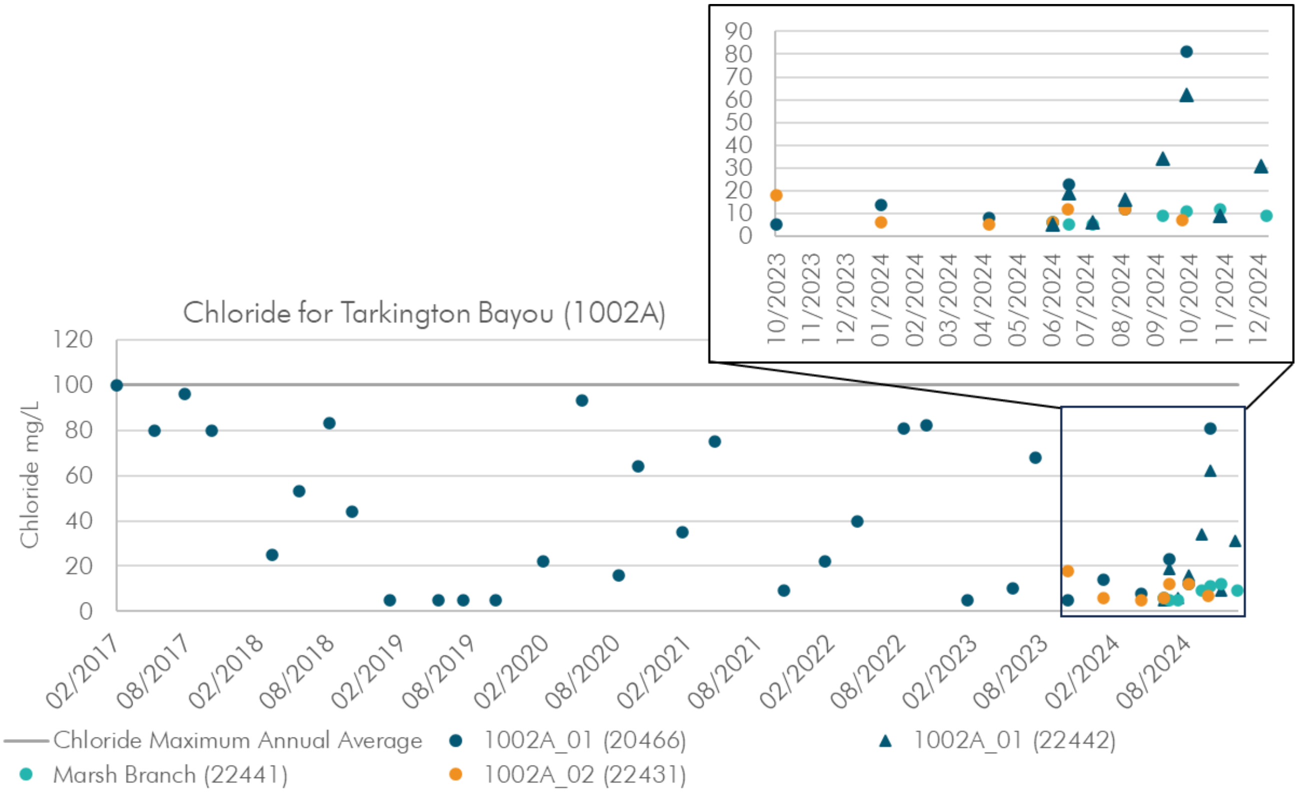


Figure 44. Chloride (Cl-) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The Cl- standard of 100 mg/L for the receiving water body, Lake Houston (1002), is plotted in grey line.

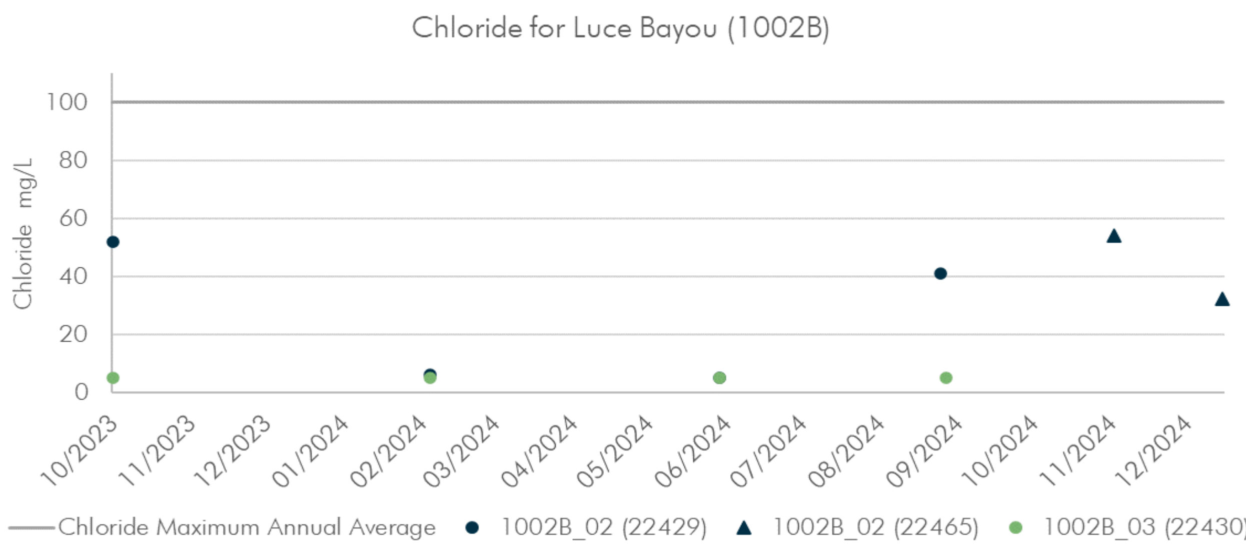


Figure 45. Chloride (Cl-) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The Cl- standard of 100 mg/L for the receiving water body, Lake Houston (1002), is plotted in grey line.

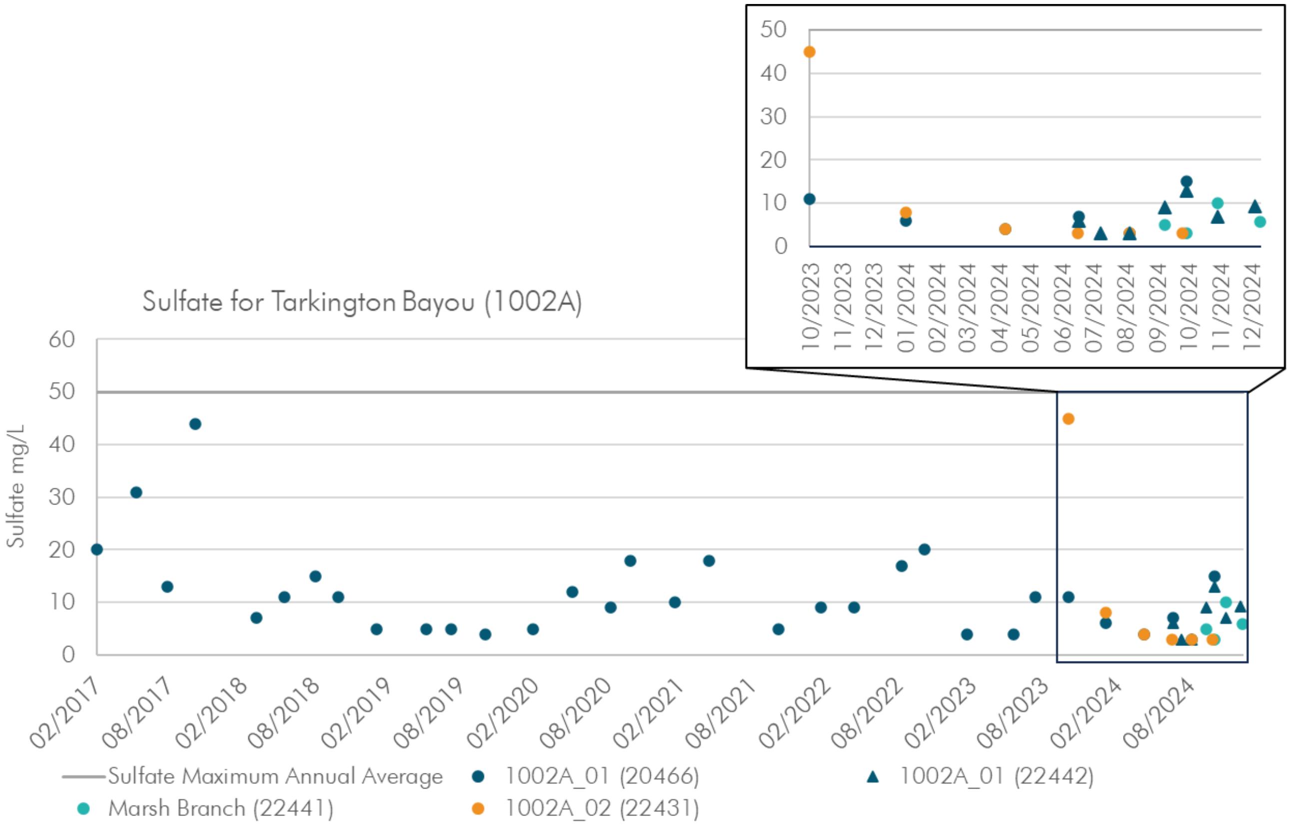


Figure 46. Sulfate (SO_4^{2-}) grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The SO_4^{2-} standard of 50 mg/L for the receiving water body, Lake Houston (1002), is plotted in grey line.

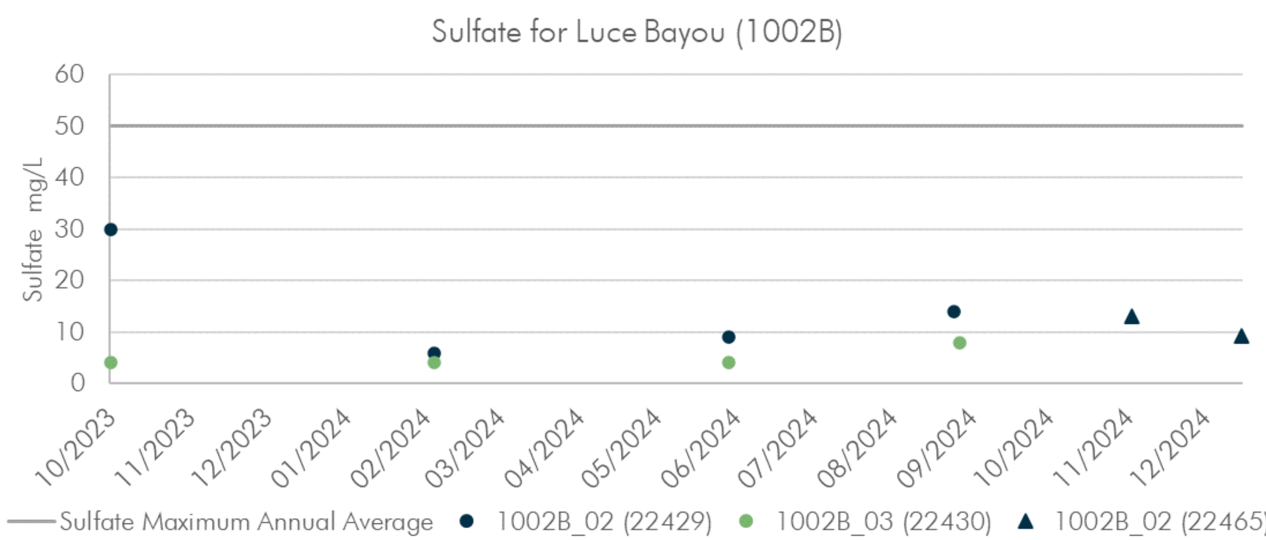


Figure 47. Sulfate (SO_4^{2-}) grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The SO_4^{2-} standard of 50 mg/L for the receiving water body, Lake Houston (1002), is plotted in grey line.

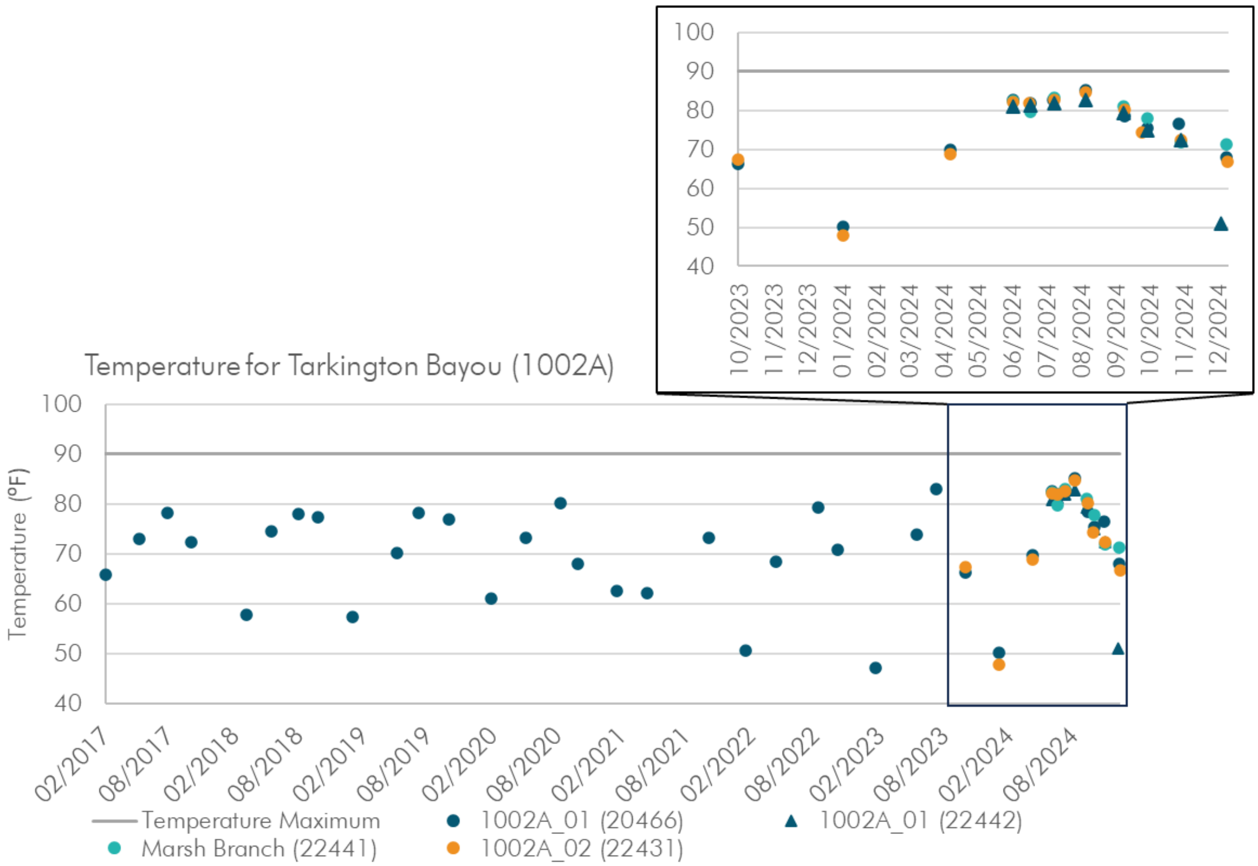


Figure 48. Temperature grab results by assessment unit (AU) through time for Tarkington Bayou, segment 1002A. The temperature standard of 90ºF for the receiving water body, Lake Houston (1002), is plotted in grey line.

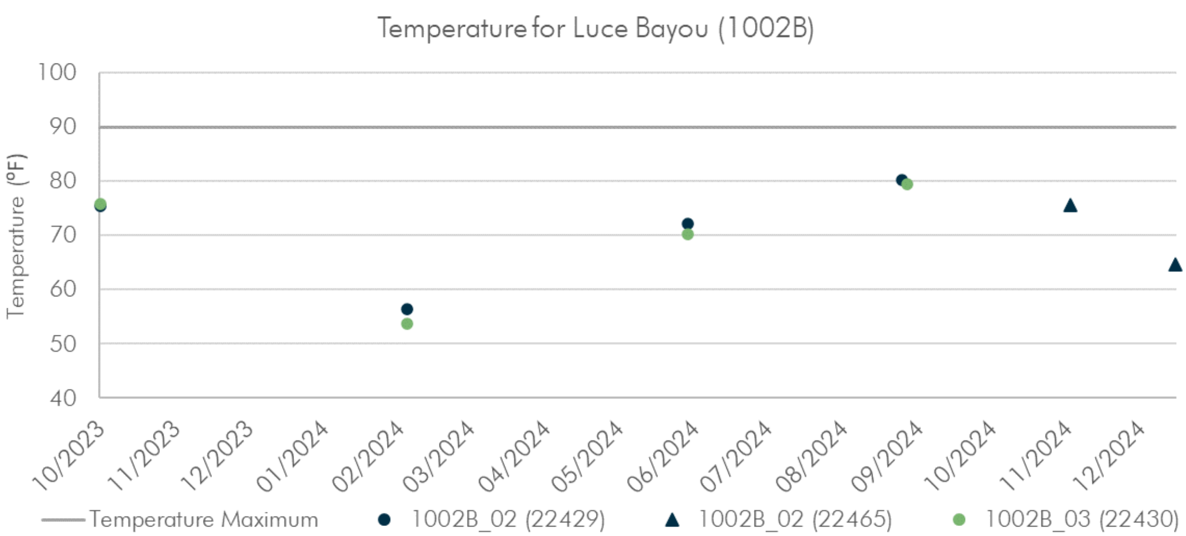


Figure 49. Temperature grab results by assessment unit (AU) through time for Luce Bayou, segment 1002B. The temperature standard of 90ºF for the receiving water body, Lake Houston (1002), is plotted in grey line.