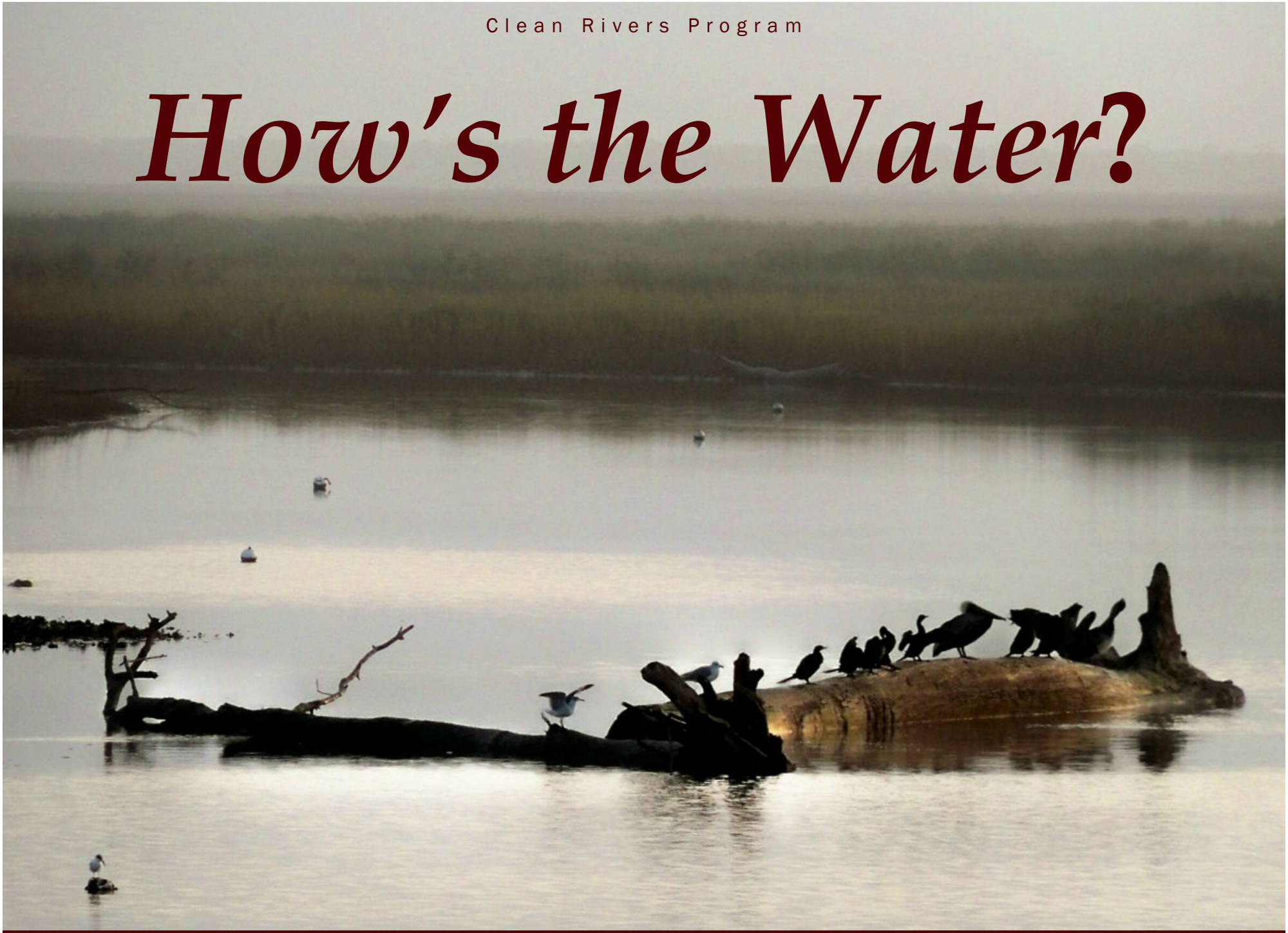
Clean Rivers Program

How's the Water?



2013 Houston-Galveston Area Council Basin Highlights Report

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Introduction

The Texas Clean Rivers Act requires an ongoing statewide assessment of water quality issues and management strategies as a guide for water resources policy and decision-making. The Act established the Texas Clean Rivers Program under the Texas Water Commission (now the Texas Commission on Environmental Quality, or TCEQ. The Act requires river authorities to prepare written reports for the Governor, TCEQ, the Texas State Soil and Water Conservation Board (TSSWCB) and the Texas Parks and Wildlife Department on the results of the basin assessment process in their respective basins. The Clean Rivers Program works to ensure safe, clean water for the future of Texas - for drinking water needs, for industry, for irrigation, for recreation, for healthy ecosystems and for all other uses.

Regionally, the Houston-Galveston Area Council Clean Rivers Program is the state-designated lead assessment agency for the San Jacinto River Basin, the Trinity-San Jacinto Coastal Basin, the San Jacinto-Brazos Coastal Basin and the Brazos-Colorado Coastal Basin. H-GAC oversees all aspects of the Clean River Program in these basins and is responsible for the following tasks:

- project administration
- quality assurance
- water quality monitoring
- data management
- data analysis and reporting
- stakeholder participation and public outreach

Clean Rivers Program Assessment Basins

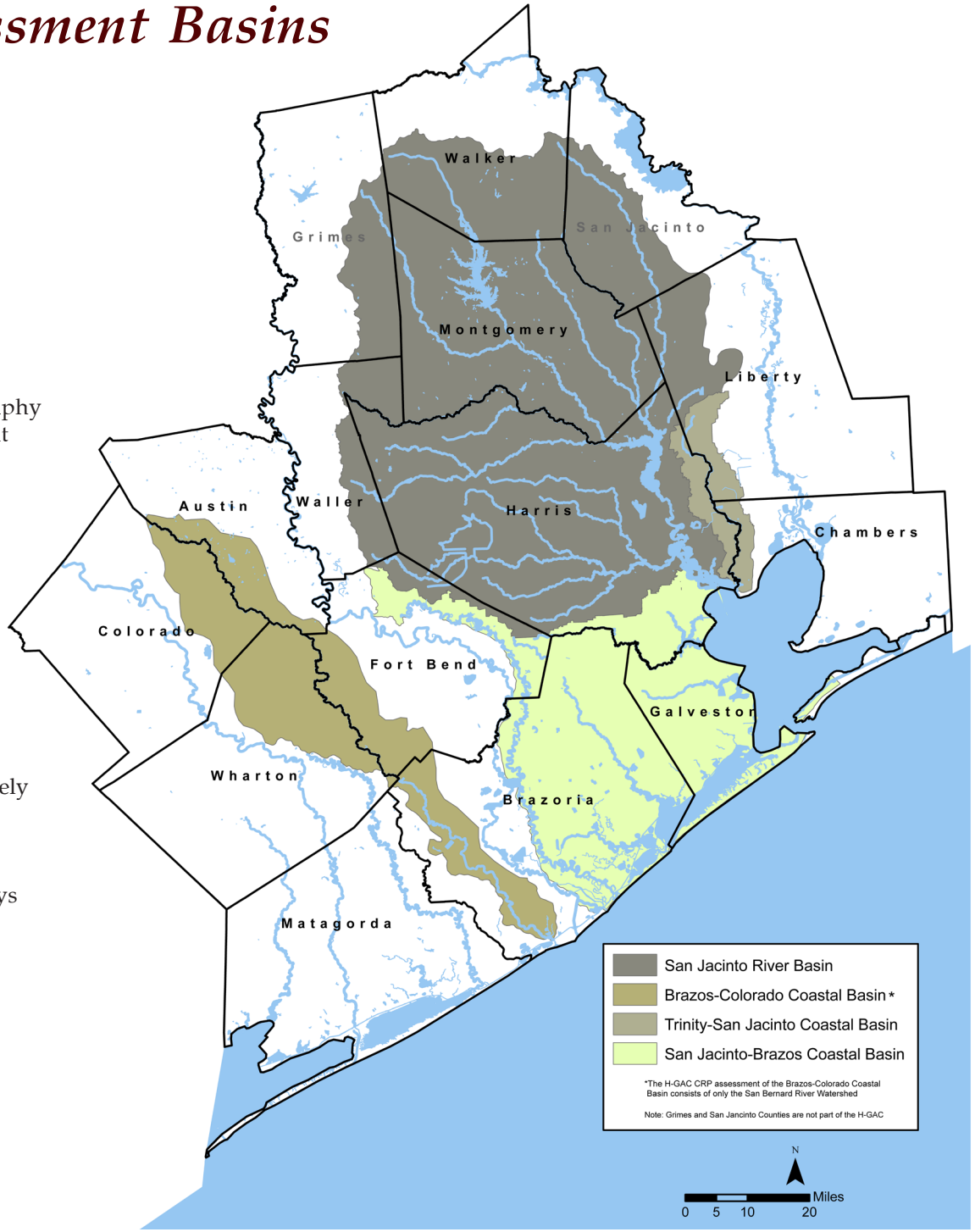
The H-GAC region includes 13 counties in southeast Texas. The region includes four river basins containing a total of 39 watersheds encompassing 51 classified segments.

Land uses range from scattered development with large acreages of undeveloped land to dense industrial development. This provides a challenging array of issues for water quality management.

The area receives an average of 45 inches of rain each year. Topography ranges from just over 400 feet in the northern counties to sea level at Galveston Bay and the Gulf Coast. Surface water bodies include streams, rivers, bayous, lakes, reservoirs, estuaries and the open waters of Galveston Bay and the Gulf of Mexico.

The San Jacinto River's headwaters are in areas of undeveloped forested land used primarily for grazing. Scattered small towns and communities are found along the San Jacinto. Further downstream is more dense development from the northern suburbs of Houston through the core of the city and to the highly industrial Houston Ship Channel, where the river drains into Galveston Bay and ultimately to the Gulf of Mexico.

The coastal basins typically drain from agricultural areas to moderately dense urban settings. The southwestern portion of the San Jacinto-Brazos Coastal Basin, the Trinity-San Jacinto Coastal Basin and the Brazos-Colorado Coastal Basin segments drain through small rural communities, industrial areas, coastal wetlands and estuaries, to bays and then the Gulf of Mexico.



Basin Highlights Report Overview

Although there are not currently state water quality standards for nutrients, 74% of streams in the H-GAC Clean Rivers Program (CRP) region have elevated levels of nutrients. In response to concerns about nutrient levels, the TCEQ is beginning to develop nutrient standards.

For this Basin Highlights Report, H-GAC staff chose to highlight six watersheds that demonstrate significant trends in nutrient concentrations - Cedar Bayou Above Tidal, Lake Houston, Cypress Creek, Buffalo Bayou Above Tidal, Lake Creek and Clear Creek Above Tidal.

Each watershed summary includes:

- Segment Description
  A description of the segment, assessment unit boundaries in each segment, historically monitored sites and sites believed to be responsible for the impairment or interest
- Hydrologic Characteristics
  Streamflow variability, reservoir dynamics, seasonality of flow, typical flow trends
- Land Use and Natural Characteristics
  The land surrounding the segment, including cities, agricultural lands, permitted discharges, landfills, quarry operations, industrial areas, animal feeding operations, and oil and gas operations
- Description of Water Quality Issue
  Identification of why the water body is listed and when it first appeared on the 303(d) list or why it is an area of interest, including the number of samples, parameters of concern or impairment, assessment results, and appropriate state standards for comparison
- Potential Sources of Water Quality Issues
  Possible sources of water quality issues identified through the use of satellite imagery, watershed surveys, and communication with stakeholders and staff from local and state agencies
- Potential Stakeholders
  Companies, agencies, organizations, or individuals who have a vested interest in the area
- Recommendations for Improving Water Quality
  Proposed next steps based on the potential sources of impairment or interest
- Ongoing Projects
  Current or future projects that will occur in the segment
- Major Watershed Events
  Anticipated or known occurrences that have the potential to either positively or negatively impact water quality

The summaries include:

- **photographs of the watershed and areas of interest**
- **maps showing waterways, potential sources of pollution, land cover and assessment units (AUs)**
- **graphs and charts indicating water quality trends**

Regional Issues

The *Texas Water Quality Integrated Report (IR)* describes the status of Texas' natural waters based on historical data. It identifies water bodies that are not meeting state standards.

Water bodies must meet certain standards for recreational uses, including swimming, wading and fishing, or they will be listed as "impaired" or as having a screening level "concern" by the TCEQ.

Water quality issues in the region vary and include:

Bacteria
High levels of bacteria can be harmful to people, and their occurrence may indicate fecal matter or dangerous pathogens are present.

Sources of bacteria contamination in the region can include
- wastewater treatment facilities (WWTF) effluent with inadequate treatment, by-passes, and sanitary sewer system overflows;
- runoff from on-site sewage facilities (OSSFs); and
- runoff contaminated with waste from pets, wildlife, and livestock.

Dissolved Oxygen
Low dissolved oxygen (DO) levels hamper the ability of the waterway to sustain aquatic life, including fisheries.

DO levels can be negatively impacted by
- concentrations of nutrients in area waterways;
- amounts of organic/inorganic matter washing or being discharged to streams;
- loss of in-stream habitat to channel modifications or development; and
- reduced stream side canopy. (Shaded streams are usually cooler and can support higher DO concentrations.)

Nutrients
In high concentrations, nutrients can cause taste and odor problems in drinking water, as well as health issues. Nutrients can lead to algae growth. Decomposing algae also consume oxygen, threatening a water body's aquatic population.

Sources of nutrient pollution can include
- WWTF effluent or stormwater flow from permitted outfalls;
- illegal dumping;
- urban runoff from construction and development;
- runoff from fertilized lawns;
- runoff from natural gas or oil well pumping and gathering facilities;
- runoff from industry;
- runoff from golf courses and parks;
- runoff from OSSFs; and
- runoff from agricultural related operations.

PCBs and Dioxin
PCBs and dioxin are chemical compounds that can cause severe human issues. Advisories about high levels of these compounds in fish tissue in Galveston Bay have led to impairment concerns for its tributaries.

For a snapshot of water quality issues in the H-GAC region, see page 6.

Basin Highlights Report Methodology

H-GAC completed a conservative trend analysis of ambient data from up to three representative monitoring stations in the classified portion of each segment. This analysis used methods that are not sensitive to extreme values in the data. H-GAC staff also reviewed pre-drought data to identify current trends that might reflect sample collection during non-representative conditions. Staff then analyzed data suggesting statistically significant trends using a time-series technique (SAS Unobserved Components Modeling) to ensure that the observed trends were not the result of seasonal variation alone. A subset of segments was selected for this Basin Highlights Report based on the degree of change observed in the parameter, the current status of the segment (degree of impairment, length of time on the 303d list, Total Maximum Daily Loads (TMDLs) or Watershed Protection Plans in progress), and the relationship between trends within the segment.

For example, if evidence of increasing nutrient concentrations and declining dissolved oxygen concentrations was obtained from the trend analysis for a segment not currently listed for a dissolved oxygen problem, that segment would be favored over a segment showing only one trend for a constituent that was the focus of an existing TMDL program.

Summary of Water Quality Impairments and Concerns in the H-GAC Region

Ranking Key

The numbers represent the percent of total segment length that is impaired or of concern for each parameter. Cells without numbers represent stream segments that are currently meeting state standards but may be improving or degrading for each parameter.

Severe, multiple water quality impairments and/or concerns exist in the majority of the water body.

Significant, multiple water quality impairments and/or concerns exist in a majority of the water body.

Impairments or concerns exist in a substantial portion of the water body.

Impairment or concern exists in the water body.

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

Improving	Degrading

** Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

Basin and Segment Name	Segment Number	DO	Bacteria	Chlorophyll *a*	Nutrients	Dioxin/ PCBs	Other*	Frog(s)
Cedar Bayou	0901		100	100		100		
Cedar Bayou Above Tidal	0902							
Buffalo Bayou Above Tidal	1014	8.6	84.4		72.8			
Buffalo Bayou Tidal	1013	30.8	63.3		36.4		27	
Caney Creek	1010	16.1	34.6					
Cypress Creek	1009	41	84.6		84.6		10.4	
East Fork San Jacinto River	1003		100					
Greens Bayou Above Tidal	1016	5.4	91.2		80.3			
Houston Ship Channel	1006	3.5	47.2	4.9	63.8	36.7	36.7	
Houston Ship Channel/Buffalo Bayou Tidal	1007	17.9	73.9		87.7	24.2	24.2	
Houston Ship Channel/San Jacinto River Tidal	1005				83.8	100		
Lake Conroe	1012	4.9		16.4				
Lake Creek	1015	66.5	40.2					
Lake Houston	1002		6.8	14.5	42.2		0.1	
Peach Creek	1011		100					
San Jacinto River Tidal	1001					43.4		
Spring Creek	1008	37.6	71.7	1.1	22.3		11.7	
West Fork San Jacinto River	1004		61		27.3			
Whiteoak Bayou Above Tidal	1017	3.5	84.6		80.8			
Armand Bayou Tidal	1113	62.9	59.7	12	17.9	25		
Bastrop Bayou Tidal	1105	80.2	86.3		6.6			
Chocolate Bayou Above Tidal	1108	100	100				100	
Chocolate Bayou Tidal	1107		100			100		
Clear Creek Above Tidal	1102	60.5	79.5		76.6	47.6	12.8	
Clear Creek Tidal	1101	41.6	72.8	8.3	17.9	27.6		
Dickinson Bayou Above Tidal	1104		41.3				41.3	
Dickinson Bayou Tidal	1103	62.5	86.9	10.1		48.4		
Old Brazos River Channel Tidal	1111			100				
Oyster Creek Above Tidal	1110	66.3	24.2	24.2				
Oyster Creek Tidal	1109		100					
San Bernard River Above Tidal	1302	61.8	62.6		9.5			
San Bernard River Tidal	1301		100	100				

Basin and Segment Name	Segment Number	DO	Bacteria	Chlorophyll *a*	Nutrients	Dioxin/ PCBs	Other*	Frog(s)
Barbours Cut	2436				100	100		
Bastrop Bay / Oyster Lake	2433							
Bayport Ship Channel	2438			100	100	100		
Black Duck Bay	2428			100	100	100		
Burnett Bay	2430			100	100	100		
Chocolate Bay	2432	35.6	62.6		4.8	38.7		
Christmas Bay	2434							
Clear Lake	2425	8.4	18.4	65.1	80	92.3		
Drum Bay	2435							
East Bay	2423	30		100		100		
Lower Galveston Bay	2439			100		100		
Moses Lake	2431			19.6	19.6	54.4		
San Jacinto Bay	2427			100	100	100		
Scott Bay	2429			100	100	100		
Tabbs Bay	2426				72	72		
Texas City Ship Channel	2437			100	100	100		
Upper Galveston Bay	2421			89.5	95.7	100		
West Bay	2424	9	4.3	11.4	1.3	88.5		
Gulf of Mexico	2501						44	

Water quality impairments and concerns are identified in the *Texas Draft 2012 Integrated Report (IR)* for Clean Water Act Sections 305(b) and 303(d), formerly called the Texas Water Quality Inventory and 303(d) List. The IR is a comprehensive evaluation of the condition of surface waters in the Texas based in historical monitoring data and provides resource managers with a tool for making informed decisions when directing agency programs. It identifies water bodies that are not meeting standards set for their use in the Texas Surface Water Quality Standards, published in Title 30, Chapter 307 of the Texas Administrative Code. The federal Clean Water Act requires TCEQ to submit an updated IR to the EPA every two years.

Acronyms

2010 IR	*2010 Integrated Report*
ALU	Aquatic Life Use
AU	Assessment Unit
BIG	Bacteria Implementation Group
CFS	Cubic Feet Per Second
CRP	Clean Rivers Program
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
Draft 2012 IR	*Draft 2012 Integrated Report*
EIH	Environmental Institute of Houston
EPA	Environmental Protection Agency
H-GAC	Houston-Galveston Area Council
I-Plan	*Bacteria Reduction Implementation Plan*
MGD	Million Gallons Per Day
OSSF	On-Site Sewage Facility
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TMDL	Total Maximum Daily Load
TPDES	Texas Pollution Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
USGS	U.S. Geological Survey
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility

Regional Issues

50% Stream miles are impaired by bacteria.

24% Stream miles are impaired or have a concern for low Dissolved Oxygen (DO).

29% Stream miles have a nutrient concern.

76% Tidal waterways are impaired by PCBs/dioxins.

0902 - Cedar Bayou Above Tidal

Length 25.7 Miles (classified portion)	**Watershed Area** 145.5 Square Miles
Texas Stream Team Monitors 0	**Permitted Outfalls** 19
Number of Active Monitoring Stations 3	
Designated Uses Contact Recreation; High Aquatic Life; Public Water Supply	

Segment Description:

The segment lies in the Trinity-San Jacinto Coastal Basin. The stream segment begins at a point 4.6 miles upstream of FM 1960 in Liberty County and flows 25 miles downstream to a point 1.4 miles upstream of I-10 on the Chambers/Harris County line. The above tidal segment drains a watershed area of 145.5 square miles.

In the *Draft 2012 Integrated Report* (*Draft 2012 IR*), there is only one assessment unit (AU) identified for evaluation and no unclassified water body associated with this segment at this time. This segment currently has three active routine monitoring stations. Site 11120 is a long-time monitoring station located in the middle of the segment. Site 11123, which is located in the upper half of the segment, was added to the monitoring schedule in the fall of 2008. Site 11118, which is located at the downstream end of the segment, but not a part of the *Draft 2012 IR*, was added to the schedule in the fall of 2011. In December 2012, two other special study monitoring stations were added to collect extra data for future modeling activities and best management practices implementation associated with the development of a Watershed Protection Plan (WPP). See Figure - 6 on page 13 for a location of all the stations, both routine and special study related. Figure - 5 on page 12 provides a complete description of the CRP monitoring sites and sampling being conducted in FY2013.

Hydrological Characteristics:

Besides receiving flow from general runoff, this waterway receives WWTF effluent or stormwater flow from 19 permitted outfalls scattered throughout the segment and occasional discharges or flow from irrigated crops. A U.S. Geological Survey (USGS) flow gage has been operating at site 11120 for many years. Records show a daily discharge average of 12 cubic feet per second (CFS) at this site. The entire upper half of this 25-mile long waterway has been channelized on one or both banks in the past 10 to 15 years making it subject to flash flows.

Land Use & Natural Characteristics:

The majority of this watershed is used for agricultural purposes with sod/grass farms being the dominant crop today. Row crops, rice and hay production occur to a lesser extent. While there are no concentrated animal operations in the watershed, cattle are common throughout, especially where fields have been allowed to go fallow. See Figure - 6 on page 13 for more details.

Figure - 1

Summary of Water Quality Impairments and Concerns - Segment 0902-Cedar Bayou Above Tidal							
Segment ID	**Bacteria**	**Dioxin/PCBs**	**DO**	**Chlorophyll *a***	**Nutrients**	**Other***	**Frog(s)****
0902			100				

Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 6 (?= no stations/no data in the assessment unit)*

In the upper half of the watershed, the waterway has been modified or channelized. Beginning 0.4 miles upstream of FM 1960, mowed grass banks are the only vegetated buffer between the water and the agricultural fields. Conversely, the downstream half of the waterway has wide riparian buffers composed of forests and woody wetlands on both sides of the stream. See Figure - 6 on page 13.

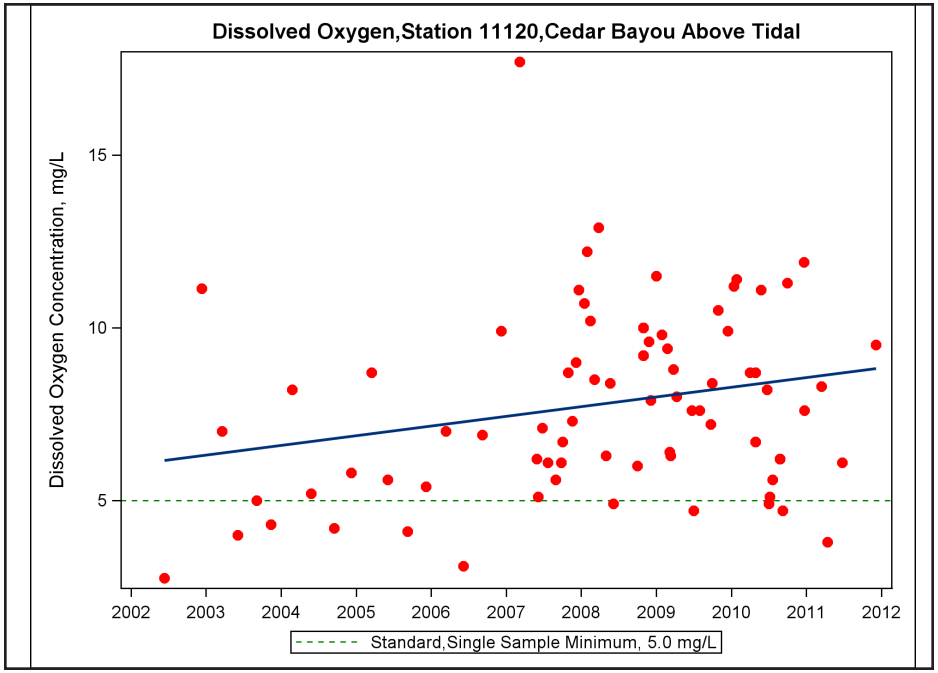
Industrial and urban development is concentrated in the extreme southern potion of the watershed within the city of Mount Belvieu, along Texas Highway 146 just northeast of Baytown. Small ranchettes are the primary type of rural residential development throughout the rest of the watershed. Most are serviced by OSSFs. In recent years, residential development has accelerated along three major transportation corridors in the watershed. The corridors are: I-10 – just outside the southern end of the watershed, U.S. Highway 90 – in the middle of the watershed, and FM 1960 – in the upper portion east of Lake Houston and near Huffman. Historically, oil and natural gas production was fairly common. Today, only a few active production facilities exist.

Description of Water Quality Issues:

This segment's designations include contact recreation, public water supply and high aquatic life use (ALU). The contact recreation designation is fully met with bacteria concentrations consistently measured below the grab standard of 394 MPN/100 mL and the geometric mean of 126 MPN/100 mL. The public water supply use designation is also met with chloride, sulfate, and total dissolved solids (TDS) being found below the maximum standards.

Segment 0902 was identified in the *2010 Integrated Report (2010 IR)* as having a concern for DO because grab samples had frequently been measured below the grab screening level of 5.0 mg/L. However, in the *Draft 2012 IR*, the concern was removed. An analysis performed by H-GAC indicates that grab sample concentrations have been improving over the past 10 years. Figure - 2 on page 9 shows the DO concentration trend for station 11120 located at U.S Highway 90. The trend shows that most of the grab measurements are above or only slightly below the screening level. To confirm the segment has no concerns for DO, H-GAC and Environmental Institute of Houston (EIH) have deployed multi-parameter sondes throughout the watershed to measure concentrations against the 24-hour standards instead of the screening level. A full year of 24-hour deployment results are expected to be gathered before the *2014 Integrated Report* is completed. A summary of key impairments and concerns appears in Figure - 1 on page 9 for this segment. H-GAC's analysis to create this summary also confirms that DO is improving in the segment. Chlorophyll *a* concentrations are declining as well.

Figure - 2



The *2010 IR* also included a concern for a degraded macrobenthic community in the segment. Additional biological sampling in this segment in FY2011 revealed that the ALU for this segment was being met and therefore, the concern was removed in the *Draft 2012 IR*. Despite past channelization, the macrobenthic community in the bayou seems to have recovered from the disturbance and loss of habitat.

H-GAC's data analysis also indicates nitrate nitrogen concentrations are declining. While not a concern for this segment, data shows there has been a downward trend over the past 10 years. There was a period between 2006 and 2009 when concentrations appeared to be on the rise, but since 2009 the nitrate concentrations have stayed below 0.8 mg/L, which is half of the screening level. Figure - 3 on page 10 illustrates this downward trend. H-GAC also analyzed the relationship between *E.coli* density, total phosphorus concentrations, and stream flow. Figure - 4 on page 10 indicates that as flow increases both *E.coli* density and total phosphorus concentrations increase. Similar analyses were performed for data from other segments discussed in this report.

Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite photography to identify a variety of potential sources of pollution in this segment. Figure - 7 on page 14 identifies the limited number of potential sources of pollution or points of interest. Agriculture-related activities and wastewater disposal (WWTFs and OSSFs) are the two primary sources of pollution.

Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes and sanitary sewer system overflows;
- runoff from OSSFs; and
- runoff contaminated with waste from pets, and wildlife; and
- runoff from fields used for cattle grazing.

There are 19 permitted WWTFs in this watershed and some or all are likely sources of most of the nutrient load in many segments, but there are no significant domestic wastewater discharges into the above tidal portion of Cedar Bayou. The flow in Cedar Bayou is almost entirely dependent on rainfall, and flow rates dropped to zero during the peak of the recent drought. Runoff from rain events appears to be the primary source of both nutrients and bacteria. This watershed has the highest concentration of agricultural uses of the segments discussed in this report. Fertilizer and livestock waste runoff, as well as OSSF runoff and pet waste, are the likely sources of nutrient loading in the bayou.

Figure - 3

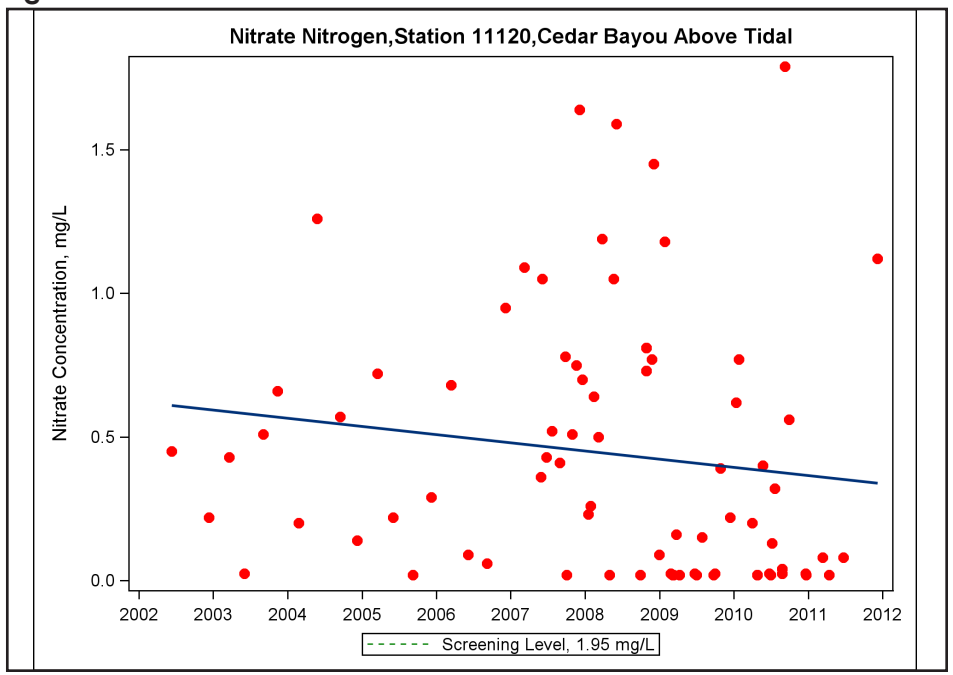
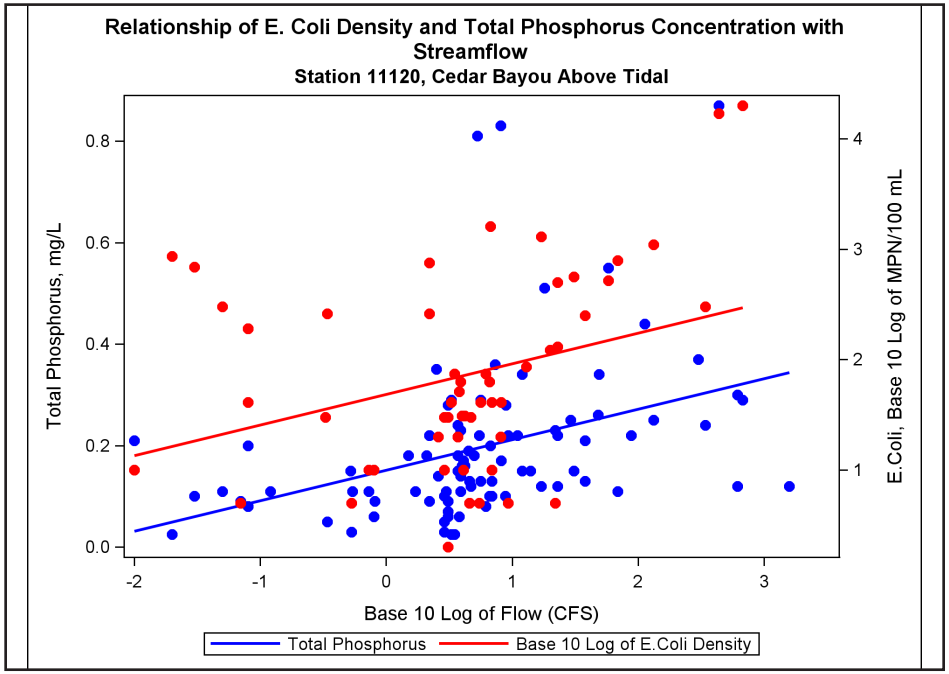


Figure - 4



DO levels can be affected by
- concentrations of nutrients in area waterways;
- organic matter washing or being discharged to streams; and
- reduced stream side canopy.

Shaded streams are usually cooler and can support higher DO concentrations.

There is also still the potential for the loss of in-stream habitat due to on going maintenance of modified channels, modification of additional stream miles, or additional development.

Potential Stakeholders:

Stakeholders in this segment include
- City of Mont Belvieu;
- numerous large industries located in the lower portion of the segment;
- agricultural producers;
- non-agricultural residents;
- Several Soil and Water Conservation districts and Utility districts (MUDs, PUDs, etc.) scattered throughout the segment;
- Crosby ISD and several other ISDs;
- Harris, Chambers, and Liberty counties;
- Harris County Flood Control District (HCFCD);
- Baytown Area Water Authority; and
- community organizations.

Representatives from most of these groups currently serve on the Cedar Bayou Watershed Partnership Stakeholders Committee.

Ongoing Projects:

H-GAC and TSSWCB initiated the development of the Cedar Bayou WPP in December 2010.

Major Watershed Events:

The known or anticipated occurrences that have the potential to either positively or negatively impact this segment include population growth and additional drought. In general, faster development is occurring along the three primary corridors that cross the watershed: I-10 is just outside the southern boundaries of the segment, U.S. Highway 90 which splits the segment in half, and FM 1960 which crosses the segment in the upper half. Development brings more OSSFs, more land clearing, more lawns and fertilizer, and more pets producing waste.

The last major watershed event was the drought that occurred in 2010 and 2011. This record drought caused one of the monitoring stations in the far upstream reaches to go dry.

The proposed Luce Bayou Interbasin Transfer Project, which conveys water from the Trinity River to Lake Houston, may potentially impact the northern area of this segment. While the current preferred route would not enter the Cedar Bayou watershed, alternative routes crossing south of U.S. Highway 90 could potentially impact flow conditions in impacted subwatersheds. Construction for this alternate route could cause temporary degradation for macrobenthic communities, but no long term water quality impact is expected.

Recommended Actions:

Activity	Responsible Entity(s)
Continue facilitating the development of the WPP	H-GAC, TSSWCB and local stakeholders
Continue collecting water quality data to support actions associated with WPP development and future modeling	TCEQ and CRP partners
Support, maintain, and/or increase programs that conduct septic system inspections and oversee maintenance and repairs	County and local agencies and stakeholders
H-GAC, CRP partners and other stakeholders should continue ongoing public outreach to numerous groups throughout the watershed. Topics include programs for • farmers and private residents to minimize fertilizers in runoff from field and yards; • residents and small commercial property owners on how to properly maintain OSSFs and dispose of pet waste; and • public organizations or agencies involved in the maintenance of the waterways on how to minimize habitat destruction and sedimentation.	

Figure - 5

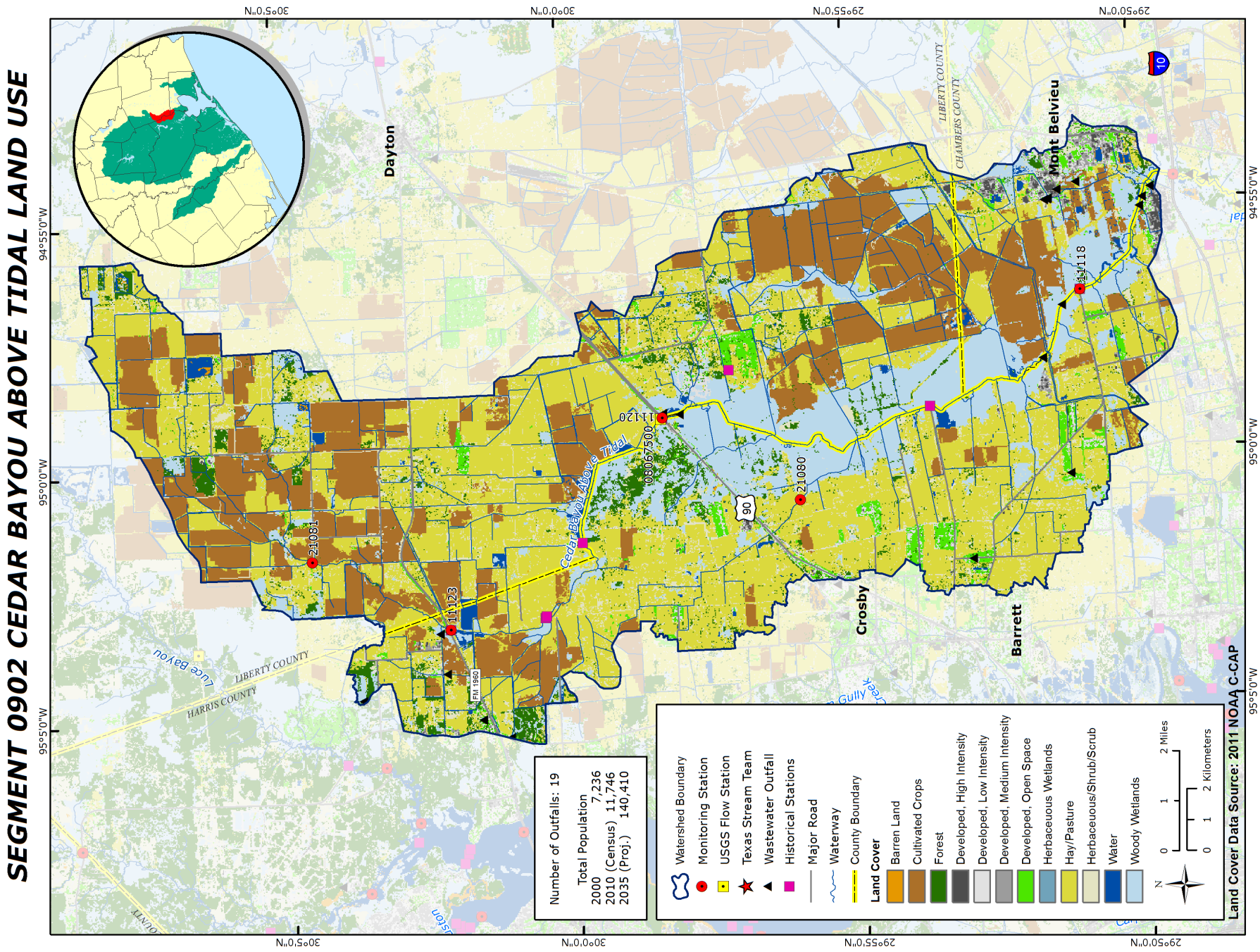
Fiscal Year 2013 Monitoring Sites - Segment 0902 - Cedar Bayou Above Tidal									
Segment ID	**Site Description**	**Station ID**	**Collecting Entity**	**Monitoring Type**	**Field Parameters* / Frequency**	**Conventional Parameters**/ Frequency**	**Bacteria***/ Frequency**	**Flow / Frequency**	**24 hr DO**
902	CEDAR BAYOU ABOVE TIDAL 0.02 MILES DOWNSTREAM OF FM 1942 AT EAST BANK	11118	H-GAC	Routine	4	4	4	4	
902	CEDAR BAYOU ABOVE TIDAL 0.03 MILES DOWNSTREAM OF FM 1960 NORTHEAST OF HUFFMAN	11123	H-GAC	Biased Season				4	4
902	CEDAR BAYOU ABOVE TIDAL 0.03 MILES DOWNSTREAM OF FM 1960 NORTHEAST OF HUFFMAN	11123	H-GAC	Routine	4	4	4	4	

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Total Depth, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity*

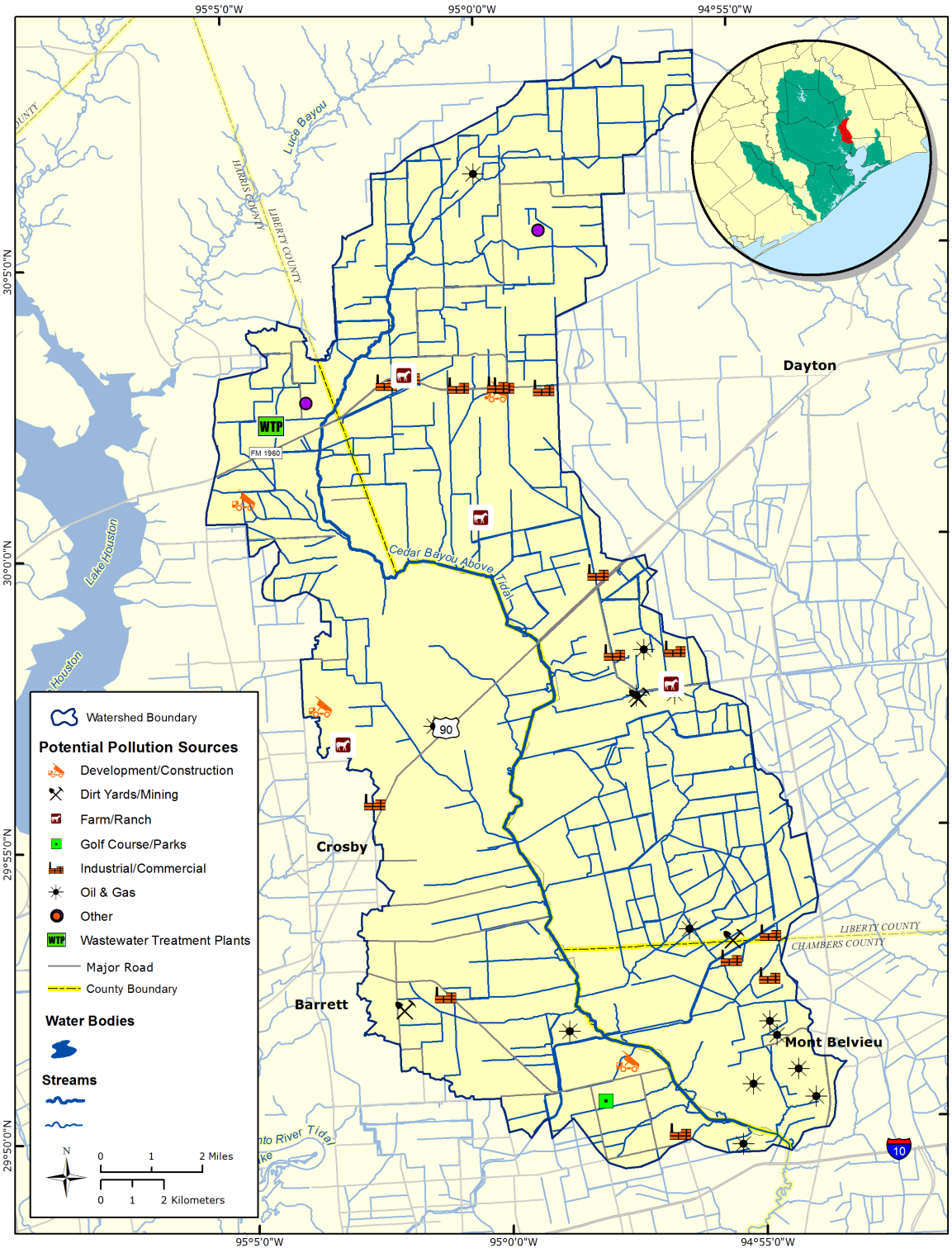
***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrite+Nitrate, Total Phosphorus, Chloride, Sulfate*

****Bacteria Parameters: E. coli and Enterococci*

Figure - 6


SEGMENT 0902 CEDAR BAYOU ABOVE TIDAL LAND USE
Dayton
Mont Belvieu
Crosby
Barrett
LIBERTY COUNTY
CHAMBERS COUNTY
HARRIS COUNTY
Cedar Bayou Above Tidal
Luce Bayou
FM 1960
90
10
11120
11123
11118
21081
21080
08067500
Number of Outfalls: 19
Total Population
2000 7,236
2010 (Census) 11,746
2035 (Proj.) 140,410
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Waterway
County Boundary
Land Cover
Barren Land
Cultivated Crops
Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Herbaceuous Wetlands
Hay/Pasture
Herbaceuous/Shrub/Scrub
Water
Woody Wetlands
0 1 2 Miles
0 1 2 Kilometers
N
Land Cover Data Source: 2011 NOAA C-CAP
30°5'0"N
30°0'0"N
29°55'0"N
29°50'0"N
94°55'0"W
95°0'0"W
95°5'0"W

SEGMENT 0902 CEDAR BAYOU ABOVE TIDAL POLLUTION SOURCES



Understanding Potential Sources of Pollution

Development/Construction: obvious land clearing and construction sites.

Dirt Yard/ Mining: dirt yards, quarry operations, sand and gravel operations.

Farm /Ranch: obvious livestock watering holes, large commercial farms, such as chicken farms or hog farms, heavy concentrations of cattle, but not the same as a defined CAFO (concentrated animal feeding operation).

Golf Course/Park: golf courses and other parks with ball fields or soccer fields or football fields of natural grass.

Industrial/Commercial: small manufacturing facilities, pipe yards, assembling yards, railroad trestle yards. WWTFs are included in the category. Refer to the land cover map for the actual location of the WWTFs.

Oil & Gas: natural gas well pads, gathering facilities, obvious footprints of units associated with the oil and gas industry.

1002 - Lake Houston

Length 23.5 Miles (classified portion)	**Watershed Area** 292 Square Miles
Texas Stream Team Monitors 0	**Permitted Outfalls** 16
Number of Active Monitoring Stations 12	
Designated Uses Contact Recreation, High Aquatic Life; Public Water Supply	

Segment Description:

Located in the far northeast corner of Harris County with portions extending into Liberty and San Jacinto Counties, this segment includes all of Lake Houston – from the dam in Harris County upstream to the confluence with Spring Creek on the West Fork San Jacinto River arm of the lake and up the East Fork San Jacinto River arm to the confluence of Caney Creek. The lake segment also includes Tarkington Bayou which merges with Luce Bayou then flows into the east arm of the lake and Lake Isabell. The segment watershed includes 292 square miles with the lake being 21 miles long. The tributaries, Luce and Tarkington bayous, add approximately 50 miles of waterway.

In the *Draft 2012 IR*, one classified and three unclassified water bodies were evaluated. This segment currently has 12 active routine monitoring stations in FY2013. There are three agencies that monitor in this segment. The City of Houston Water Quality Division (a CRP partner) monitors eight stations on the lake and one station on Luce Bayou. H-GAC monitors one station on Tarkington Bayou at Texas Highway 105 southeast of Cleveland. The TCEQ monitors two stations – one near the dam and a second site at U.S. Highway 59 on the west arm of the lake. Unclassified water bodies in this segment include:.

- 1002A – Tarkington Bayou (unclassified water body): From Luce Bayou confluence upstream to a point just upstream of FM 2025 in Liberty County
- 1002B – Luce Bayou (unclassified water body): From the confluence with Lake Houston (Harris County) to FM 1008 (Liberty County)
- 1002C – Lake Isabell (unclassified water body): A small lake located at the southern end of Lake Houston Park northeast of the Caney Creek (1001) and East Fork of the San Jacinto River (1003) confluence in Harris County

See Figure - 12 on page 21 for the location of all the stations and Figure - 11 on page 20 for a complete description of FY2013 CRP monitoring stations.

Hydrological Characteristics:

Impounded in 1954, Lake Houston provides water for irrigation and is a primary source of drinking water for the city of Houston and several communities in the region. Texas Water Development Board records show the reservoir has a current capacity of about 130,000 acre-feet, a surface area of 11,854 acres, and a mean depth of 12 feet with a maximum depth of about 50 feet near the dam. Over the years, the USGS has conducted

Figure - 8

Summary of Water Quality Impairments and Concerns - Segment 1002 Lake Houston							
Segment ID	**Bacteria**	**Dioxin/PCBs**	**DO**	**Chlorophyll a**	**Nutrients**	**Other***	**Frog(s)****
1002	25.5			54.5	83.7		
1002A					43.9		
1002B							
1002C							?

Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 6 (?= no stations/no data in the assessment unit)*

numerous studies on the lake. The Lake Houston basin can be divided into an eastern subbasin and a western subbasin. Tributaries in the eastern subbasin include Caney Creek, East Fork San Jacinto River, Luce Bayou, Tarkington Bayou, and Peach Creek. Tributaries in the western subbasin include Cypress Creek, Spring Creek, Lake Creek, and the West Fork San Jacinto River. The western basin is the larger of the two subbasins making up about 62% of the entire Lake Houston watershed. Numerous USGS studies have determined water residence time in Lake Houston ranges from about 12 hours up to 400 days depending on rainfall. USGS employees Beussink and Graham conducted a record search in 2011 that revealed long-term mean inflow to the lake (1984 – 2008) was 1,200 CFS.

Land Use & Natural Characteristics:

The west fork of Lake Houston is highly urbanized with the communities of Humble, Kingwood, and Atascocita covering most of the western portions of the segment. Developments are also located on the southwest shores and the eastern shore primarily near FM 1960. Smaller subdivisions dot the main body of Lake Houston on both shores. Luce and Tarkington bayous flow into the northeastern portion of the lake and are primarily forested lands with small ranchettes and homes scattered throughout. The city of Cleveland lies in the upper Tarkington Bayou watershed. Forests, woody wetlands, and hay or pasture fields are the primary land cover types in the sub-segments of Luce and Tarkington bayous with low density cattle ranching operations throughout. Lake Isabell is also surrounded by forests, woody wetlands, and scattered homesteads.

See Figure - 12 on page 21 for the land use/land cover for this segment.

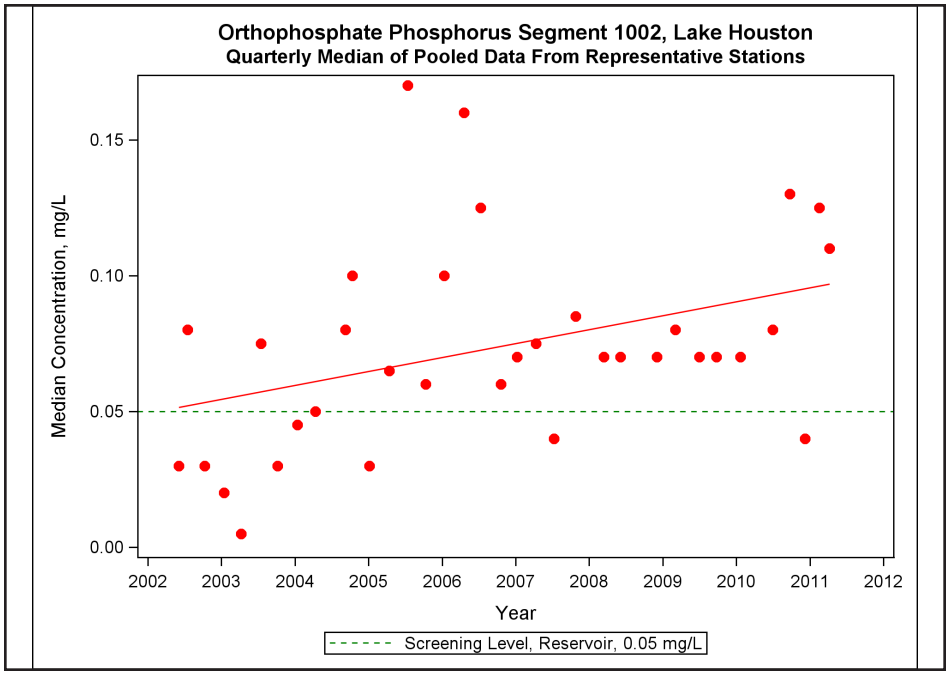
Description of Water Quality Issues:

A summary of key impairments and concerns appears in Figure - 8 on page 17 for this segment. Lake Houston has a public water supply designation but is also designated for contact recreation use and high ALU. Sub-segments Luce Bayou and Tarkington Bayou are designated for contact recreation and have minimal and intermediate ALU, respectively. Lake Isabell has only a fish consumption use for which the Texas Department of State Health Services (TDSHS) has issued a fish consumption advisory due to "mercury in edible tissue."

The public water supply use of the lake is fully supported. Contact recreation is also fully supported in Tarkington Bayou, Luce Bayou and all of Lake Houston except for one stretch of the upper West Fork San Jacinto River arm from West Lake Houston Parkway upstream to the confluence with Spring Creek. The *Draft 2012 IR* reported that AU 1002_06 had a geometric mean of 255 MPN from 218 samples of bacteria collected when the standard criteria is 126 MPN. This means the bacteria level in the sample is more than double the state standard. The AU was first listed as impaired in 2006. See Figure - 13 on page 22 for the location of the bacteria impairment.

High nutrient concentrations are the primary water quality concern in Lake Houston. Six of the seven AUs in Lake Houston have nutrient concentrations greater than the screening levels more than 29% of the time. The nutrients of concern include total phosphorus, orthophosphorus, nitrate, and ammonia. Orthophosphorus is a concern in all six of the AUs having concerns with exceedances ranging from 42% – 88%. The two AUs that make up the west arm of the lake have concerns for all four parameters while additional flow from the east fork appears to be sufficient to dilute the nutrient loading going

Figure - 9



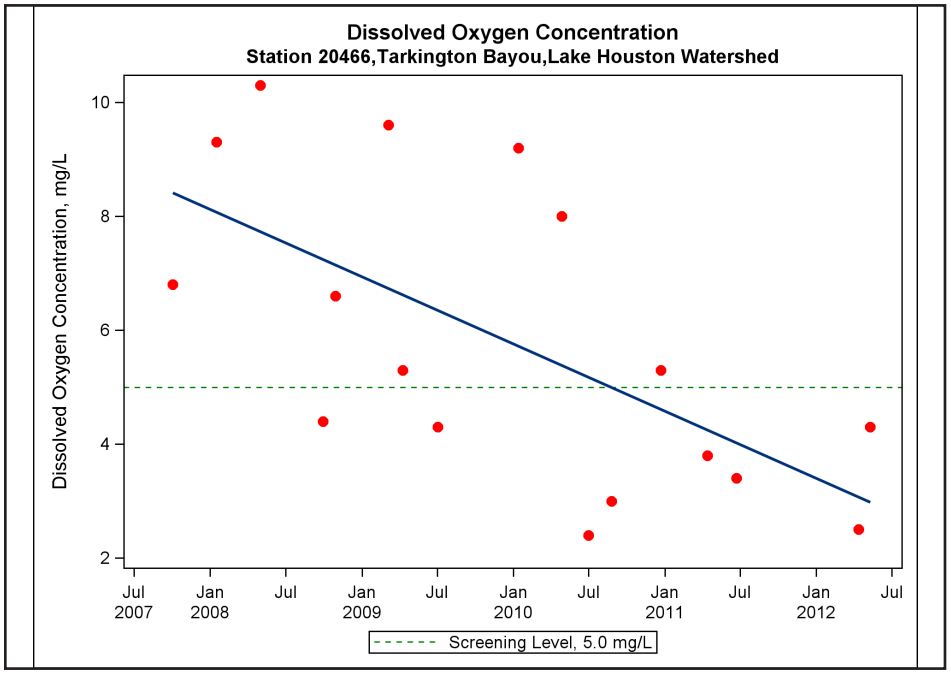
into the main body of the lake. However, the concern is only lessened and not altogether eliminated. Unfortunately, both orthophosphorus and total phosphorus have an upward trend over time. See Figure - 9 on page 18 for an illustration of the orthophosphorus trend.

Chlorophyll *a* is also a concern in two AUs – the west arm of the lake and near the dam. Only the upper arm of the East Fork San Jacinto River (AU 1002_07) upstream of the confluence with Luce Bayou has no nutrient concerns. Tarkington Bayou, which drains into Luce Bayou and then to Lake Houston, also has a concern for orthophosphorus and total phosphorus, but Luce Bayou does not have those concerns. See Figure - 14 on page 23 for the location of the nutrient concerns.

Lake Isabell is a small lake located in Lake Houston Park northeast of the confluence of Caney Creek and the East Fork San Jacinto River. The lake was first listed as having a fish consumption impairment for "mercury in edible tissue" in 2010. See Figure - 15 on page 24 for the location of the lake and the fish consumption advisory.

In the *2010 IR*, DO was a concern in Luce Bayou because grab samples were frequently below the screening level. In the *Draft 2012 IR*, DO is no longer a concern in Luce Bayou. However, H-GAC's data analysis identified a downward trend in DO over the past 5 years for Tarkington Bayou and the

Figure - 10



past 10 years for Luce Bayou, so the situation requires watching. Figure - 10 on page 18 shows DO concentration in Tarkington Bayou.

Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite imagery and identified a variety of potential sources of pollution in this segment. See Figure - 16 on page 25, identifying the potential sources of pollution or points of interest. Urban development with both residential and commercial construction surround the upper west, north, and east shores of the lake.

Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes and sanitary sewer system overflows;
- runoff from OSSFs; and
- runoff contaminated with waste from pets, wildlife, and livestock.

Elevated nutrients draining or being discharged to area waterways come from the same sources plus runoff from row crops, fallow fields, timber harvested land, and contaminated runoff from fertilized urbanized properties such as landscaped areas, residential lawns, golf courses, and sport fields. Illegal dumping is also a potential source for any of the contaminations found in the segment waterways. Luce and Tarkington bayous have

many agricultural related sources of pollution, while Tarkington Bayou specifically is experiencing tremendous growth in residential and commercial development.

Tarkington Bayou and the upper Luce Bayou watershed have many natural gas or oil well pumping and gathering facilities. While not causing great harm at this time, they are considered points of interest.

Potential Stakeholders:

Stakeholders in the segment include

- Cities of Houston, Cleveland, Humble, Atascocita, Kingwood, and many smaller communities that rely on the lake for drinking water;
- Kingwood community associations;
- Friendswood Development Corporation;
- utility districts;
- local businesses; and
- residents.

Ongoing Projects:

No special CRP or TCEQ projects have been conducted on this segment. However, from 2006 to 2008 the USGS, in cooperation with the City of Houston, implemented a continuous monitoring network to track daily water quality changes in the lower quadrant of the lake. The report (*USGS Data Series 485*) can be found online at http://pubs.usgs.gov/ds/485/pdf/ds485.pdf. Due to growing concerns over water quality in Lake Houston, a detailed assessment was also conducted focusing on water quality constituents that affect the aesthetic quality of drinking water. Results can be found in *Scientific Investigations Report 2011–5121* at http://pubs.usgs.gov/sir/2011/5121/pdf/sir2011-5121.pdf. The most recent USGS study (*Scientific Investigations Report 2012–5006*) used discrete water quality samples between 2005 and 2009 in conjunction with continuously monitoring real-time water quality data, including stream flow and other physical properties, to develop regression models for the estimation of concentrations of selected constituents to serve as potential surrogates. The final report can be found at http://pubs.usgs.gov/sir/2012/5006/SIR%202012-5006_Lee%20Regression%20Model_FOR%20WEB.pdf.

Major Watershed Events:

During 2011, the drought greatly affected Lake Houston by leaving numerous piers and boat ramps on the upper half of the reservoir exposed. The rains began in early 2012 and, today, water levels have returned to normal.

The proposed Luce Bayou Interbasin Transfer Project will ultimately convey approximately 500 million gallons of water per day from the Trinity River Basin to Lake Houston. The impact of the project on Lake Houston water quality will likely depend on the difference in water quality and contaminant loading between the Trinity water and the receiving waters.

Recommended Actions:

Activity	Responsible Entity(s)
Continue to address various concerns through stakeholder involvement	H-GAC
Coordinate with the City of Houston and the USGS on future projects to maximize dollars and achieve the greatest benefits for all projects	H-GAC, City of Houston, and USGS
Continue collecting water quality data to support actions associated with future WPP development and future modeling efforts	H-GAC and City of Houston
Conduct additional fish tissue testing to determine if the mercury contamination is isolated to Lake Isabell only (Lake Isabell fish contamination is believed to be caused by atmospheric deposition)	TDSHS

H-GAC, CRP partners and other stakeholders should continue ongoing public outreach to numerous groups throughout the watershed. Topics include programs for

- farmers and private residents to minimize fertilizers in runoff from field and yards;
- residents and small commercial property owners on how to properly maintain OSSFs and dispose of pet waste; and
- public organizations or agencies involved in the maintenance of the waterways on how to minimize habitat destruction and sedimentation.

Figure - 11

Fiscal Year 2013 Monitoring Sites - Segment 1002 - Lake Houston

Segment ID	Site Description	Station ID	Collecting Entity	Monitoring Type	Field Parameters* / Frequency	Conventional Parameters**/ Frequency	Bacteria***/ Frequency	Flow / Frequency
1002	LAKE HOUSTON NORTH SIDE OF MISSOURI PACIFIC RAILROAD BRIDGE 0.09 MILES SOUTH AND 0.85 MILES WEST OF INTERSECTION OF PINO LN AND SUNOCO RD	11208	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON AT FM 1960 WEST END PASS BRIDGE 0.17 MILES N AND 0.45 MILES E OF INTERSECTION OF ATASCOCITA SHORES AND FM 1960/CITY HO SITE 9	11211	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON AT FM 1960 EAST END PASS BRIDGE 20.15 MILES S AND 0.58 MILES WEST OF INTERSECTION OF FM 1960 AND FAIRLAKE LANE/CITY HO SITE 13	11212	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON 0.06 MILES S AND 0.22 MILES W OF INTERSECTION OF MAGNOLIA PT DR AND DIAMOND WAY CANEY CREEK ARM IN HOUSTON	16623	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LK HOUSTON W OF LK SHADOWS SUBDIVISION MID LAKE NW OF HOUSTON 1.3 MILES N AND 0.86 MLES E OF INTERSECT OF LK HOUSTON PKWY AND DITE CAYLIN	16668	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON IN THE WEST FORK SAN JACINTO RIVER CHANNEL 0.17 MILES EAST AND 0.04 MILES NORTH OF MISTY COVE AT ATASCOCITA PLACE DR	18667	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON/LUCE BAYOU 0.08 MILES NORTH AND 10.12 MILES WEST OF LAKEWATER DR AT WATERWOOD DR IN WATER WONDERLAND SUBDIVISION IN HARRIS COUNTY	18670	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002	LAKE HOUSTON WEST FORK SAN JACINTO RIVER ARM UNDER POWER LINES 0.35 MILES EAST AND 0.33 MILES NORTH FROM THE INTERSECTION OF BELLEAU WOOD DRIVE AND SOUTHSHORE DRIVE IN HOUSTON	20782	City of Houston-Water Quality Division (HW)	RT	12	12	12	N/A
1002A	TARKINGTON BAYOU AT SH 105/SH 321 SOUTHEAST OF CLEVELAND	20466	H-GAC	RT	4	4	4	4
1002B	LUCE BAYOU/SAN JACINTO RIVER EAST FORK AT HUFFMAN-NEW CANEY ROAD	11187	City of Houston-Water Quality Division (HW)	RT	6	6	6	N/A

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity. H-GAC includes: Total Depth*

***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrite+Nitrate, Total Phosphorus, Chloride, Sulfate*

****Bacteria Parameters: E. coli and Enterococci*

Figure - 12

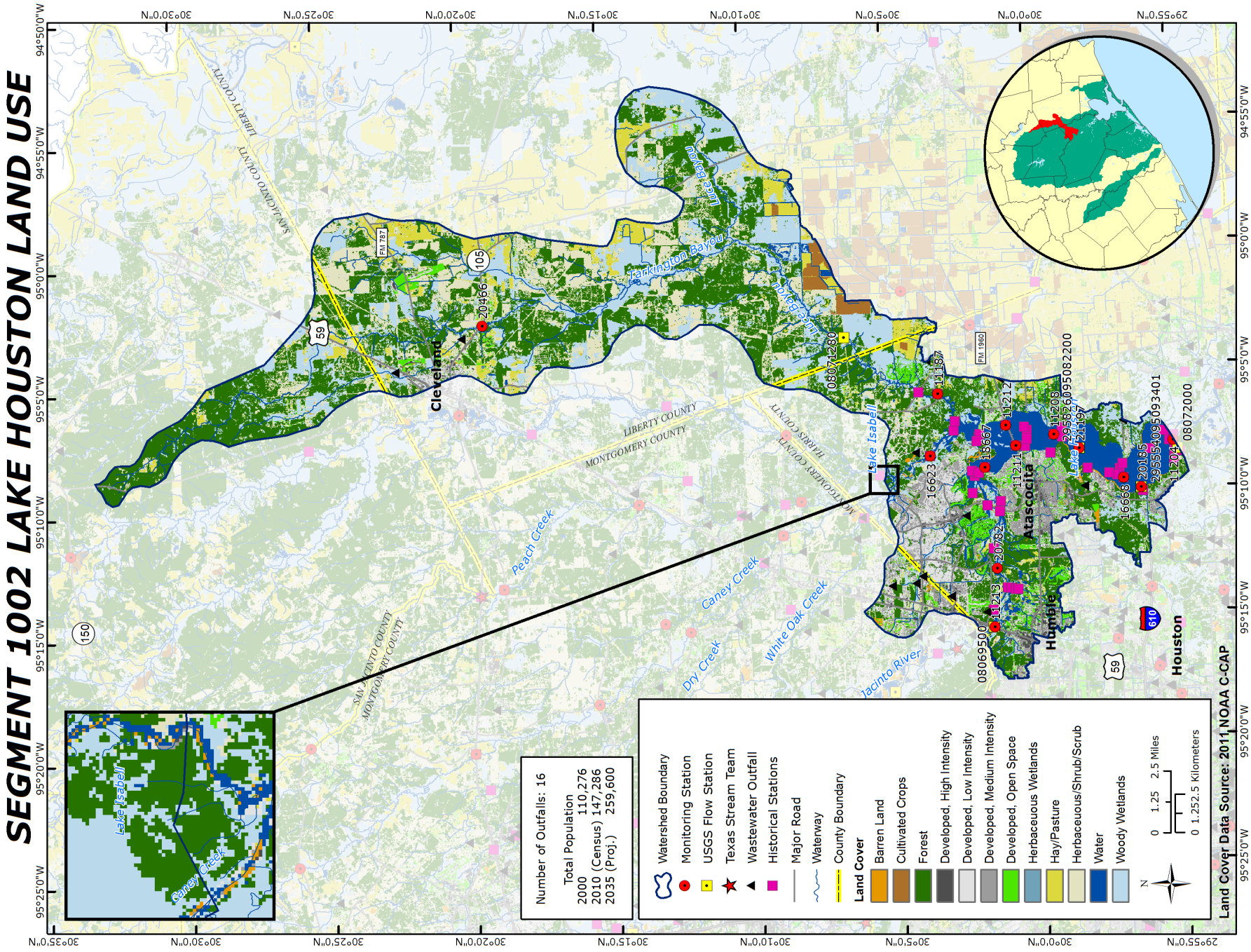

SEGMENT 1002 LAKE HOUSTON LAND USE
Cleveland
Atascocita
Humble
Houston
Lake Isabella
Caney Creek
Peach Creek
White Oak Creek
Dry Creek
Jacinto River
Tarkington Bayou
Luce Bayou
LIBERTY COUNTY
MONTGOMERY COUNTY
HARRIS COUNTY
SAN JACINTO COUNTY
Number of Outfalls: 16
Total Population
2000 110,276
2010 (Census) 147,286
2035 (Proj.) 259,600
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Waterway
County Boundary
Land Cover
Barren Land
Cultivated Crops
Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Herbaceuous Wetlands
Hay/Pasture
Herbaceuous/Shrub/Scrub
Water
Woody Wetlands
0 1.25 2.5 Miles
0 1.252.5 Kilometers
Land Cover Data Source: 2011 NOAA C-CAP

Figure - 13

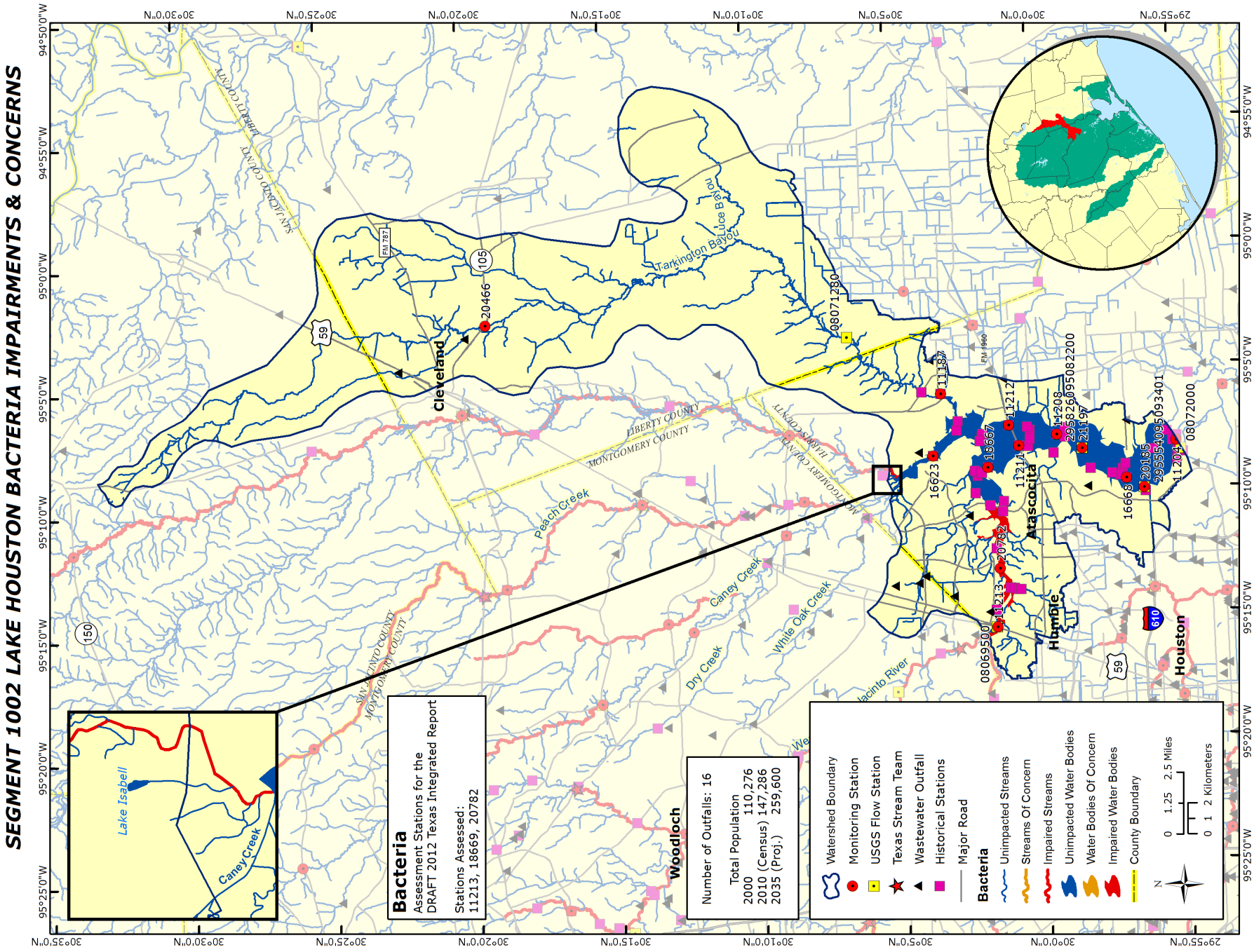

SEGMENT 1002 LAKE HOUSTON BACTERIA IMPAIRMENTS & CONCERNS
Bacteria
Assessment Stations for the
DRAFT 2012 Texas Integrated Report
Stations Assessed:
11213, 18669, 20782
Number of Outfalls: 16
Total Population
2000 110,276
2010 (Census) 147,286
2035 (Proj.) 259,600
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Bacteria
Unimpacted Streams
Streams Of Concern
Impaired Streams
Unimpacted Water Bodies
Water Bodies Of Concern
Impaired Water Bodies
County Boundary
0 1.25 2.5 Miles
0 1 2 Kilometers
Cleveland
Woodloch
Atascocita
Humble
Houston
Lake Isabell
Caney Creek
Peach Creek
Dry Creek
White Oak Creek
Tarkington Bayou
Luce Bayou
LIBERTY COUNTY
MONTGOMERY COUNTY
SAN JACINTO COUNTY
HARRIS COUNTY
20466
08071250
11137
11212
11211
11208
295826095082200
21197
18667
16623
16668
20185
295554095093401
11204
08072000
11213
20782
08069500

Figure - 14

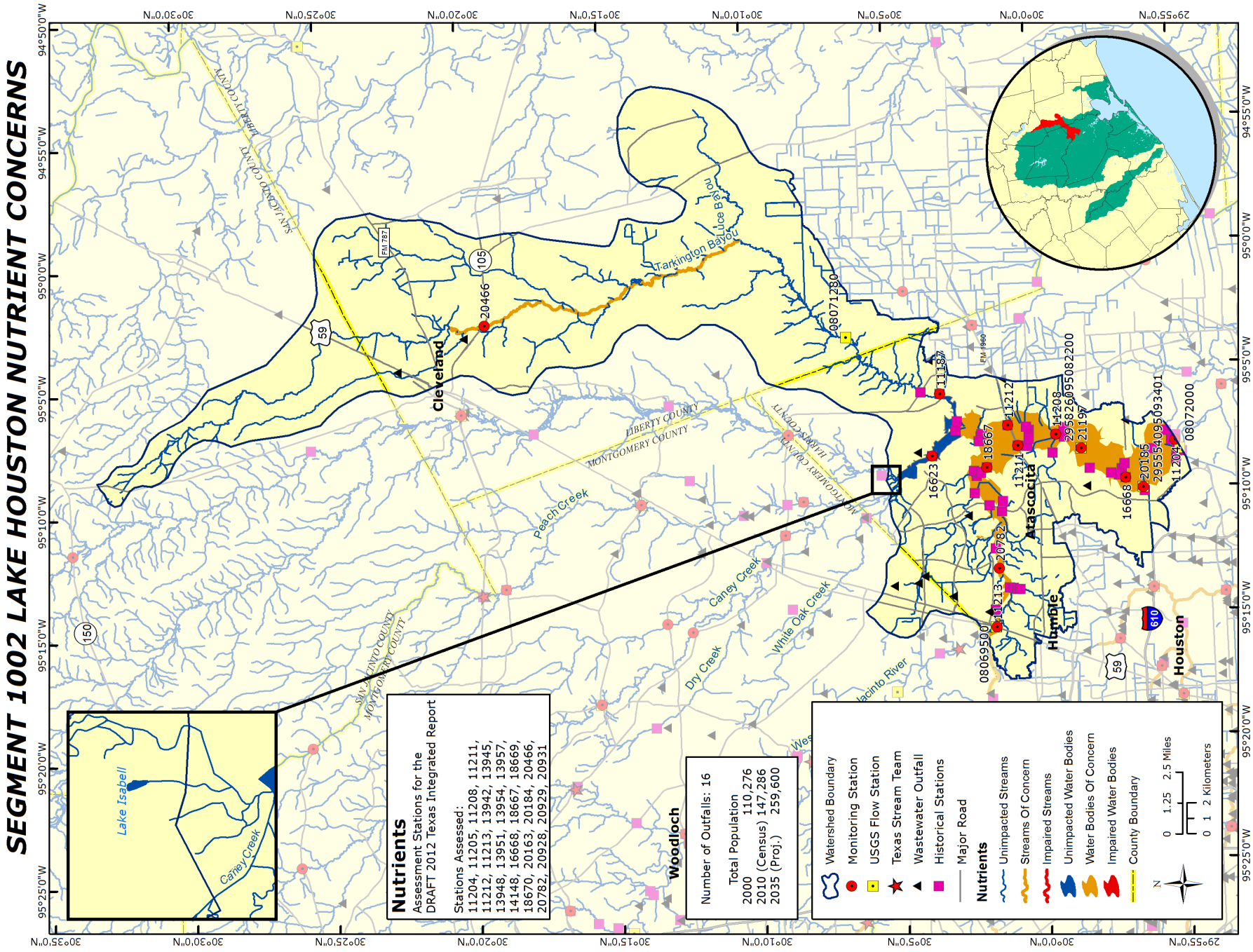
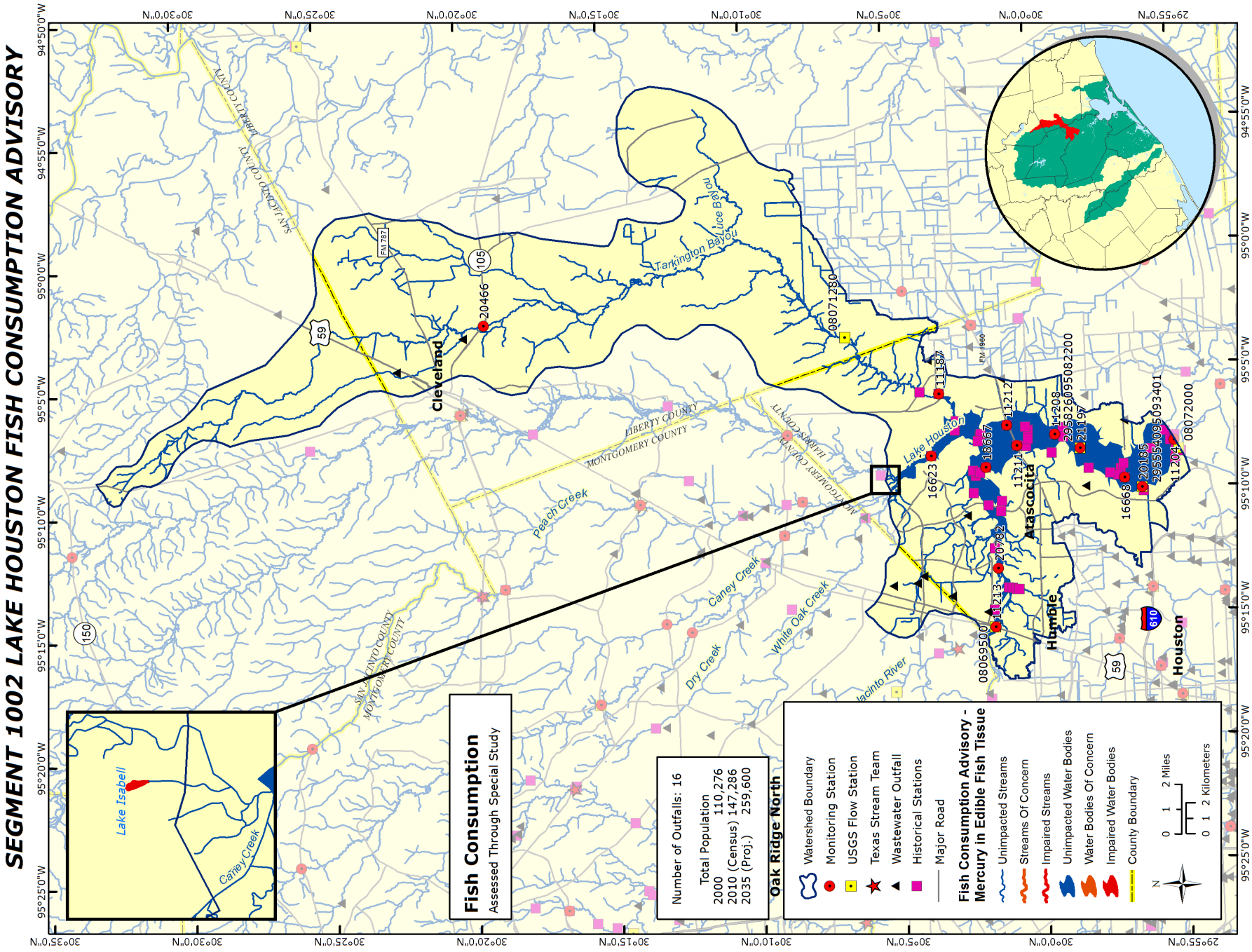
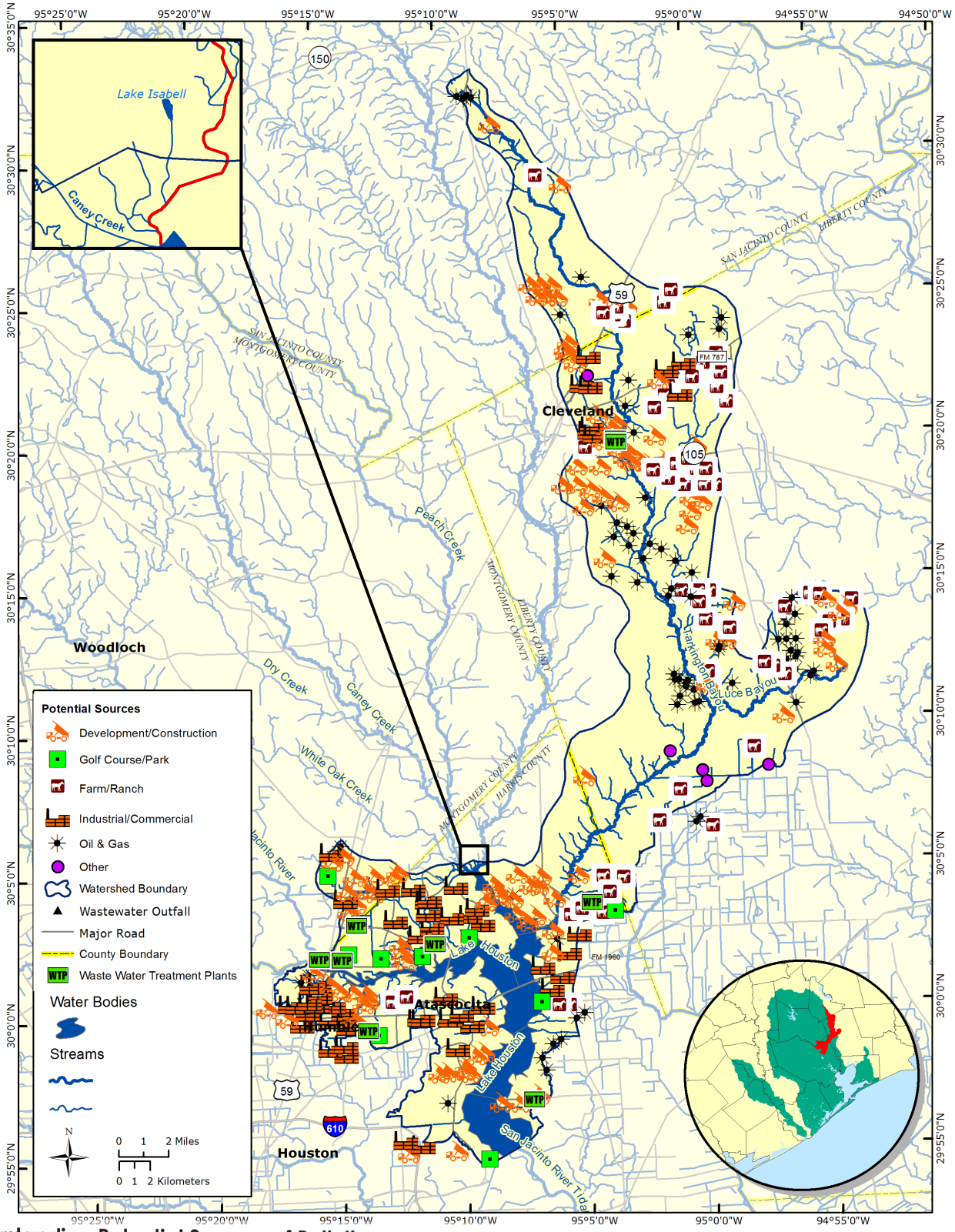

SEGMENT 1002 LAKE HOUSTON NUTRIENT CONCERNS
Nutrients
Assessment Stations for the
DRAFT 2012 Texas Integrated Report
Stations Assessed:
11204, 11205, 11208, 11211,
11212, 11213, 13942, 13945,
13948, 13951, 13954, 13957,
14148, 16668, 18667, 18669,
18670, 20163, 20184, 20466,
20782, 20928, 20929, 20931
Number of Outfalls: 16
Total Population
2000 110,276
2010 (Census) 147,286
2035 (Proj.) 259,600
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Nutrients
Unimpacted Streams
Streams Of Concern
Impaired Streams
Unimpacted Water Bodies
Water Bodies Of Concern
Impaired Water Bodies
County Boundary
Cleveland
Woodloch
Humble
Atascocita
Houston
Lake Isabell
Caney Creek
Peach Creek
Dry Creek
White Oak Creek
Tarkington Bayou
Trinity River
LIBERTY COUNTY
MONTGOMERY COUNTY
HARRIS COUNTY
SAN JACINTO COUNTY
20466
08071280
11187
18667
11212
11208
295826095082200
21197
16623
11214
20782
11213
08069500
20185
295554095093401
16668
11204
08072000

Figure - 15


SEGMENT 1002 LAKE HOUSTON FISH CONSUMPTION ADVISORY
Fish Consumption
Assessed Through Special Study
Number of Outfalls: 16
Total Population
2000 110,276
2010 (Census) 147,286
2035 (Proj.) 259,600
Oak Ridge North
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Fish Consumption Advisory - Mercury in Edible Fish Tissue
Unimpacted Streams
Streams Of Concern
Impaired Streams
Unimpacted Water Bodies
Water Bodies Of Concern
Impaired Water Bodies
County Boundary
Cleveland
Atascocita
Humble
Houston
Lake Houston
Lake Isabell
Caney Creek
Peach Creek
Dry Creek
White Oak Creek
Tarkington Bayou
Luce Bayou
Jacinto River
LIBERTY COUNTY
MONTGOMERY COUNTY
HARRIS COUNTY
SAN JACINTO COUNTY
LIBERTY COUNTY
20466
08071250
11137
11212
11211
11208
295826095082200
21197
18667
16623
16668
20185
295554095093401
11204
08072000
20782
11213
08069500
105
59
150
610
FM 787
FM 1960

SEGMENT 1002 LAKE HOUSTON POLLUTION SOURCES



Understanding Potential Sources of Pollution

Development/Construction: obvious land clearing and construction sites.

Dirt Yard/ Mining: dirt yards, quarry operations, sand and gravel operations.

Farm /Ranch: obvious livestock watering holes, large commercial farms, such as chicken farms or hog farms, heavy concentrations of cattle, but not the same as a defined CAFO (concentrated animal feeding operation).

Golf Course/Park: golf courses and other parks with ball fields or soccer fields or football fields of natural grass.

Industrial/Commercial: small manufacturing facilities, pipe yards, assembling yards, railroad trestle yards. WWTFs are included in the category. Refer to the land cover map for the actual location of the WWTFs.

Oil & Gas: natural gas well pads, gathering facilities, obvious footprints of units associated with the oil and gas industry.


MERCURY


X7138AY

1009 - Cypress Creek

Length 52.2 Miles (classified portion)	**Watershed Area** 306 Square Miles
Texas Stream Team Monitors 1	**Permitted Outfalls** 142
Number of Active Monitoring Stations 11	
Designated Uses Contact Recreation; High Aquatic Life; Public Water Supply	

Segment Description:

Flowing across the northern portion of Harris County, the Cypress Creek segment extends approximately 48 miles due west from the confluence with Spring Creek to the confluence of Snake Creek and Mound Creek in Waller County. The watershed covers 306 square miles and includes five tributaries and six unclassified water bodies. They are described as follows:

- 1009A – Dry Creek (unclassified water body): Perennial stream from the confluence with Cypress Creek upstream to the beginning of channelization at Jarvis Road, 0.37 miles upstream from the confluence with Cypress Creek north of U.S. Highway 290
- 1009B – Dry Gully (unclassified water body): Perennial stream from the point where channelization begins at Jarvis Road, which is 0.37 miles upstream of the confluence with Cypress Creek, upstream to Spring Cypress road, 0.75 miles upstream of Jarvis Road north of U.S. Highway 290
- 1009C – Faulkey Gully (unclassified water body): From the Cypress Creek confluence upstream 2 miles, which is approximately 0.6 miles upstream of Louetta Road
- 1009D – Spring Gully (unclassified water body): From the Cypress Creek confluence upstream to near Spring Cypress Road
- 1009E – Little Cypress Creek (unclassified water body): From the Cypress Creek confluence to a point 6.8 miles upstream in Harris County
- 1009F – Mound Creek (unclassified water body): From the confluence with Snake Creek, which together form Cypress Creek, upstream to an unnamed tributary 1.2 miles upstream of FM 362

The segment has 11 active routine monitoring stations in FY2013. There are six agencies that monitor is this segment. CRP partners include three divisions of the City of Houston – Health & Human Services (seven sites), Water Quality (one site), and Public Works (one site) in cooperation with the Harris County Flood Control District. H-GAC monitors at two locations in the upper watershed, while TCEQ monitors one station. The USGS operates one continuous monitoring station at Cypress Creek and I-45. See Figure - 24 on page 33 for a complete descriptions of the CRP monitoring stations and Figure - 25 on page 34 for the location of all monitoring sites.

Hydrological Characteristics:

Cypress Creek and its tributaries drain an area of 306 square miles. Cypress Creek proper (the classified portion of the segment) has a length of roughly 52 miles, and the unclassified tributaries have a combined length of roughly 48 miles. H-GAC downloaded and analyzed discharge flow data from the

Figure - 17

Summary of Water Quality Impairments and Concerns - Segment 1009 Cypress Creek

Segment ID	Bacteria	Dioxin/PCBs	DO	Chlorophyll *a*	Nutrients	Other*	Frog(s)**
1009	100		36.9		100	19.9	🐸
1009A							?
1009B							?
1009C	100				100		🐸🐸
1009D	100				100		🐸🐸
1009E	100		100		100		🐸
1009F							🐸🐸🐸🐸🐸

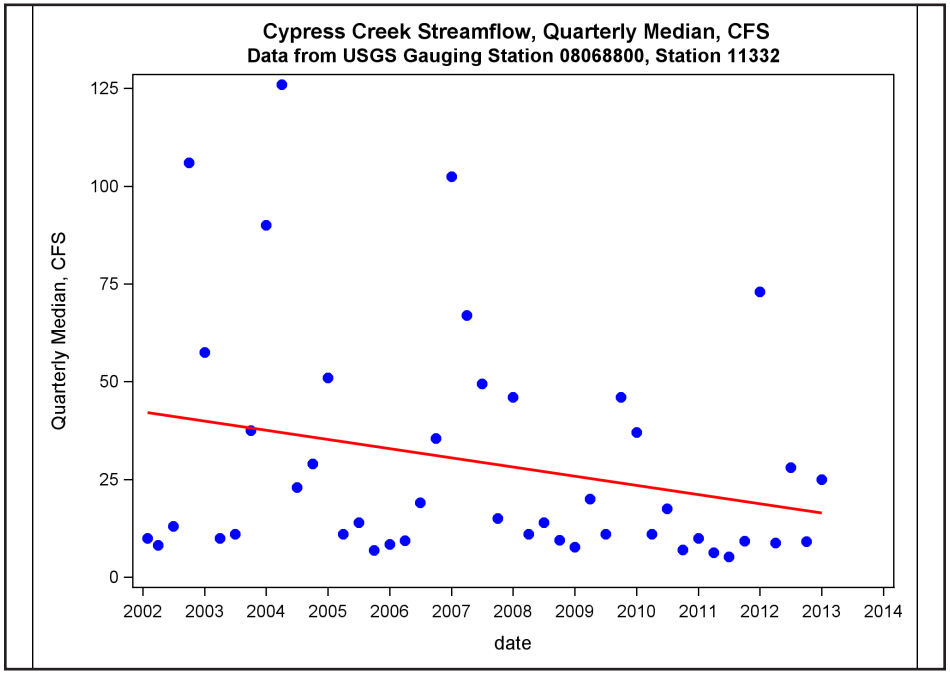
Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 6 (?= no stations/no data in the assessment unit)*

USGS Gaging Station 08068800, located near the Grant Road bridge over Cypress Creek near TCEQ monitoring station 11132. This gage is located at the upstream end of the lower third of the watershed, so the total flow into Spring Creek is greater. The median flow between January 2002 and January 2013 is 17 million gallons per day (MGD). See Figure - 18 on page 29 for the quarterly median flows. The minimum and maximum recorded flows during this time period are 2.3 and 8,090 MGD respectively. Periods of increased flow are associated with significant rainfall. Analysis of quarterly median flows shows a general downward trend, reflecting drought conditions the region has experienced since the summer of 2011.

Figure - 18



Land Use & Natural Characteristics:

The eastern portion of this segment is dominated by residential developments within forested lands. Development has expanded along the I-45 corridor and has become more concentrated. Grasslands and cultivated fields are sparse and quickly disappearing from the area. Development in the middle portion of the watershed has exploded in the past five years. Where grasslands and cultivated fields were, subdivisions and commercial building now dominate. The western portion is still dominated by rice fields and grasslands used for cattle grazing. Many fields are rotated and allowed to go fallow for years at a time. Even though there were four new WWTFs built to service small developments or commercial operations built off of U.S. Highway 290, many larger farms in the area have been subdivided into ranchettes and hobby farms using OSSFs as their primary waste disposal method. See Figure - 25 on page 34 for detailed land cover of the segment.

Figure - 19

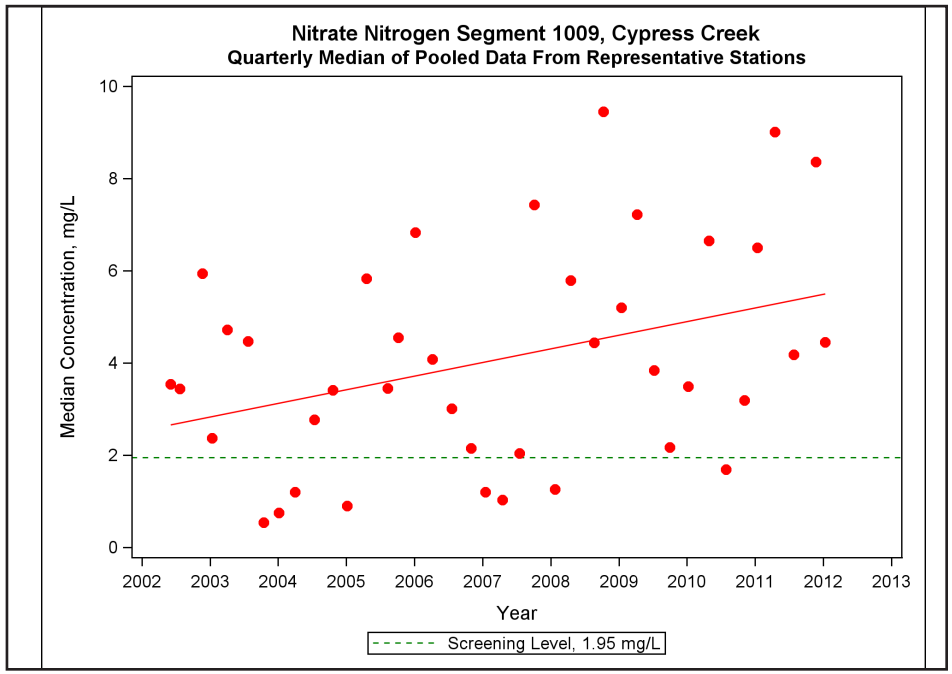
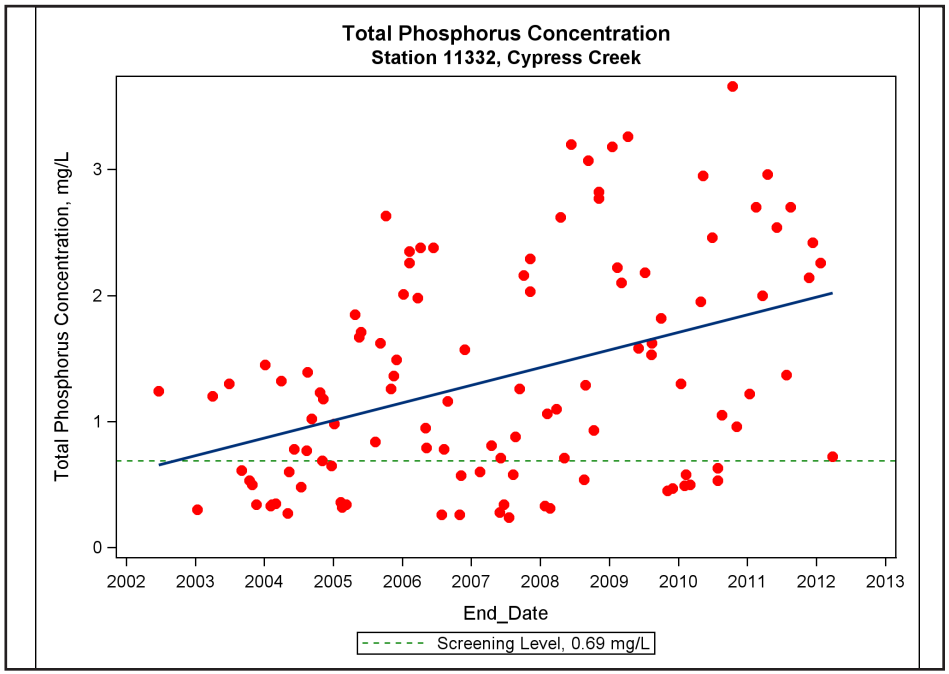


Figure - 20



Description of Water Quality Issues:

A summary of key impairments and concerns appears in Figure - 17 on page 29 for this segment. One hundred percent of Cypress Creek and three tributaries are impaired for bacteria, while nutrients are a concern in all the same areas. DO is a concern in the downstream portion of the creek and in one tributary - Little Cypress Creek. Nutrients and chlorophyll *a* concentrations are getting worse in tributaries Faulkey Gully and Spring Gully, while bacteria densities are going down or getting better in Little Cypress Creek.

There are 10 AUs in the Cypress Creek watershed. Four lie on the classified portion of Cypress Creek and six are on unclassified tributaries. The *Draft 2012 IR* lists seven assessment units for both high bacteria geometric means and nutrient concerns. These AUs were listed as impaired for high bacteria geomeans in the *2010 IR* (category 5a). A Total Maximum Daily Load (TMDL) was completed by H-GAC and approved by the TCEQ, so the bacteria impairments are now categorized as "4a" and do not appear on the draft 303(d) list. DO levels are listed as "concerns" based upon grab sample data in two AUs (1009_01 and 1009E_01). See Figure - 26 on page 35 for bacteria impairments. See Figure - 27 on page 36 for DO concerns. See Figure - 28 on page 37 for nutrient concerns.

Sufficient evidence of impaired habitat exists for 1009_02 to identify that area of Cypress Creek as having a screening level concern although it currently supports the designated ALU. The *Draft 2012 IR* also indicates AU1009_02 has a concern for near-nonattainment of the water quality standards for the macrobenthic community. Figure - 29 on page 38 shows where the macrobenthic community concern is located. The DO and macrobenthic community concerns were not mentioned in the *2010 IR* but the impaired habitat concern was. No monitoring stations have been established in 1009A or 1009B, so those tributaries could not be evaluated.

H-GAC identified a statistically significant trend of increasing nitrate and total phosphorus levels at representative stations on Cypress Creek. This trend pre-dated the recent drought. See Figure - 19 on page 30 for nitrate levels trends, Figure - 20 on page 30 for total phosphorus concentration at Station 11332 and Figure - 21 on page 31 for total phosphorus levels trends at representative stations.

H-GAC performed additional analysis of data from station 11332 to assess the relationship between total phosphorus, *E. coli*, flow, and rainfall. Regression analysis showed that total phosphorus concentrations are inversely related to stream flow, strongly suggesting point source impacts. Total phosphorus

Figure - 21

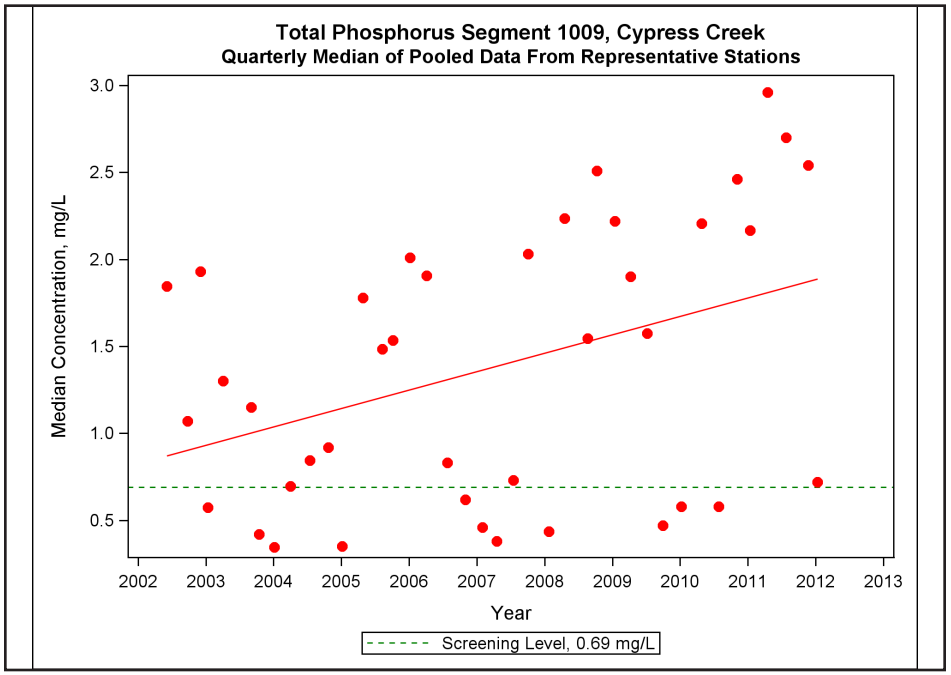


Figure - 22

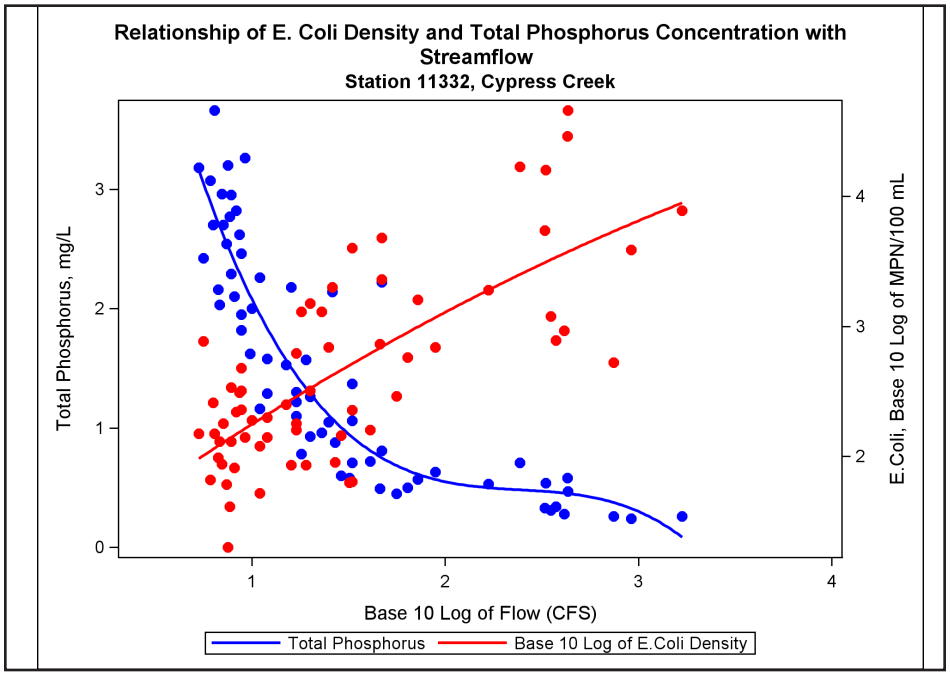
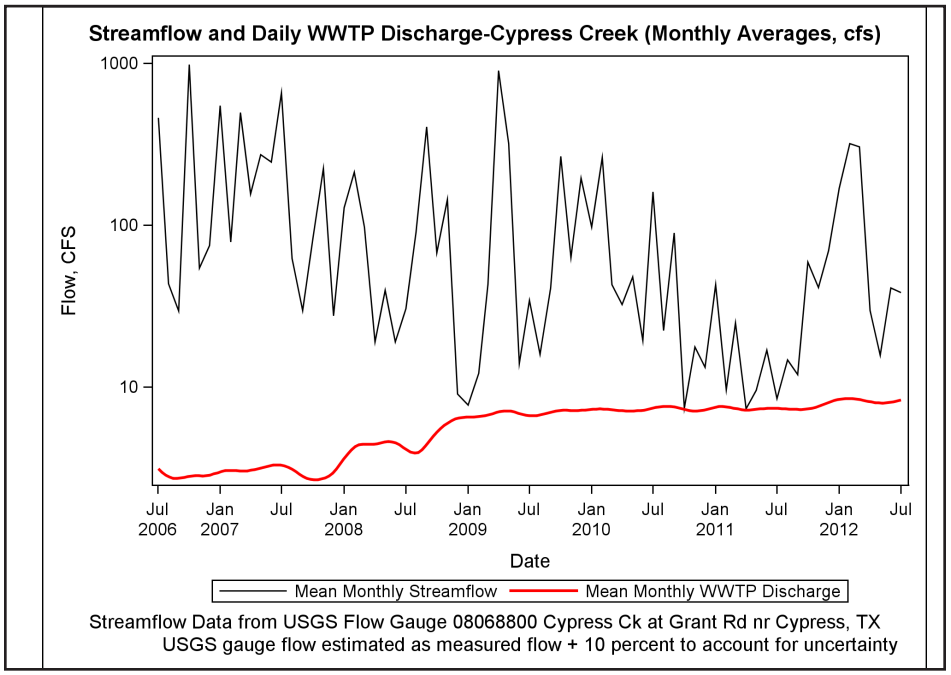


Figure - 23



was not closely correlated with rainfall. Figure - 22 on page 31 illustrates this relationship. *E. coli* levels are highest during high flow periods after significant rainfall, suggesting that runoff from non-point sources is involved.

During periods of little rainfall, it is likely that Cypress Creek could be considered "effluent dominated." H-GAC records indicate that TCEQ has issued Texas Pollution Discharge Elimination System (TPDES) permits for 84 municipal wastewater treatment facilities, accounting for a total of roughly 77 MGD of treated domestic wastewater or stormwater in the watershed. Thirty-five permits are held by private entities (roughly 3.7 MGD), and two permits have been issued to industrial facilities (0.2 MGD). Discharge Monitoring Report (DMR) data supplied by TCEQ shows that total reported discharges seldom exceed 30 MGD. Total effluent discharges have increased over time, which is to be expected given the 65% increase in population between 2000 and 2010. Figure - 23 on page 31 illustrates the contribution of WWTF effluent to flow during periods of low flow. The relationship between total phosphorus concentration and flow provides evidence that domestic wastewater is the source of much (if not most) of the nutrient load in Cypress Creek.

Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite imagery to identify a variety of potential sources of pollution in this segment. Figure - 30 on page 39 identifies the potential sources of pollution or points of interest. Urban development with both residential and commercial construction occurs throughout the eastern two-thirds of the watershed and along the U.S. Highway 290 corridor.

Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes,sanitary sewer system overflows and collection system overflows;
- runoff from OSSFs; and
- runoff contaminated with waste from pets, wildlife, and livestock.

In the western portion of the segment, construction and pollution related to development is only beginning to occur. However, there are numerous agricultural activities related to animal operations that are a major source of pollution. OSSFs being used on homesteads and ranchettes in the western portion of the segment would also be a potential source for bacteria and nutrients.

Potential Stakeholders:

Stakeholders in this segment include

- Harris and Waller counties;
- Cities of Houston, Waller, and Prairie View;
- Harris County Flood Control District;
- area drainage districts;
- road and Bridge Departments in Harris and Waller counties;
- Cy-Fair ISD, Spring ISD, Klein ISD, Waller ISD, and Prairie View ISD;
- local colleges;
- Harris-Galveston and Fort Bend subsidence districts;
- Gulf Coast Waste Disposal Authority;
- various utility districts scattered throughout the watershed;
- area home owner's associations; and
- commercial/industrial facilities.

There are representatives of most of these entities currently serving on the Bacteria Implementation Group (BIG) Steering Committee.

Ongoing Projects:

The BIG *Implementation Plan (I-Plan)* for bacteria reduction was recently approved by TCEQ Commissioners. Now the stakeholders will begin addressing bacteria impairments and concerns in the various manners they identified through a consensus process. Most importantly to the success of the plan is finding adequate funding to support implementation.

Major Watershed Events:

The known or anticipated occurrences that have the potential to either positively or negatively impact this segment include population growth and additional drought. Development brings more WWTFs, more land clearing, fertilized lawns and other landscapes, and pets producing waste.
The last major watershed event was the drought that occurred in 2010 and 2011. This record drought caused at least one of the monitoring stations in the far upstream reaches to go dry.

Recommended Actions:

Activity	Responsible Entity(s)
Begin implementing the *I-Plan* for bacteria reduction	Stakeholders
Continue collecting water quality data to support actions associated with future WPP development, TMDLs and future modeling efforts	TCEQ, H-GAC and CRP partners
Support, maintain, and/or increase programs that conduct septic system inspections, and oversee maintenance and repairs	County and local agencies and stakeholders
H-GAC, CRP partners and other stakeholders should continue ongoing public outreach to numerous groups throughout the watershed. Topics include programs for • farmers and private residents to minimize fertilizers in runoff from field and yards; • residents and small commercial property owners on how to properly maintain OSSFs and dispose of pet waste; and • public organizations or agencies involved in the maintenance of the waterways on how to minimize habitat destruction and sedimentation.	

Figure - 24

Fiscal Year 2013 Monitoring Sites - Segment 1009 - Cypress Creek

Segment ID	Site Description	Station ID	Collecting Entity	Monitoring Type	Field Parameters* / Frequency	Conventional Parameters**/ Frequency	Bacteria***/ Frequency	Flow / Frequency
1009	CYPRESS CREEK BRIDGE ON IH 45 15 MILES NORTH OF HOUSTON	11328	City of Houston-Water Quality Division (HW)	RT	6	6	6	6
1009	CYPRESS CREEK AT STEUBNER-AIRLINE ROAD IN HOUSTON	11330	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1009	CYPRESS CREEK AT SH 249	11331	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1009	CYPRESS CREEK IMMEDIATELY DOWNSTREAM OF GRANT ROAD NEAR CYPRESS	11332	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1009	CYPRESS CREEK IMMEDIATELY DOWNSTREAM OF GRANT ROAD NEAR CYPRESS	11332	City of Houston-Public Works (HP)	RT	15	N/A	15	15
1009	CYPRESS CREEK IMMEDIATELY DOWNSTREAM OF HOUSE HAHL ROAD NEAR CYPRESS	11333	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1009	CYPRESS CREEK AT KATY HOCKLEY ROAD 4.35 MILES SOUTH OF SH 290 WEST OF CYPRESS	20457	H-GAC	RT	4	4	4	4
1009C	FAULKEY GULLY OF CYPRESS CREEK 105 METERS DOWNSTREAM OF LAKEWOOD FOREST DRIVE NORTHWEST OF HOUSTON	17496	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1009D	SPRING GULLY AT SPRING CREEK OAKS DRIVE IN TOMBALL	17481	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1009E	LITTLE CYPRESS CREEK IMMEDIATELY DOWNSTREAM OF KLUGE ROAD IN HOUSTON	14159	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1009E	LITTLE CYPRESS CREEK AT MUESCHKE ROAD 2.73 MILES NORTH OF SH 290 NORTHWEST OF CYPRESS	20456	H-GAC	RT	4	4	4	4

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity. H-GAC includes: Total Depth*

***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrate (only), Total Phosphorus, Chloride, Sulfate. H-GAC includes: Nitrite+Nitrate*

****Bacteria Parameters: E. coli and Enterococci*

Figure - 25

SEGMENT 1009 CYPRESS CREEK LAND USE

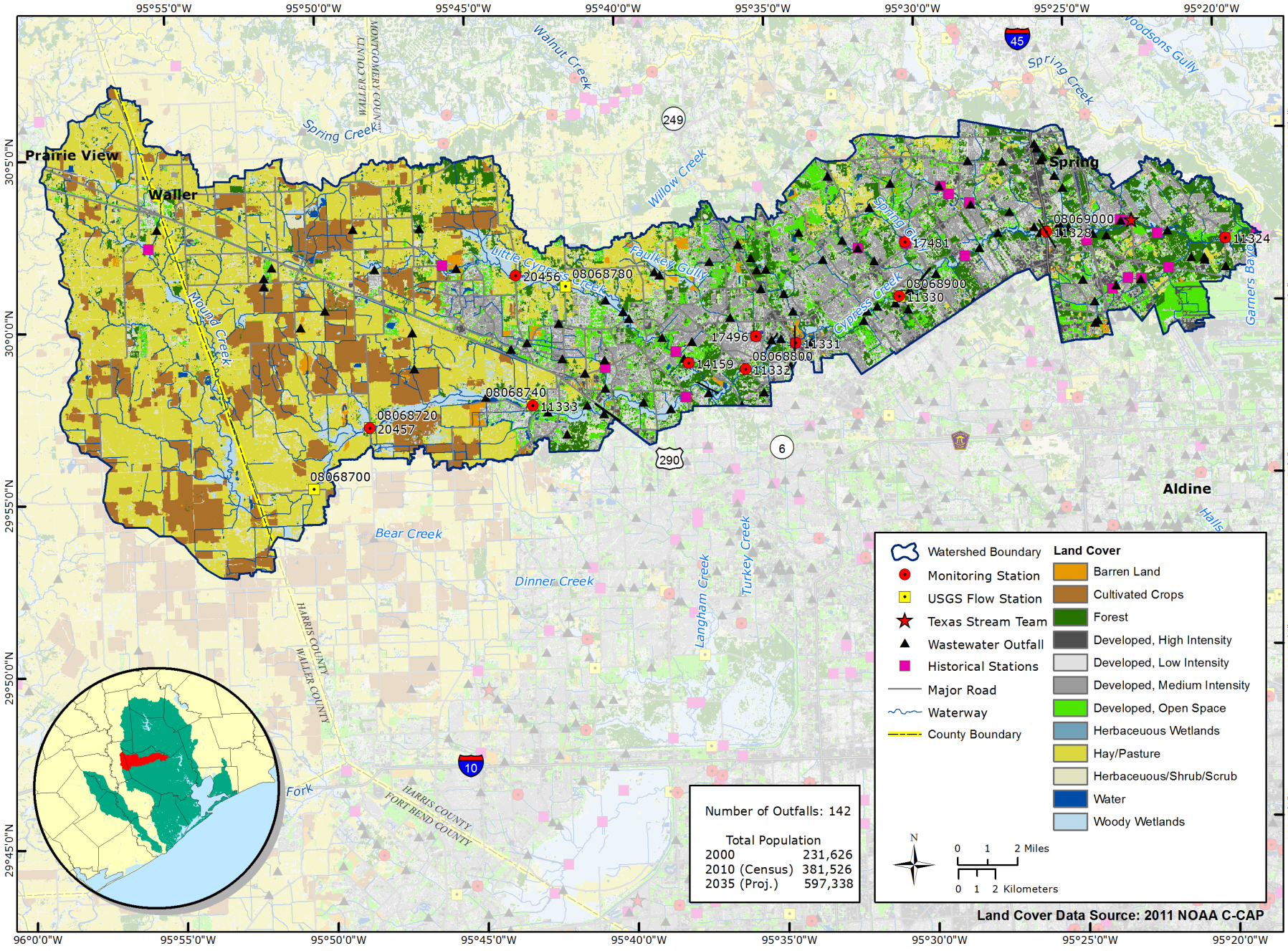


Figure - 26

SEGMENT 1009 CYPRESS CREEK BACTERIA IMPAIRMENTS & CONCERNS

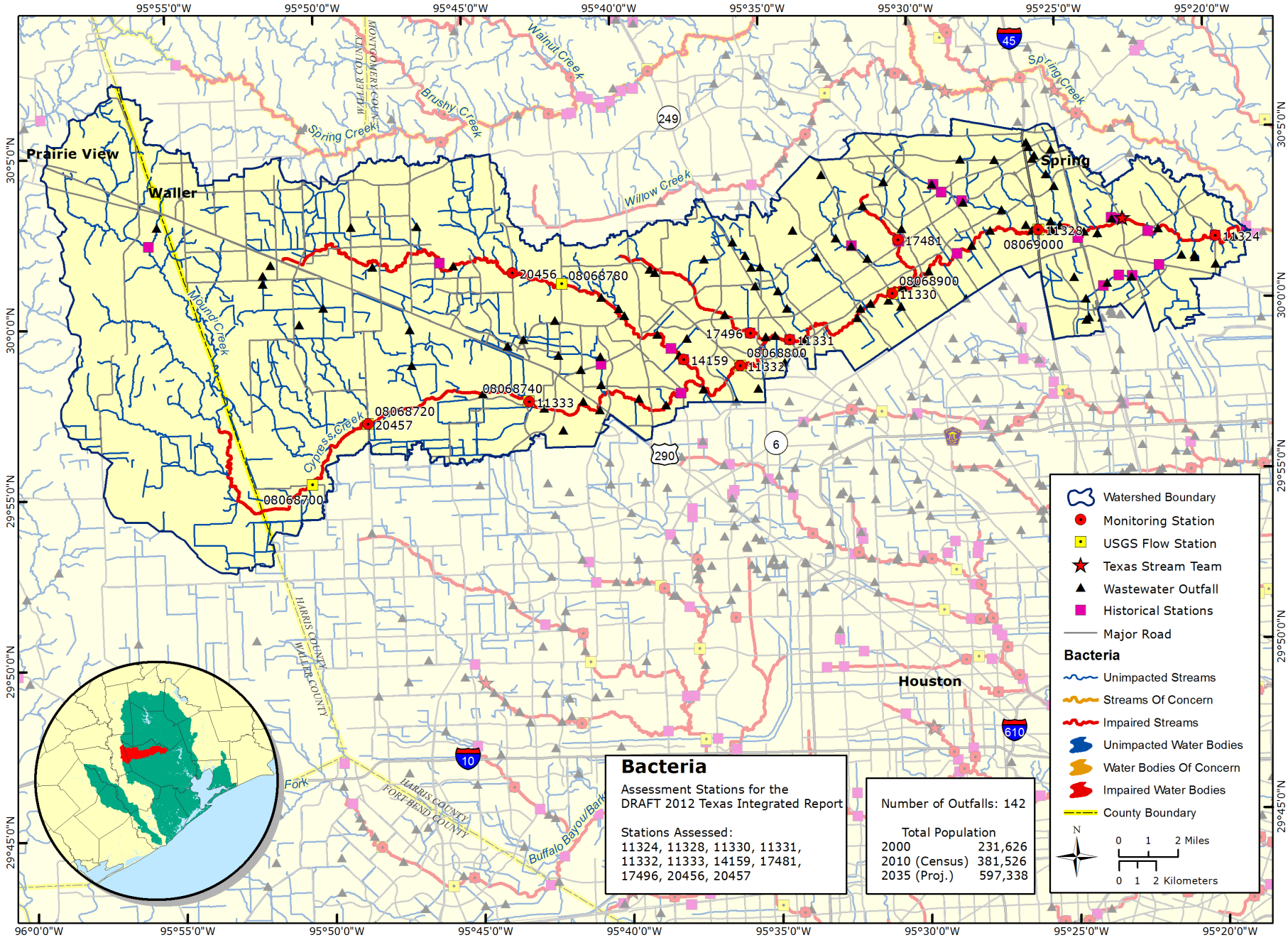


Figure - 27

SEGMENT 1009 CYPRESS CREEK DISSOLVED OXYGEN IMPAIRMENTS & CONCERNS

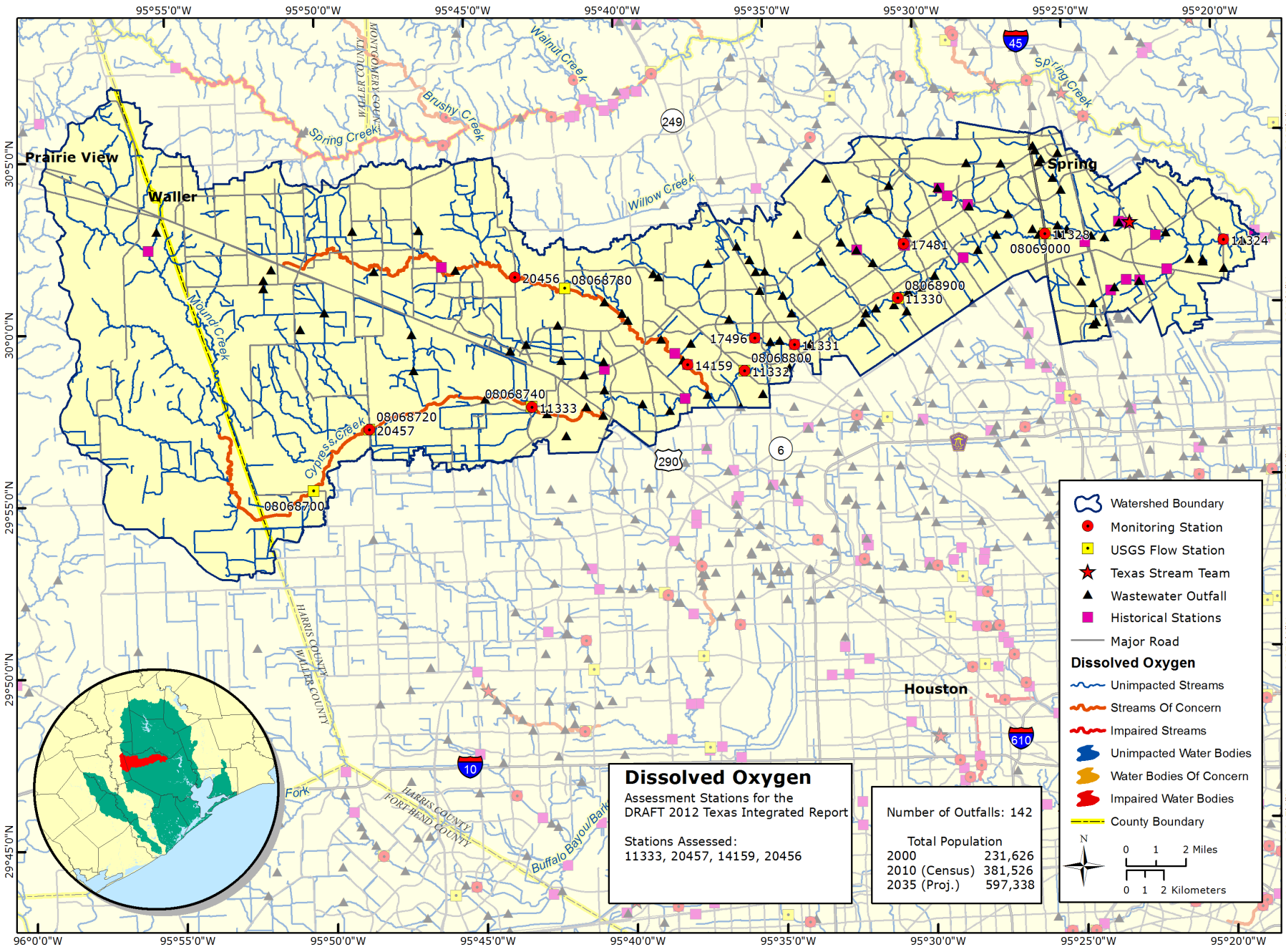


Figure - 28

SEGMENT 1009 CYPRESS CREEK NUTRIENT CONCERNS

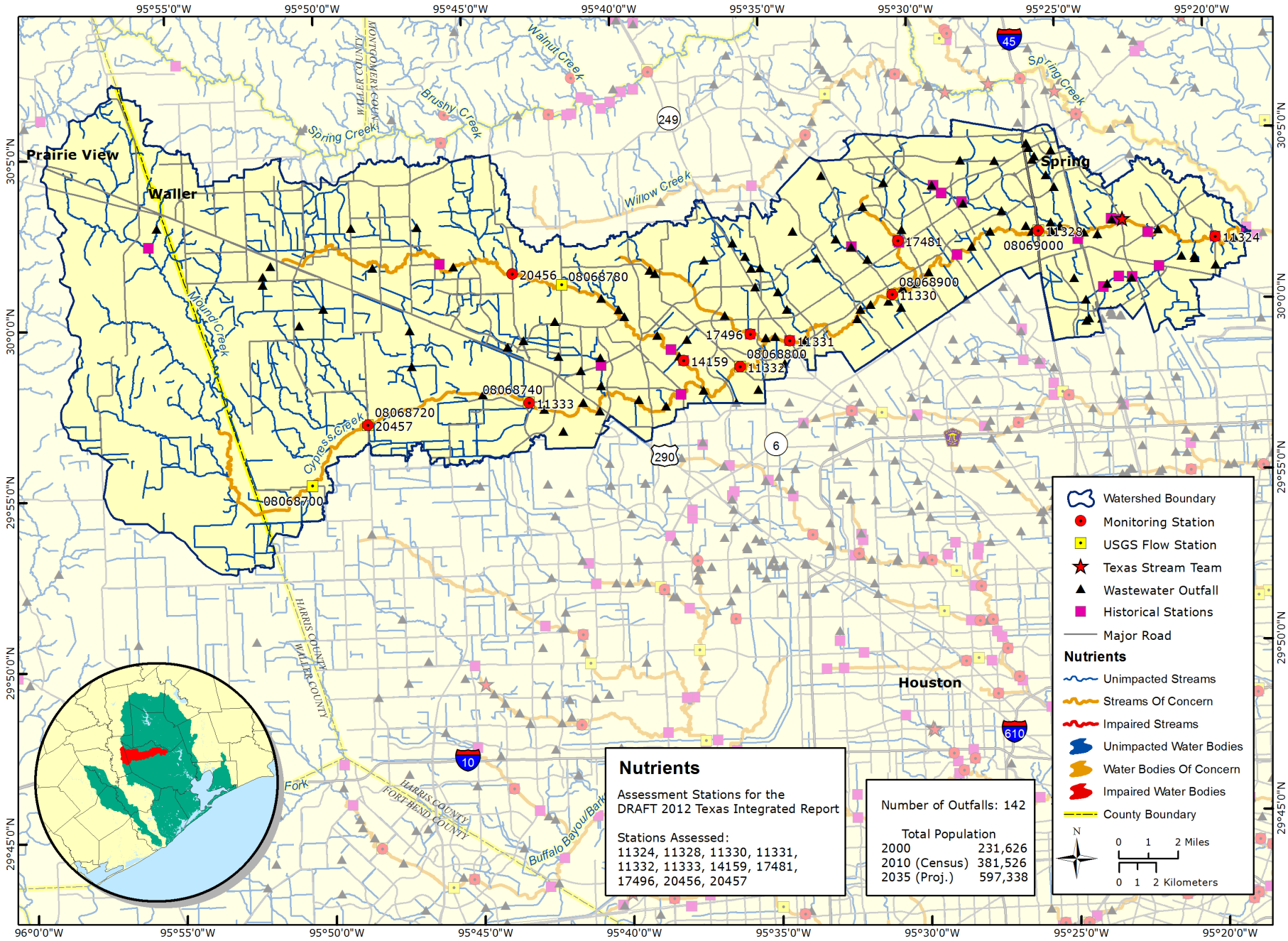


Figure - 29

SEGMENT 1009 CYPRESS CREEK MACROBENTHIC COMMUNITY IMPAIRMENTS

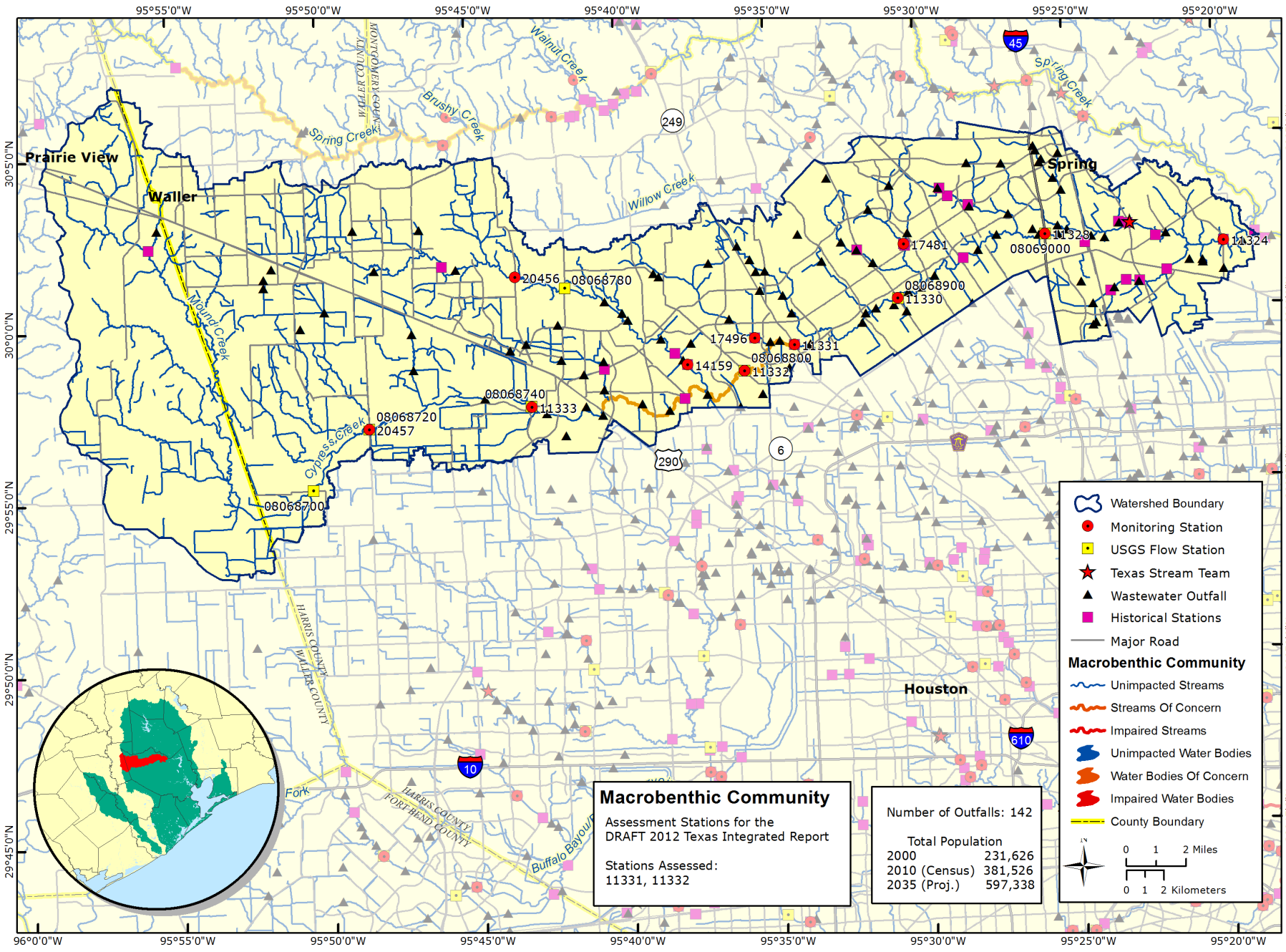
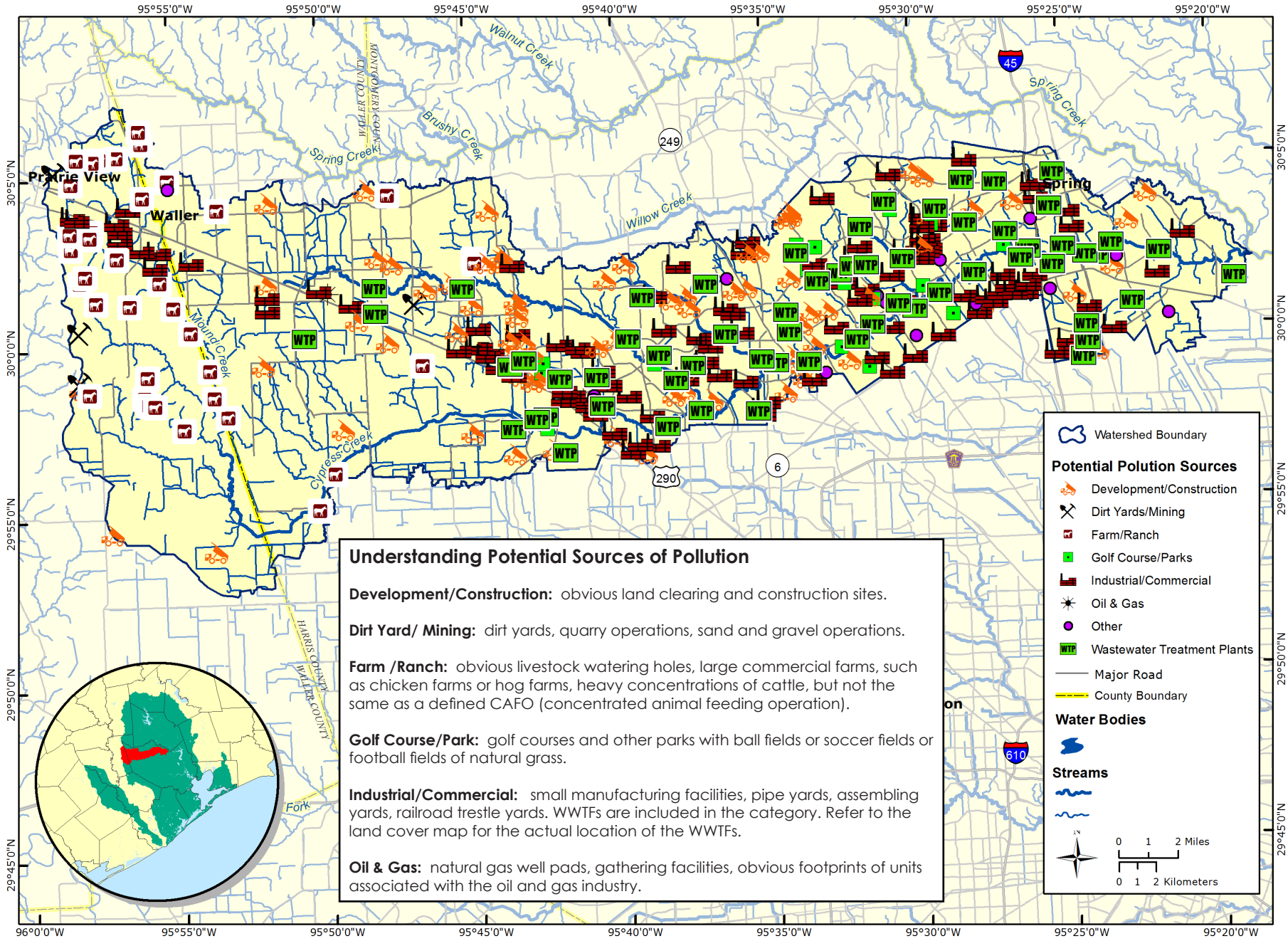
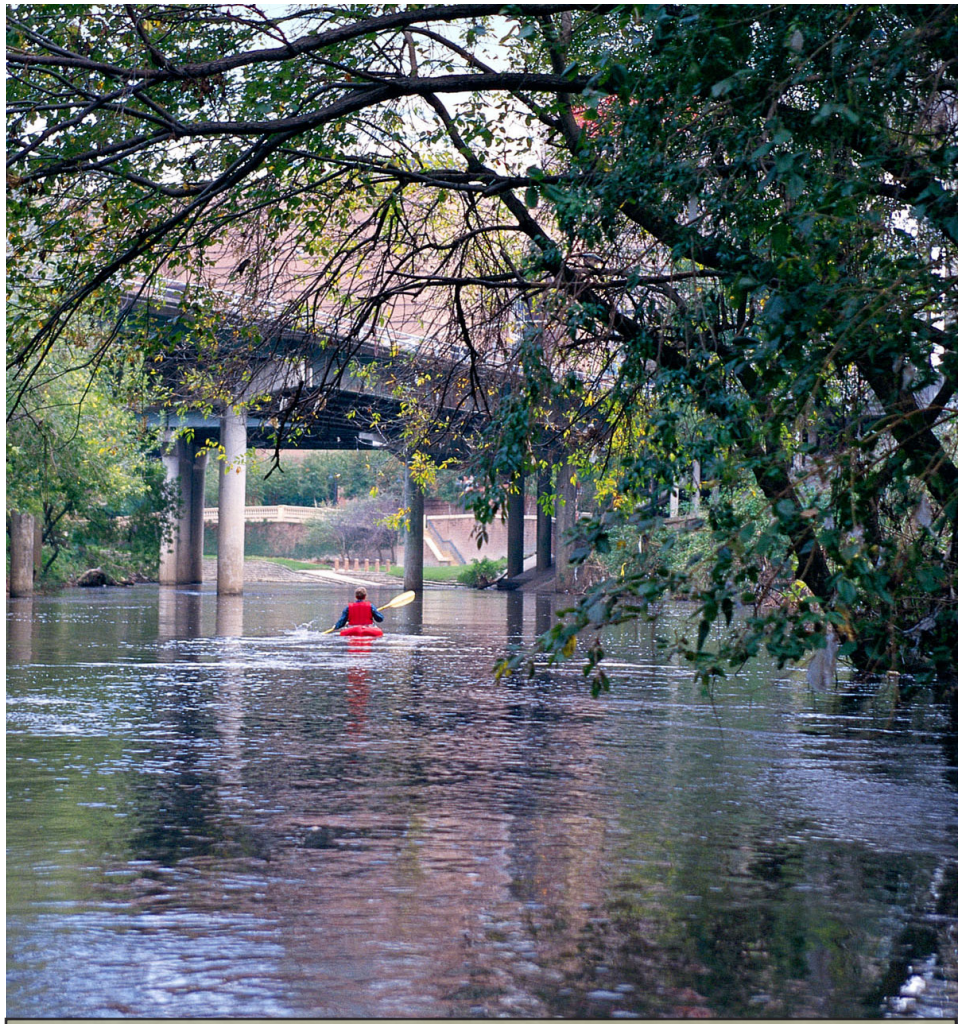


Figure - 30

SEGMENT 1009 CYPRESS CREEK POLLUTION SOURCES





1014 - Buffalo Bayou

Length 22.7 Miles (classified portion)	**Watershed Area** 358 Square Miles
Texas Stream Team Monitors 4	**Permitted Outfalls** 144
Number of Active Monitoring Stations 23	
Designated Uses Intermediate Aquatic Life; Contact Recreation	

Segment Description:

This segment begins near downtown Houston extending approximately 23 miles from the heavily developed areas of the city's urban core west and north through dense residential areas to the primarily rural and agricultural areas of western Harris County and eastern Waller County. Buffalo Bayou Above Tidal drains into Buffalo Bayou Tidal and then into the Houston Ship Channel and the Galveston Bay system. It drains an area that includes two storm water reservoirs. Regulated releases from both Barker and Addicks reservoirs, located mid segment, greatly affect the amount of water flowing down Buffalo Bayou at any given time.

The segment includes one AU on the main water body and 14 AUs on 12 unclassified water bodies described as follows:

- 1014A – Bear Creek (unclassified water body): Perennial stream from the confluence with South Mayde Creek upstream to the confluence with an unnamed tributary 0.77 miles north of Longenbaugh Road
- 1014B – Buffalo Bayou/Barker Reservoir (unclassified water body): Perennial stream from Texas Highway 6 in Harris County upstream to the confluence with Willow Fork Buffalo Bayou in Fort Bend County
- 1014C Horsepen Creek (unclassified water body): From the Langham Creek confluence upstream to a point 0.06 miles west of Barker Cypress Road
- 1014E – Langham Creek (unclassified water body): From the Dinner Creek confluence upstream to FM 529
- 1014H – South Mayde Creek (unclassified water body): From the Buffalo Bayou confluence upstream to an unnamed tributary 0.65 miles south of Clay Road
- 1014I – Willow Fork Buffalo Bayou (unclassified water body): Intermittent stream with perennial pools from the confluence with Buffalo Bayou in Fort Bend County up to 0.62 miles above U.S. Highway 90 in Waller County
- 1014J – Dinner Creek (unclassified water body): Perennial stream from the confluence with Langham Creek upstream to Frey Road
- 1014K – Turkey Creek (unclassified water body): From the South Mayde Creek confluence upstream to a point 0.68 miles directly east of FM 529 in Harris County
- 1014L – Mason Creek (unclassified water body): From the Buffalo Bayou confluence upstream to Mason Road upstream to 0.2 miles east of Katyland Drive
- 1014M – Newman Branch (Neimans Bayou) (unclassified water body): From the Buffalo Bayou Above Tidal confluence to 0.06 miles upstream of Hammerly Boulevard in Harris County
- 1014N – Rummel Creek (unclassified water body): From the Buffalo

Figure - 31

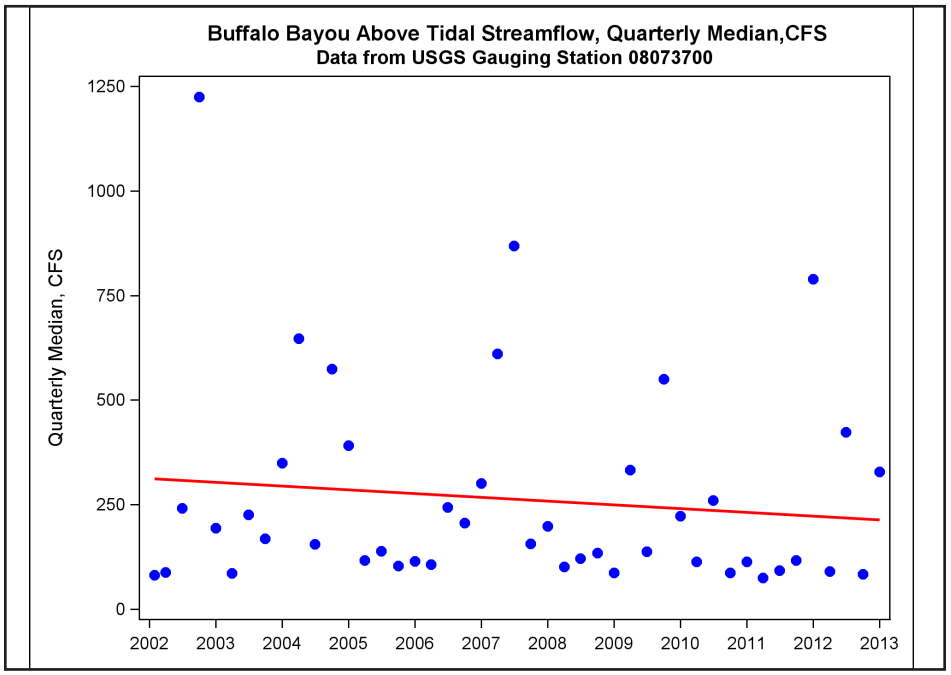
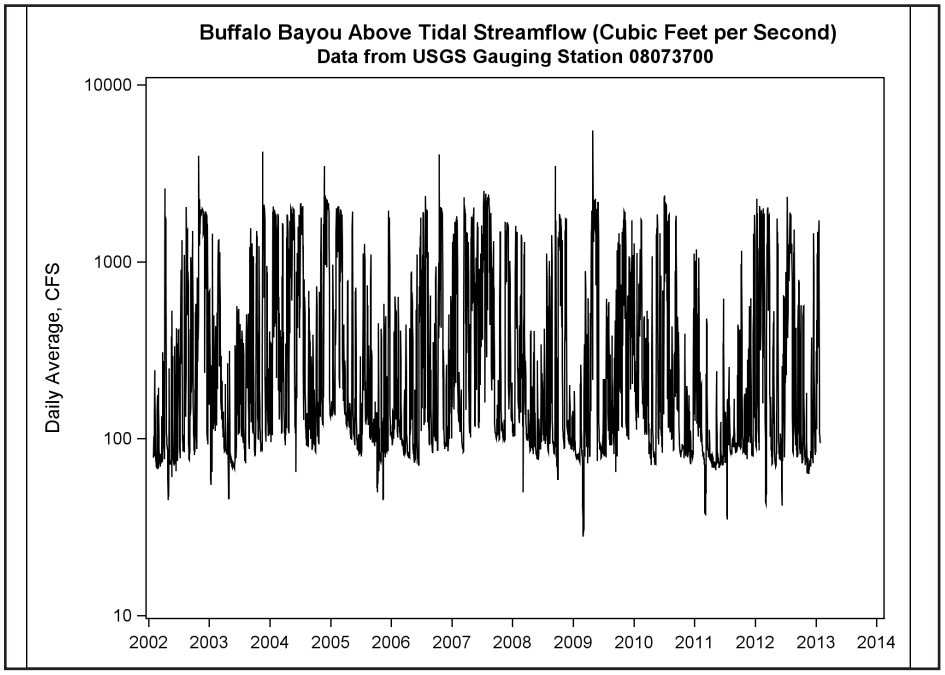


Figure - 32



Bayou Above Tidal confluence to 0.75 miles upstream to I-10 in Harris County

- 1014O – Spring Branch (unclassified water body): From the Buffalo Bayou Above Tidal confluence to 0.87 miles upstream of Long Point Road in Harris County

The segment currently has 23 active routine monitoring stations located throughout the watershed. There are four agencies that monitor in this segment. CRP partners include two divisions of the City of Houston – Health & Human Services (20 sites) and Public Works (one site) in cooperation with the Harris County Flood Control District. H-GAC monitors at two locations in the upper watershed, while TCEQ monitors two stations. See Figure - 40 on page 50 for the location of the monitoring sites and see Figure - 39 on page 48 for a detailed description of the CRP monitoring stations.

Hydrological Characteristics:

This segment and its tributaries drain an area of 358 square miles. The classified portion of Buffalo Bayou has a length of 22.7 miles, and the total length of unclassified tributaries in the watershed is 113.6 miles. Several USGS gaging stations are maintained on this segment. The median flow between July 2002 and July 2012, as measured at Piney Point south of Bunker Hill Village (USGS Station 08073700), is 150 CFS, with minimum and maximum flows of 28 and 5510 CFS, respectively. A general trend toward lower flows at this station is illustrated in Figure - 31 on page 43. Daily flow measurements at this station are displayed in Figure - 32 on page 43.

Land Use & Natural Characteristics:

Large tracts of land in the northwest areas of the segment are dedicated to cultivated crops or ranch activities, including large row crop agricultural operations. However, new residential and commercial developments are emerging in this area. New residential development is found primarily within the city limits of Katy and Houston. East of Texas Highway 6, the bayou passes through a belt of forest land and parks that have been established in the flood plain (for example, Terry Hershey Park and Cullen Park Phase 2). Further downstream, the bayou passes through a relatively affluent urban residential area, which includes additional parkland, light retail development, and golf courses.

The central portion of the watershed has the highest concentration of urban development and construction. The east central portion of the watershed is almost completely residential. Aerial photography suggests the area is almost completely saturated, with little land available for new development. Nearer

Figure - 33

Summary of Water Quality Impairments and Concerns - Segment 1014 Buffalo Bayou Above Tidal							
Segment ID	**Bacteria**	**Dioxin/PCBs**	**DO**	**Chlorophyll *a***	**Nutrients**	**Other***	**Frog(s)****
1014	100				100		
1014A	100				100		
1014B	100				100		
1014C	38.3		38.3		38.3		
1014E	92				92		
1014H	59		26.1		59		
1014I							?
1014J							?
1014K	100				57		
1014L	58.2				58.2		
1014M	100		100				X
1014N	100						
1014O	100						

Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 6 (?= no stations/no data in the assessment unit)*

to central Houston, commercial and light industrial uses (large office parks, shopping centers, manufacturing) are more common. Secondary contact recreation (canoeing and kayaking) along the narrow and deep channel of the classified stretch of the bayou is common, and primary contact recreation (swimming and wading) is less common. Hiking and biking trails have been developed along many stretches of the bayou, and at least one large park, Cullen Park (9,200 acres), adjoins the bayou. See Figure - 40 on page 50 for greater detail.

Description of Water Quality Issues:

A summary of key impairments and concerns appears in Figure - 33 on page 44 for this segment. This section of Buffalo Bayou has shown high densities of *E.coli* for many years. The *2012 Draft IR* lists 13 of the 19 AUs in the segment as unsuitable for contact recreation use due to high seven-year geometric means. Geometric means from the most recent seven-years of data analyzed by H-GAC range from 79 MPN/100 mL in Buffalo Bayou/Barker Reservoir (1014B_01) to 1900 MPN/100 mL in Rummel Creek (1014N_01) and Spring Branch (1014O_01). *E. coli* densities have exceeded 126 MPN/100 mL in 90% of samples collected in five assessment units during this period. Horsepen Creek (1014C_01) was added to the 303(d) list in 2012. See Figure - 41 on page 51 for the location of these impairments.

The levels of nutrients (phosphorus and nitrogen compounds) are of particular concern in this segment. TCEQ has identified concerns for ALU based on high concentrations of one or more nutrients in nine AUs. H-GAC analysis of the most recent seven years of data shows that the median total phosphorus concentration exceeds the screening level of 0.69 mg/L in all but four AUs. More than 90% of samples collected during the most recent seven years have exceeded the median total phosphorus screening level in four assessment units located on unclassified tributaries. Figure - 34 on page 45 illustrates the significant upward trend found in phosphorus concentrations found in Rummel Creek (1014N). See Figure - 42 on page 52 for the location of these concerns.

Figure - 34

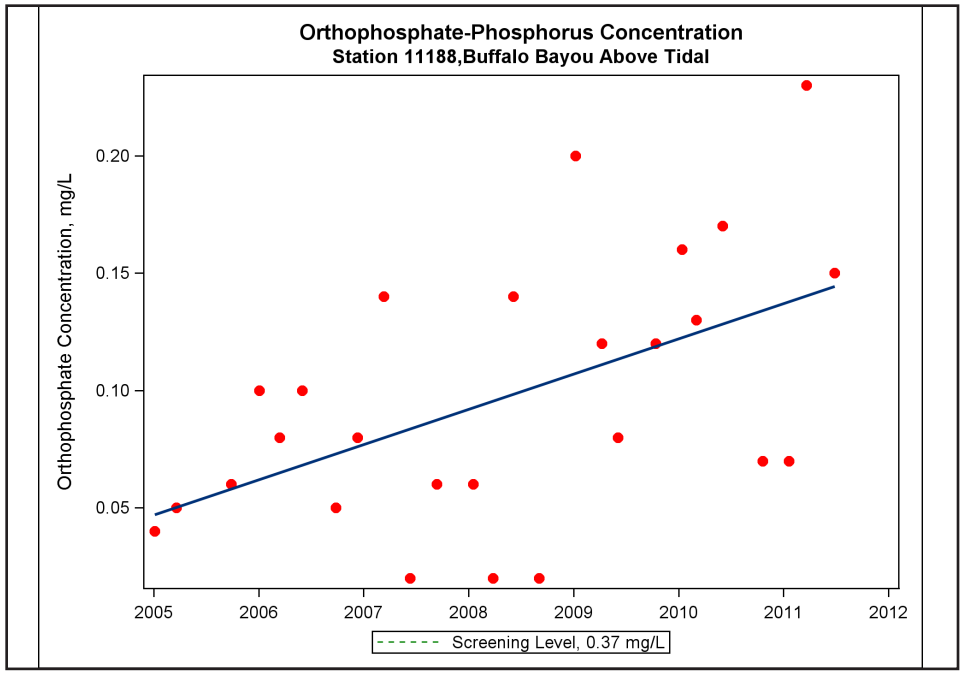
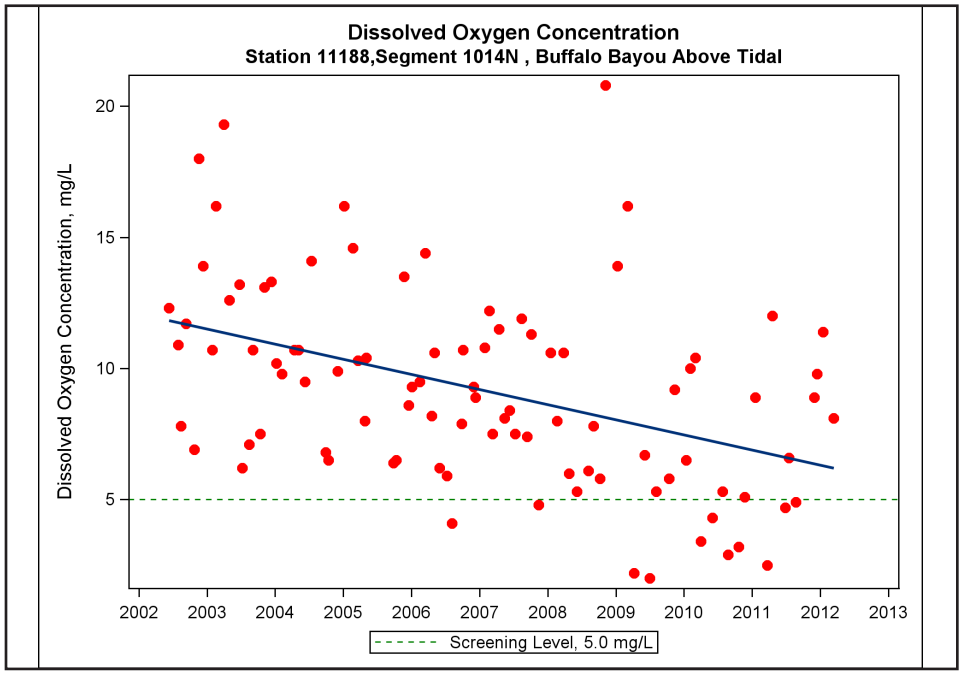


Figure - 35



Newman Branch/Neimans Bayou (1014M) has the poorest water quality of all AUs in this segment. Assessment unit 1014M is listed as impaired for bacteria and 24-hr DO. It also has an impaired fish community and an impaired macrobenthic community. There is not a concern for nutrients in this AU. It is noteworthy that the H-GAC analysis of the most recent seven-year period shows that less than 2% of samples collected at the monitoring station in this AU have exceeded the total phosphorus screening level and trend analysis suggests concentrations are declining. See Figure - 41 on page 51, Figure - 43 on page 53 and Figure - 44 on page 54 for the locations of these impairments.

Two AUs, Horsepen Creek (1014C) and a portion of South Mayde Creek (1014H_02), have concerns for DO because grab samples are frequently measured below the screening level of 3 mg/L. Additionally, DO concentrations appear to be decreasing in three other unclassified tributaries not currently identified as exhibiting aquatic life use concerns. Figure - 35 on page 45 illustrates the significant downward trend found in DO grab samples measured in Rummel Creek (1014N). All these water bodies need 24-hour monitoring to fully assess their status. See Figure - 43 on page 53 and Figure - 44 on page 54 for the locations of these impairments and concerns.

H-GAC trend analyses suggest that total phosphorus and nitrate-nitrogen concentrations in the classified portion of the segment have increased over time. Analysis of aggregated data does not suggest a DO trend, but there are some statistically significant trends in data collected on several unclassified tributaries. Figure - 36 on page 46 and Figure - 37 on page 46 illustrate these trends.

Total phosphorus, nitrate, *E. coli*, rainfall, and USGS flow data from station 11360, located immediately downstream of Beltway 8 on the classified stretch of the segment, were analyzed to explore inter-parameter relationships and station-specific trends. This station is located about 328 yards downstream of a 26 MGD WWTF, and a USGS flow gaging station is located near the monitoring station. Total phosphorus and nitrate nitrogen appear to be increasing over time, although the rate of change is not dramatic. The trend observed in the original analysis was independently predictive, showing that the trend is not related to changes in flow alone. Figure - 38 on page 46 illustrates that as the flow in the bayou increases, following rain events and releases from upstream reservoirs, the concentration of total phosphorus falls, with little change in the density of *E. coli*. Regression analysis confirms that the correlation between measured flow and the previous day's rainfall is significant.

Figure - 36

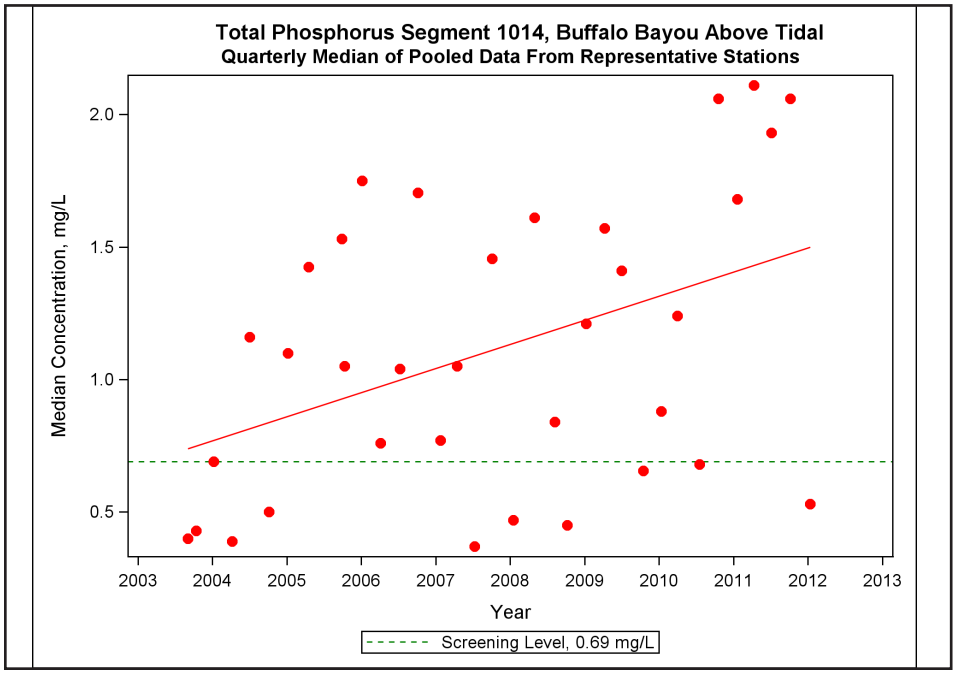


Figure - 37

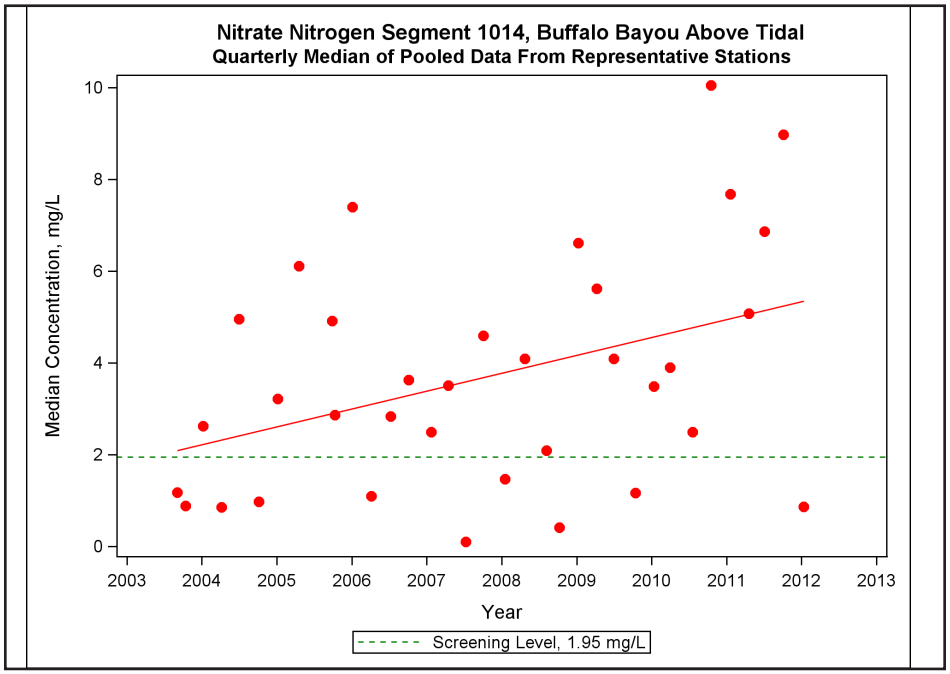
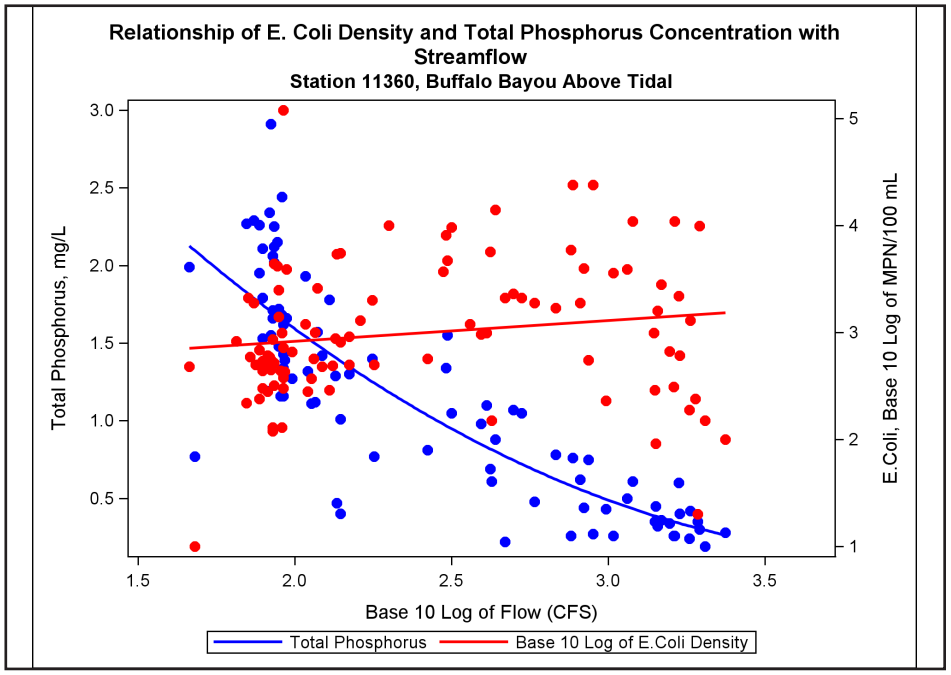


Figure - 38



Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite imagery to identify a variety of potential sources of pollution in this segment. Figure - 45 on page 55 identifies the potential sources of pollution or points of interest. The wide range of land uses and the relatively dense population in this watershed creates a similarly wide range of potential sources of pollutants.

Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes,sanitary sewer system overflows and collection system overflows; and
- runoff contaminated with waste from pets and wildlife.

There is little industrial activity, but the mix of small-scale agricultural activities, parklands, and residential developments demand significant (and increasing) wastewater treatment capacity. H-GAC records indicate 92 municipal entities hold TPDES permits allowing a total discharge of roughly 140 MGD. Nine entities hold permits to discharge industrial wastewater (13 MGD), and 18 private permitees of unspecified waste type (7.5 MGD). TCEQ DMR data show that the average daily discharge during 2012 varied between 45 and 50 MGD (68- 79 CFS). If the reported discharges are correct, a substantial component of daily flow in the segment during

dry periods is WWTF effluent. The largest municipal plants are located on unclassified tributaries, and H-GAC analysis suggest that domestic wastewater is the largest contributor of nutrients to the segment. Bacteria levels generally increase in response to rainfall, suggesting surface runoff creates a substantial bacterial load. It is likely that animal waste (from wildlife in the many strips of woodland along the bayou, and domestic pets that accompany walkers and hikers along trails) contributes to the bacterial load into the waterway.

Station 17493 is located on South Mayde Creek, an unclassified tributary of Buffalo Bayou, adjacent to Cullen Park, a 9,300-acre Houston park with four softball diamonds, hiking trails, soccer fields, and other amenities (including a water sprayground that presumably creates a small, but continuous, amount of runoff into the bayou). Two statistically significant trends have been observed at this station: increasing total phosphorus and ammonia nitrogen, and decreasing DO. Regression analysis suggests that rain events decrease the concentration of nutrients and increase *E. coli* density.

Potential Stakeholders:

Primary stakeholders are represented on the BIG Steering Committee. The stakeholder group includes

- Galveston County;
- Cities of Friendswood, Houston, Pearland and Brookside Village;
- Harris County Flood Control District;
- drainage districts and road and bridge departments in Harris, Galveston, Brazoria and Fort Bend counties;
- Clear Creek ISD and Pearland ISD;
- local colleges;
- Harris-Galveston and Fort Bend subsidence districts;
- Gulf Coast Waste Disposal Authority;
- various utility districts scattered throughout the watershed;
- area Home Owners' Associations;
- commercial/industrial facilities; and
- environmental/conservation organizations.

Ongoing Projects:

During the past seven years this segment has been subject to one TMDL project, the Buffalo/Whiteoak Bayous TMDL for bacteria. This segment is part of the geographic area for the *I-Plan*. The BIG *I-Plan* was recently approved by TCEQ Commissioners. Now stakeholders will begin addressing bacteria impairments and concerns in the various manners they identified through a consensus process. Most importantly to the success of the plan is finding adequate funding to support implementation.

Major Watershed Events:

The known or anticipated occurrences that have the potential to either positively or negatively impact this segment include population growth and additional drought. Development brings more WWTFs, more land clearing, fertilized lawns and other landscapes, and pets producing waste.

The last major watershed event was the drought that occurred in 2010 and 2011. This record drought caused at least one of the monitoring stations in the far upstream reaches to go dry.

Recommended Actions:

Activity	Responsible Entity(s)
Begin implementing the *I-Plan* for bacteria reduction	Stakeholders
Continue collecting water quality data to support actions associated with future WPP development, TMDLs and future modeling efforts	TCEQ, H-GAC and CRP partners
Support, maintain, and/or increase programs that conduct septic system inspections, and oversee maintenance and repairs	County and local agencies and stakeholders
H-GAC, CRP partners and other stakeholders should continue ongoing public outreach to numerous groups throughout the watershed. Topics include programs for • farmers and private residents to minimize fertilizers in runoff from field and yards; • residents and small commercial property owners on how to properly maintain OSSFs and dispose of pet waste; and • public organizations or agencies involved in the maintenance of the waterways on how to minimize habitat destruction and sedimentation.	

Figure - 39

Fiscal Year 2013 Monitoring Sites - Segment 1014 Buffalo Bayou								
Segment ID	**Site Description**	**Station ID**	**Collecting Entity**	**Monitoring Type**	**Field Parameters* / Frequency**	**Conventional Parameters**/ Frequency**	**Bacteria***/ Frequency**	**Flow / Frequency**
1014	BUFFALO BAYOU AT VOSS ROAD	11356	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014	BUFFALO BAYOU IMMEDIATELY DOWNSTREAM OF WEST BELTWAY 8 IN HOUSTON	11360	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1014	BUFFALO BAYOU AT WILCREST DRIVE IN HOUSTON	11361	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014	BUFFALO BAYOU IMMEDIATELY DOWNSTREAM OF DAIRY ASHFORD ROAD WEST OF HOUSTON	11362	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1014	BUFFALO BAYOU IMMEDIATELY DOWNSTREAM OF DAIRY ASHFORD ROAD WEST OF HOUSTON	11362	City of Houston-Public Works (HP)	RT	15	N/A	15	15
1014	BUFFALO BAYOU AT ELDRIDGE ROAD IN HOUSTON	11363	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014	BUFFALO BAYOU AT SH 6	11364	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1014	BUFFALO BAYOU AT CHIMNEY ROCK ROAD IN HOUSTON	15845	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014	BUFFALO BAYOU IMMEDIATELY DOWNSTREAM OF BRIAR FOREST DRIVE IN WEST HOUSTON	15846	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014	BUFFALO BAYOU NORTH SHORE IMMEDIATELY UNDERNEATH THE SOUTHBOUND FEEDER ROAD BRIDGE OF IH 610 WEST IN HOUSTON	20212	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014A	BEAR CREEK AT OLD GREENHOUSE ROAD WEST OF HOUSTON	17484	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014B	BUFFALO BAYOU IMMEDIATELY DOWNSTREAM OF GREEN BUSH ROAD 3.1 MILES SOUTHEAST OF KATY	11145	H-GAC	RT	4	4	4	4
1014B	BUFFALO BAYOU AT SOUTH MASON ROAD WEST OF HOUSTON	17492	City of Houston-Health & Human Services (HHS)	RT	9	9	9	

Fiscal Year 2013 Monitoring Sites - Segment 1014 Buffalo Bayou

Segment ID	Site Description	Station ID	Collecting Entity	Monitoring Type	Field Parameters* / Frequency	Conventional Parameters**/ Frequency	Bacteria***/ Frequency	Flow / Frequency
1014C	HORSEPEN CREEK AT FM 529 1.9 KILOMETERS EAST OF SH 6 NORTHWEST OF HOUSTON	20465	H-GAC	RT	4	4	4	4
1014E	LANGHAM CREEK AT SH 6 IN NORTHWEST HOUSTON	17482	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1014H	SOUTH MAYDE CREEK IMMEDIATELY DOWNSTREAM OF MEMORIAL DRIVE	11163	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014H	SOUTH MAYDE CREEK AT DULANEY ROAD WEST OF HOUSTON	17493	City of Houston-Health & Human Services (HHS)	RT	9	9	9	9
1014K	TURKEY CREEK IMMEDIATELY DOWNSTREAM OF MEMORIAL DRIVE IN WEST HOUSTON	15847	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014K	TURKEY CREEK IMMEDIATELY SOUTHEAST OF TANNER ROAD AND NORTH ELDRIDGE PARKWAY INTERSECTION IN HOUSTON	17483	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014L	MASON CREEK 0.09 MILES DOWNSTREAM OF PARK PINE DRIVE WEST OF HOUSTON	17494	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014M	NEWMAN BRANCH / NEIMANS BAYOU AT MEMORIAL DRIVE IN WEST HOUSTON	16597	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014N	RUMMEL CREEK IMMEDIATELY DOWNSTREAM OF MEMORIAL DRIVE IN WEST HOUSTON	11188	City of Houston-Health & Human Services (HHS)	RT	9	9	9	
1014O	SPRING BRANCH CREEK IMMEDIATELY UPSTREAM OF WIRT ROAD 0.21 MILES DOWNSTREAM OF IH 10 IN WEST HOUSTON	16592	City of Houston-Health & Human Services (HHS)	RT	9	9	9	

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Total Depth, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity*

***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrate (only), Total Phosphorus, Chloride, Sulfate. H-GAC includes: Nitrite+Nitrate*

****Bacteria Parameters: E. coli and Enterococci*

Figure - 40

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL LAND USE

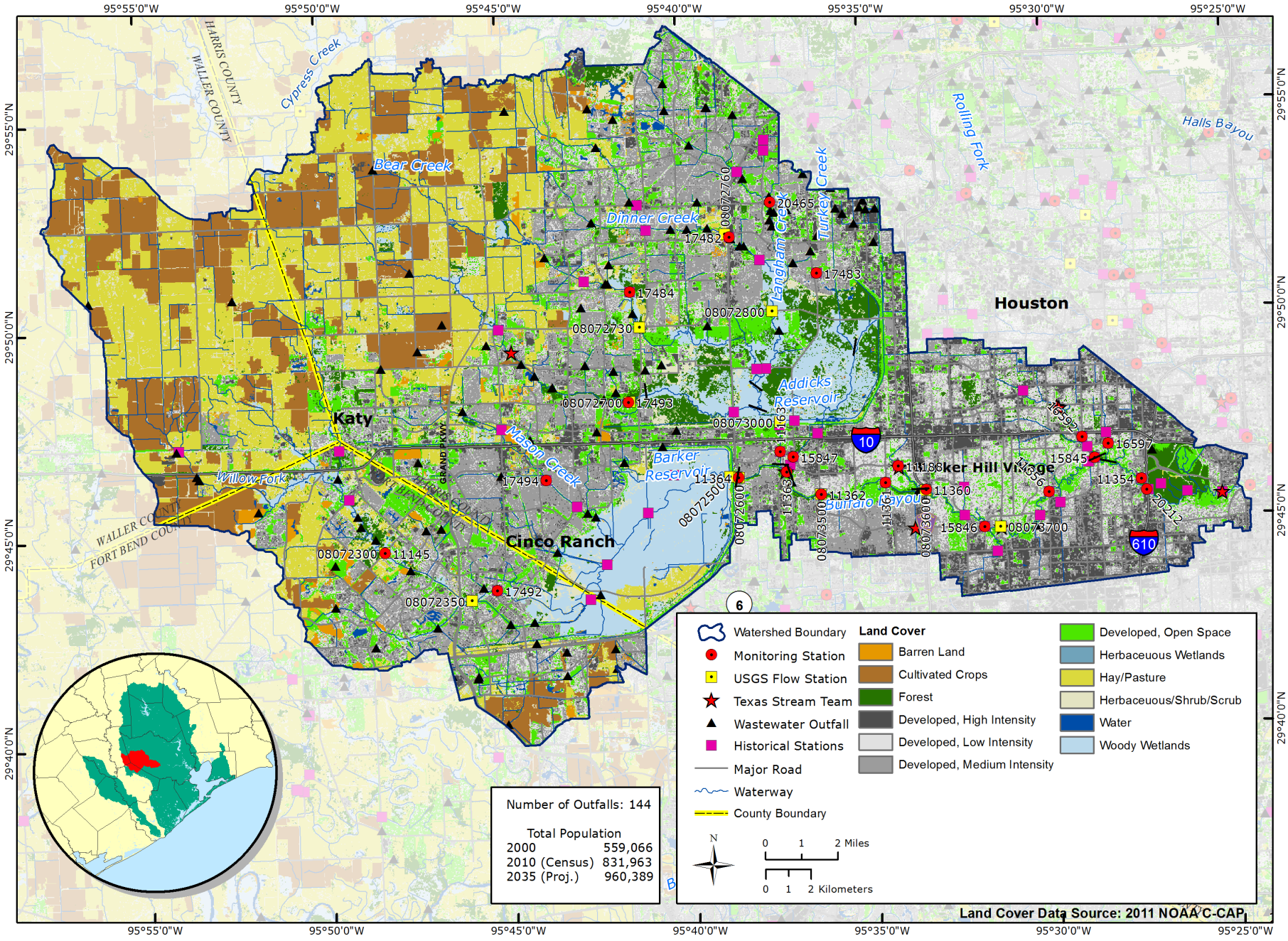


Figure - 41

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL BACTERIA IMPAIRMENTS & CONCERNS

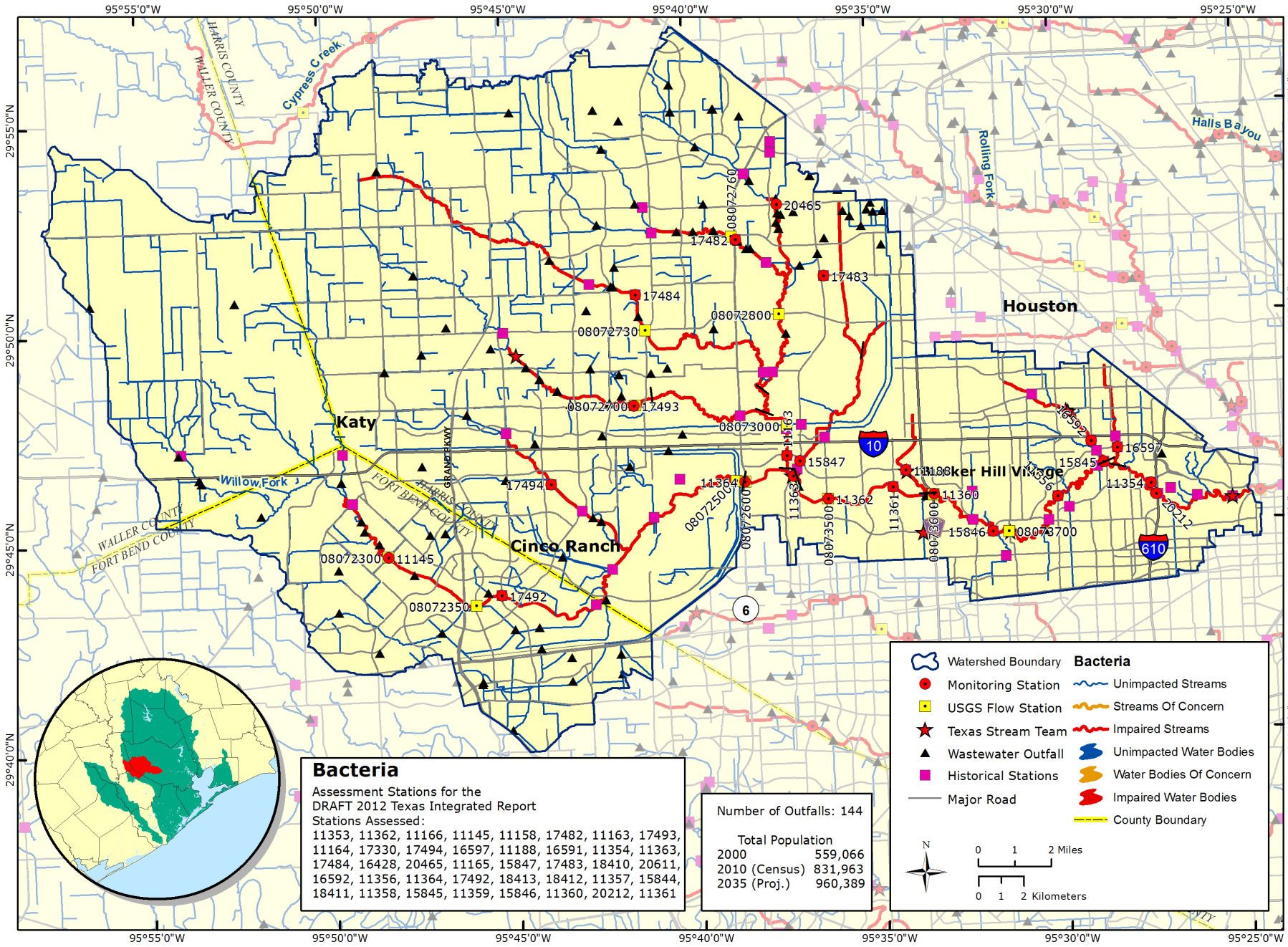


Figure - 42

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL NUTRIENT CONCERNS

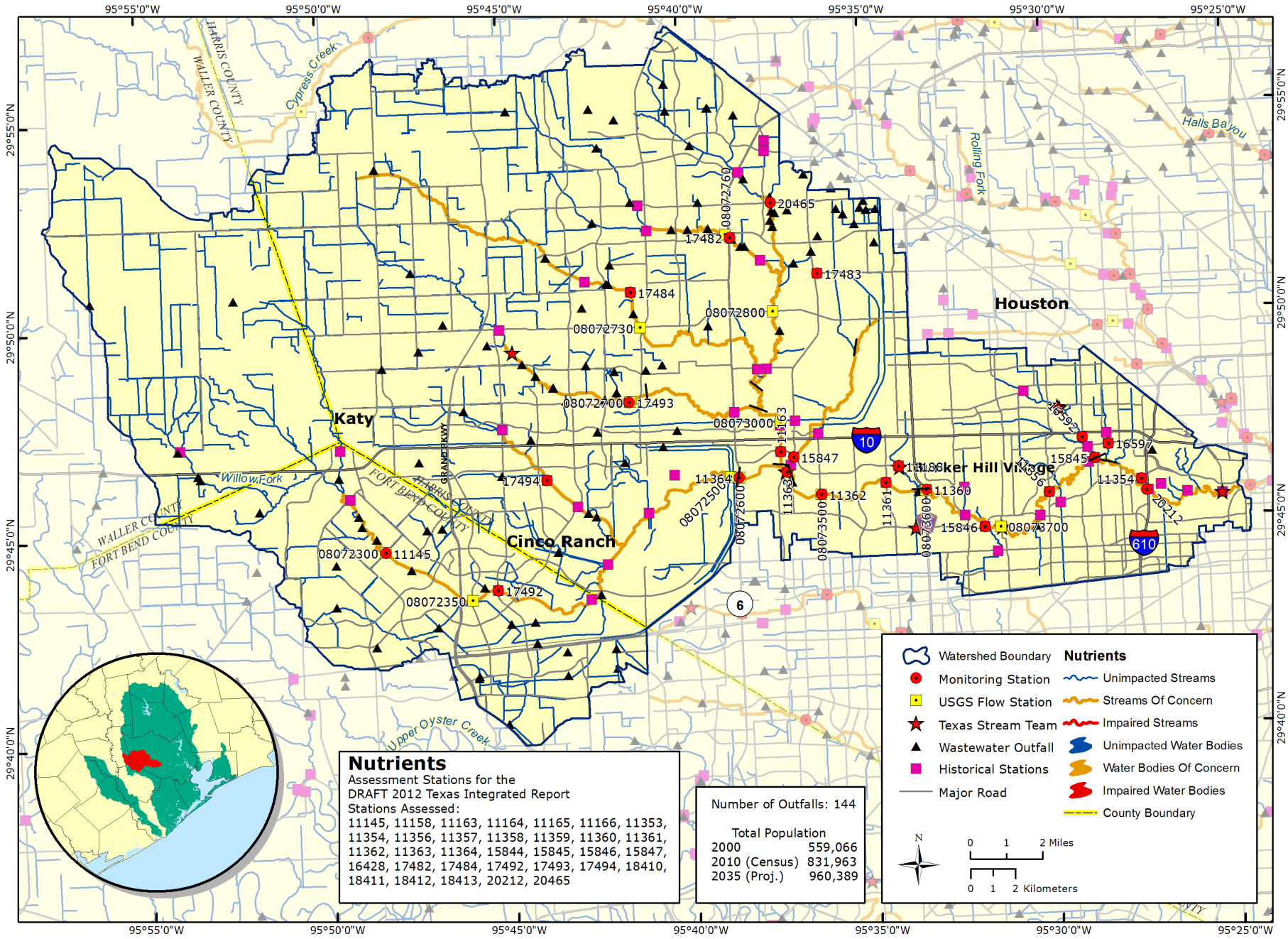


Figure - 43

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL DISSOLVED OXYGEN IMPAIRMENTS & CONCERNS

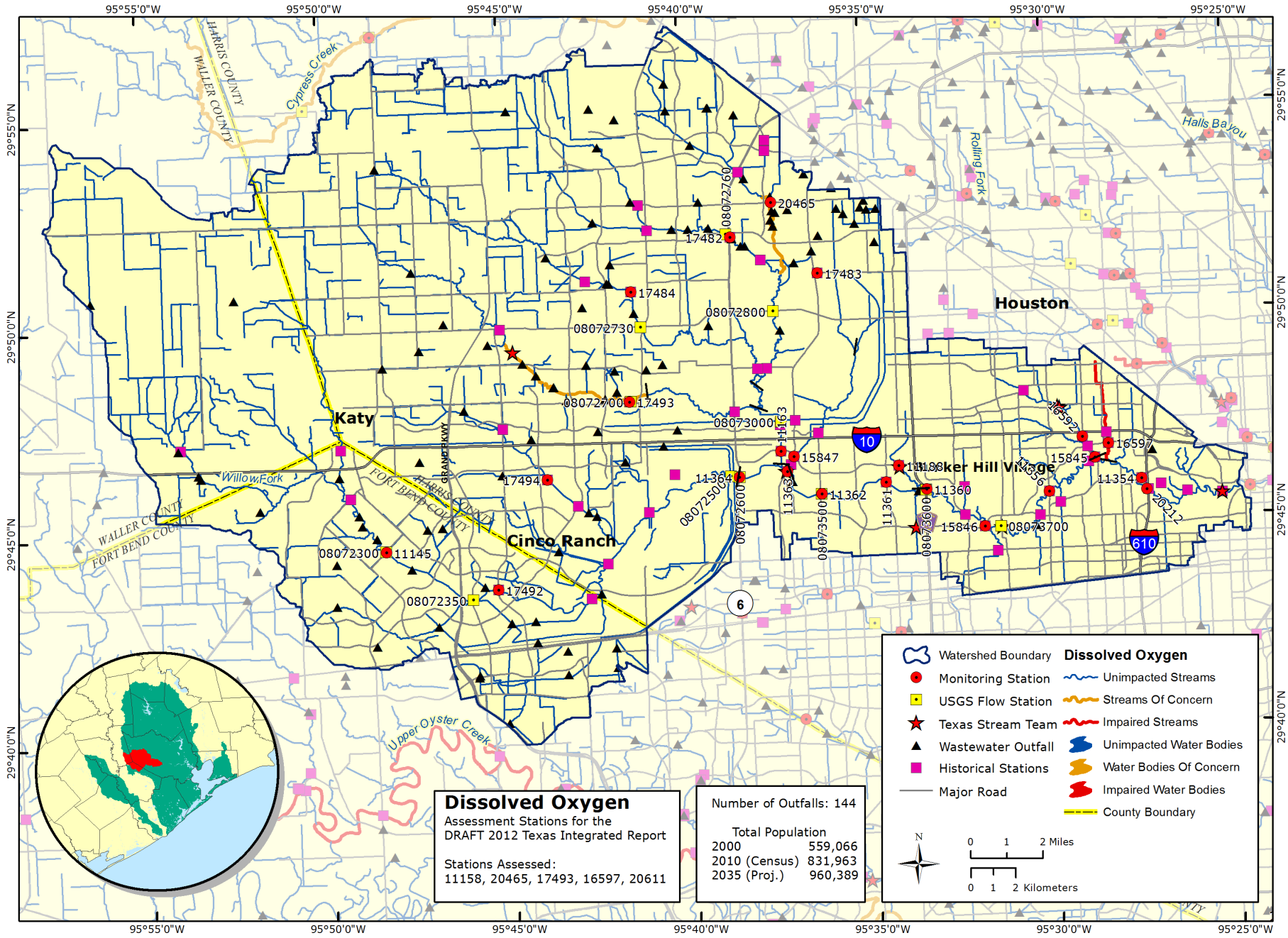


Figure - 44

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL FISH COMMUNITY & MACROBENTHIC COMMUNITY IMPAIRMENTS

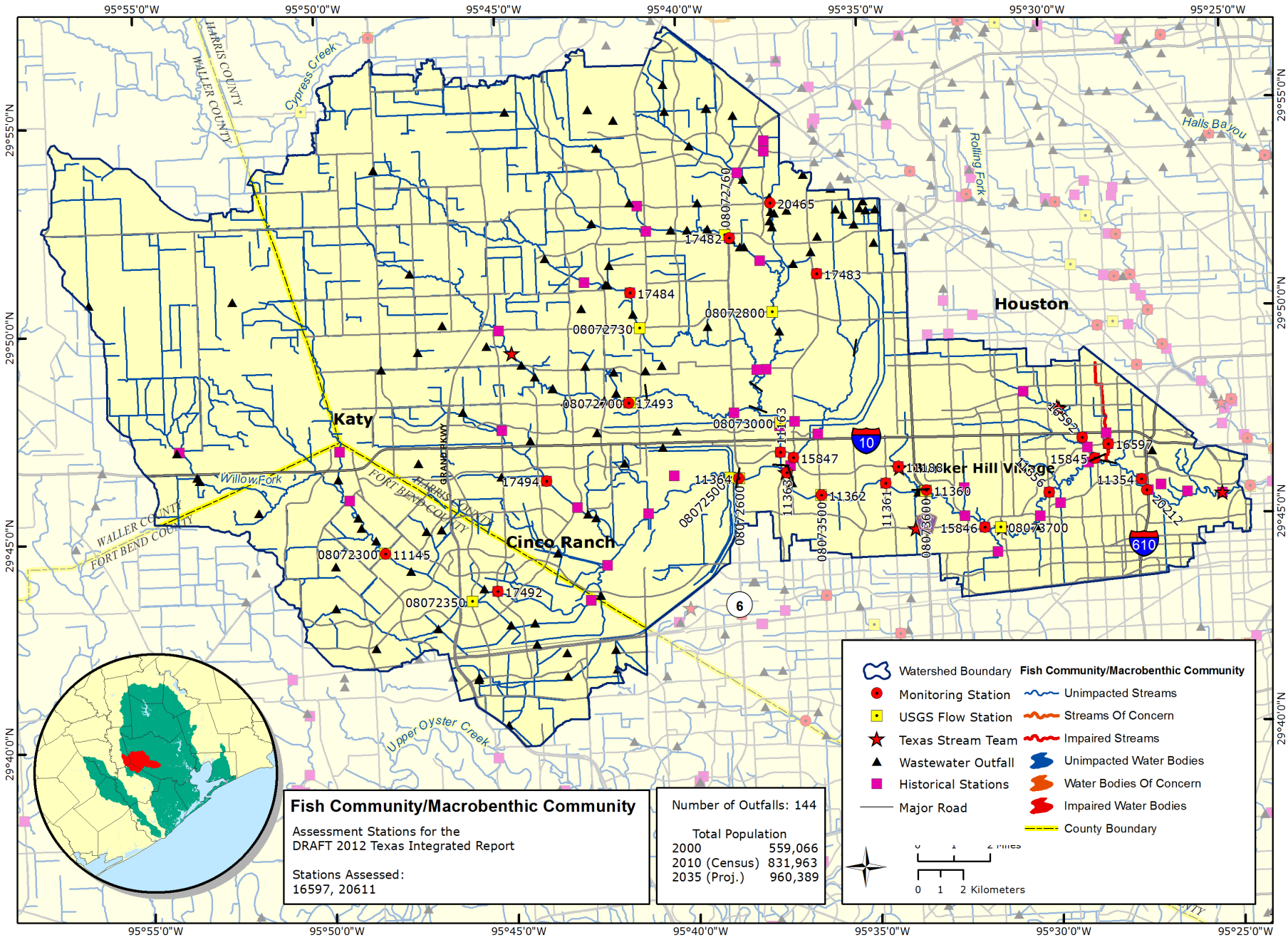
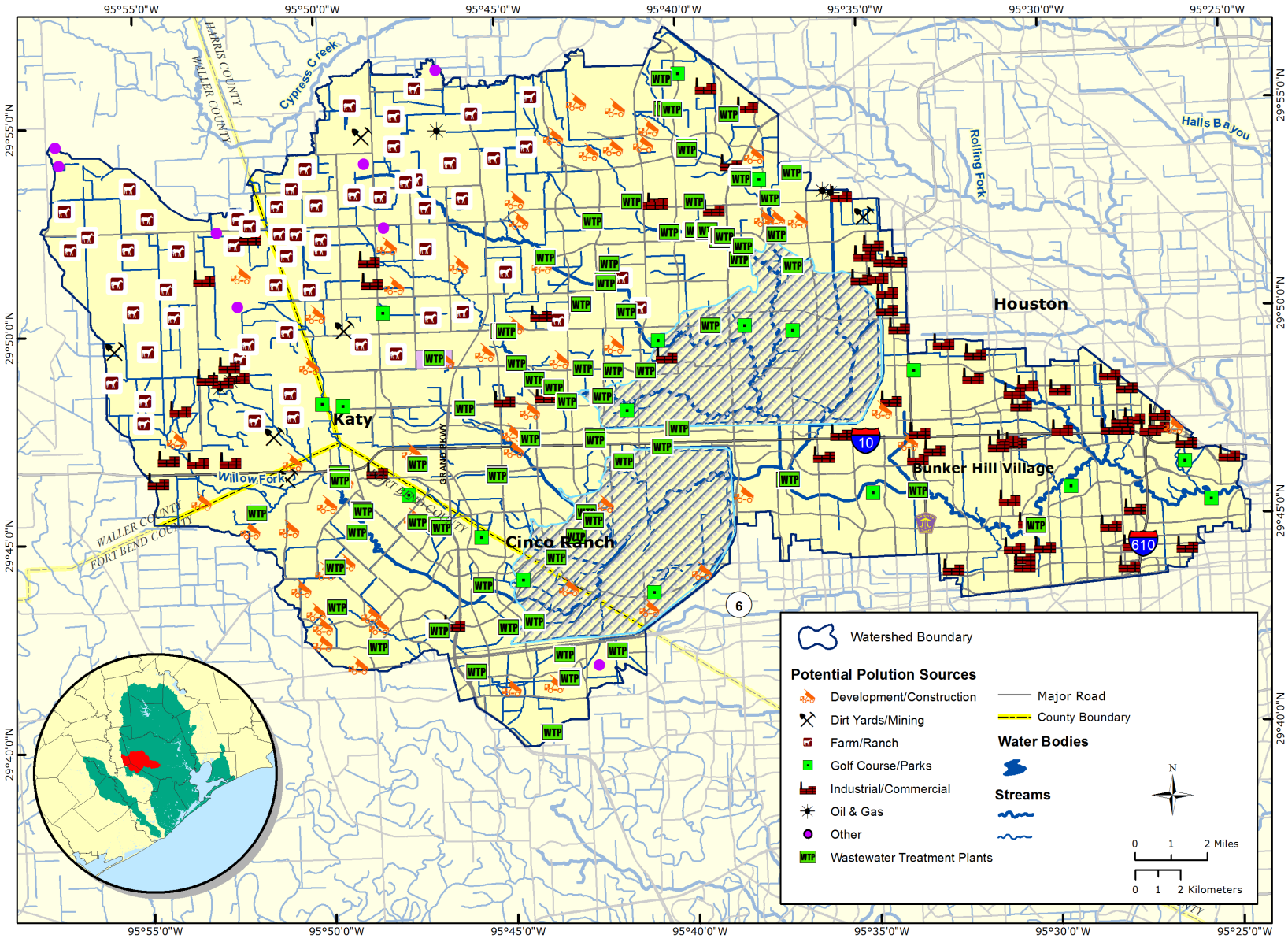


Figure - 45

SEGMENT 1014 BUFFALO BAYOU ABOVE TIDAL POLLUTION SOURCES



Understanding Potential Sources of Pollution

Development/Construction: obvious land clearing and construction sites.

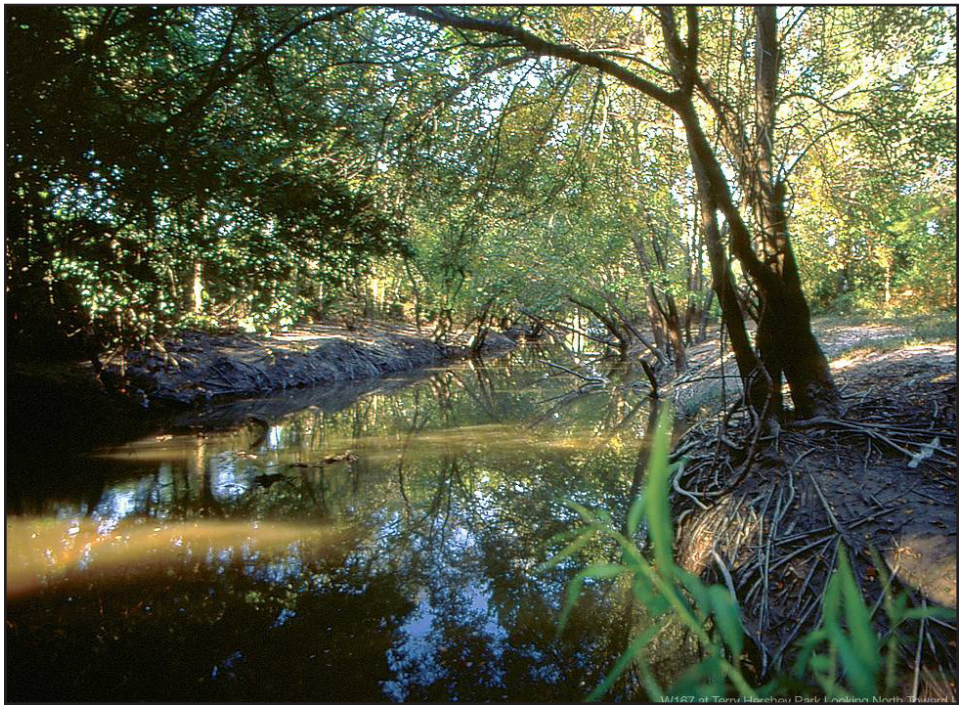
Dirt Yard/ Mining: dirt yards, quarry operations, sand and gravel operations.

Farm /Ranch: obvious livestock watering holes, large commercial farms, such as chicken farms or hog farms, heavy concentrations of cattle, but not the same as a defined CAFO (concentrated animal feeding operation).

Golf Course/Park: golf courses and other parks with ball fields or soccer fields or football fields of natural grass.

Industrial/Commercial: small manufacturing facilities, pipe yards, assembling yards, railroad trestle yards. WWTFs are included in the category. Refer to the land cover map for the actual location of the WWTFs.

Oil & Gas: natural gas well pads, gathering facilities, obvious footprints of units associated with the oil and gas industry.



1015 - Lake Creek

Length 62.5 Miles (classified portion)	**Watershed Area** 327 Square Miles
Texas Stream Team Monitors 2	**Permitted Outfalls** 12
Number of Active Monitoring Stations 3	
Designated Uses High Aquatic Life; Contact Recreation; Public Water Supply	

Segment Description:

Located in the upper west side of the San Jacinto River Basin, Lake Creek headwaters are in Grimes County and flow 48 miles south-southeast to the confluence with the West Fork San Jacinto River in Montgomery County. The segment encompasses a watershed of 327 square miles and includes two AUs on the main water body and two unclassified tributaries described as follows:

- 1015A – Mound Creek (unclassified water body): From the Lake Creek confluence upstream to point 0.69 miles east of FM 149
- 1015B – Caney Creek (unclassified water body): From the Lake Creek confluence upstream to a point 1.5 mile south of FM 1774

This segment has three active routine monitoring stations in FY2013. H-GAC has two stations on Lake Creek and one station on tributary Mound Creek. TCEQ is also conducting a biological assessment at station 18191 (one of H-GAC's monitoring stations) as it is considered a least disturbed stream site in the region. See Figure - 51 on page 62 for the location of the monitoring sites and Figure - 50 on page 61 for a detailed description of the CRP monitoring stations.

Hydrological Characteristics:

There was one USGS flow gage operating on this water body from September 2002 to January 2005. Flow ranged from 3.0 CFS to 15,700 CFS. Average stream flow was also calculated by H-GAC using flow data collected during routine monitoring events for six years from station 11367, located on Lake Creek at Honea-Egypt Road. Measured flows ranged from <1 to 998 CFS. This flow does not include any inputs from downstream WWTFs or tributary Mound Creek. Between March 2009 and June 2012, measured flow during routine monitoring ranged from <1 to 78 CFS with an average of 17 CFS. This time period also included the drought which accounts for the low flow. Many waterways upstream of Landrum Creek went dry during the drought.

Land Use & Natural Characteristics:

This watershed is primarily rural in nature and is dominated by forested land and grasslands. A small section of the Sam Houston National Forest lies in the upper, eastern section of the watershed east of Richards, Texas. With the exception of a few small towns and scattered subdivisions in the middle and upper watershed, development is concentrated primarily along major thoroughfares in the lower portion of the segment where all but two WWTFs are located. All other homesteads, ranchettes, large farms/ranches,

Figure - 46

Summary of Water Quality Impairments and Concerns - Segment 1015 Lake Creek							
Segment ID	**Bacteria**	**Dioxin/PCBs**	**DO**	**Chlorophyll a**	**Nutrients**	**Other***	**Frog(s)****
1015	55.6		100				
1015A	71.3						
1015B							

Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 4 (?= no stations/no data in the assessment unit)*

and commercial properties throughout the watershed are serviced by OSSFs. Agricultural activities range from single horse stables up to herds of cattle grazing large pastures. See Figure - 51 on page 62 for land cover in this segment.

A number of natural gas/oil well pads and gathering facilities are found concentrated in the southern part of the segment as well as the upper watershed in Grimes County.

Description of Water Quality Issues:

Lake Creek has been designated as a public water supply as well as having a contact recreational use and a high ALU. There are four AUs in the Lake Creek watershed – two on Lake Creek and one each on two tributaries. The public water supply use is fully supported, but there is a bacteria concern in two of the four AUs and a DO concern for single grab samples in two of the AUs. A summary of key impairments and concerns appears in Figure - 46 on page 59 for this segment. In the data record there is a data gap between 2005 and 2007 because there was no agency monitoring in the watershed.

The *Draft 2012 IR* identified a bacteria 'concern for near non-attainment but still supporting contact recreation' in Mound Creek and in the lower portion of Lake Creek. See Figure - 52 on page 63 for the location of the bacteria concerns. This is a change from the *2010 IR* in which there were no bacteria concerns identified anywhere in the segment. H-GAC's review of the *Draft 2012 IR* assessment results show that the number of samples exceeding the single sample criteria was not enough to request that the water bodies be listed for a bacteria impairment even though the geomeans appear to exceed the standard. While there is not a significant trend at this time, bacteria concentrations are increasing in this waterway.

The *Draft 2012 IR* also identified a DO concern in both AUs on Lake Creek (see Figure - 53 on page 64). H-GAC found a statistically significant downward trend for DO single sample measurements. This trend was found when looking at both the pooled data from the representative stations in the segment as well as when looking at only Station 18191. See Figure - 47 on page 60 for trends in the pooled data and Figure - 48 on page 60 for trends in Station 18191. This downward trend for DO was a change from the *2010 IR* in that only a portion of Lake Creek exhibited the DO concern. Now the entire creek is affected.

While not a concern at this time, H-GAC also found a significant upward trend in concentrations of orthophosphorus concentrations at station 18191. The concentrations are still consistently below the screening level of 0.37 mg/L but the trend indicates that water quality is just beginning to degrade. This site is located in the upper portion of the downstream AU. See Figure - 49 on page 60 for the trend.

Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite imagery to identify a variety of potential sources of pollution in this segment. See Figure - 54 on page 65 that identifies the potential sources of pollution or points of interest. Since there are very few point sources identified in this watershed, nonpoint source pollution is the primary cause of water quality issues in this segment.
Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes and sanitary sewer system overflows;
- runoff from OSSFs; and
- runoff contaminated with waste from pets, and wildlife; and
- runoff from fields used for cattle grazing.

Figure - 47

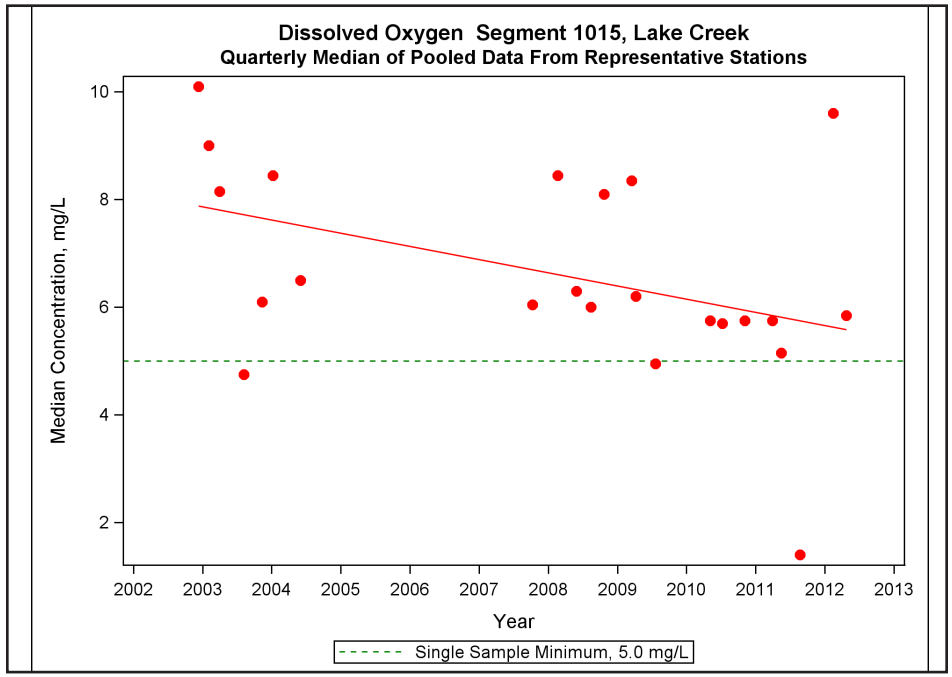


Figure - 48

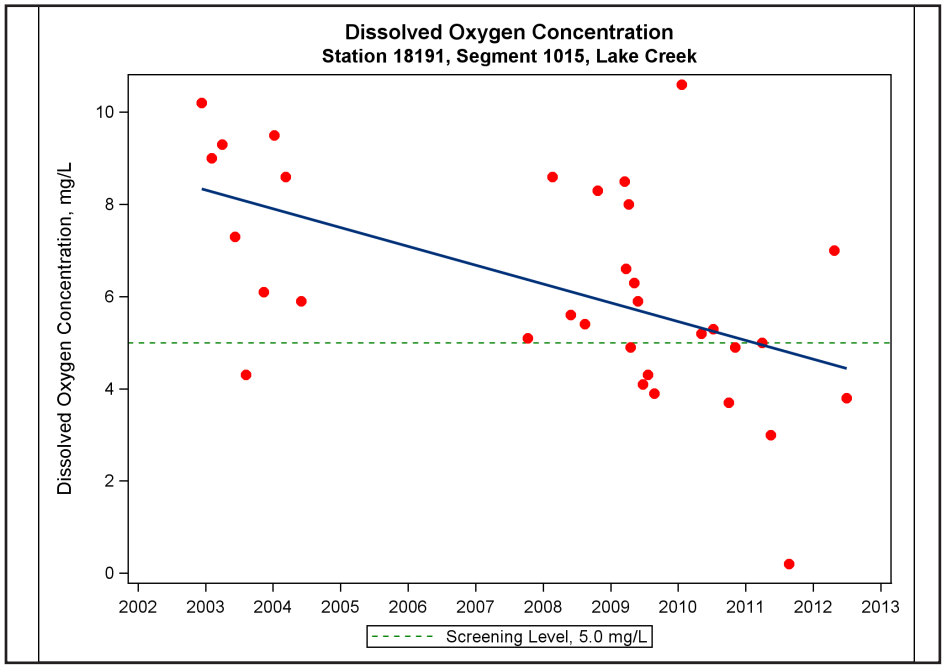
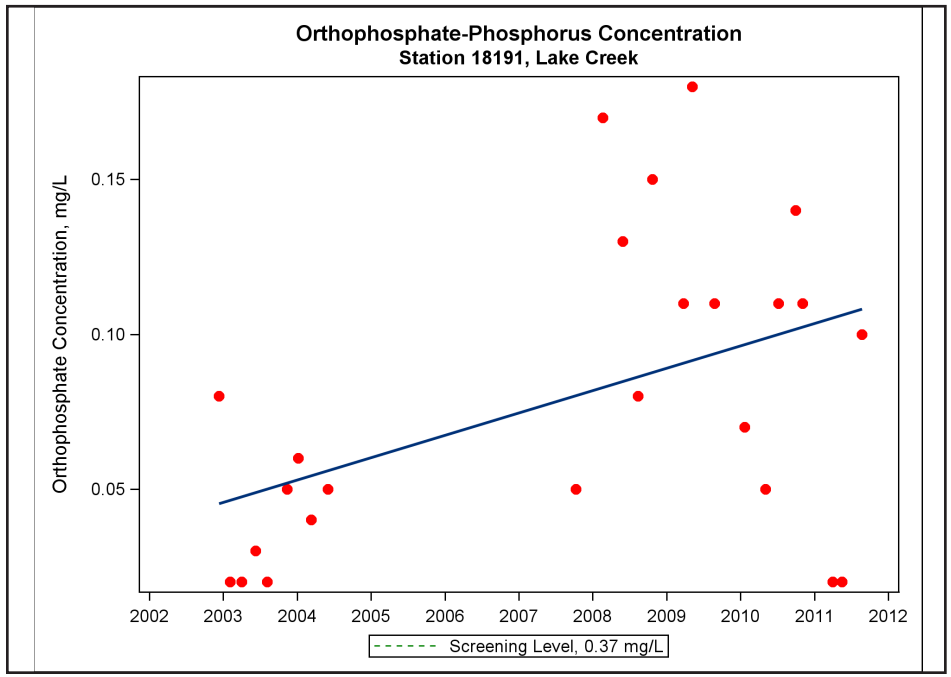


Figure - 49



While this segment is primarily agricultural in nature, there are also several distinct agricultural activities identified across the central portion of the segment that have the potential to contribute extra pollution loads to area waterways. This watershed has a few golf courses that have the potential to contribute nutrients in the form of excess fertilizers.

Potential Stakeholders:

Stakeholders in the segment include

- Montgomery County,
- 1488 Association, and
- Bayou Land Conservancy.

Ongoing Projects:

No special projects have been conducted in the watershed since the CRP sponsored a watershed characterization project conducted in 2002-03 by the USGS. One stream site least impacted by modification and/or pollution is located on this segment so TCEQ periodically re-evaluates its status.

Figure - 50

Fiscal Year 2013 Monitoring Sites - Segment 1015 - Lake Creek								
Segment ID	**Site Description**	**Station ID**	**Collecting Entity**	**Monitoring Type**	**Field Parameters* / Frequency**	**Conventional Parameters**/ Frequency**	**Bacteria***/ Frequency**	**Flow / Frequency**
1015	LAKE CREEK AT EGYPT COMMUNITY ROAD 8.3 MILES SOUTHWEST OF CONROE	11367	H-GAC	RT	4	4	4	4
1015	LAKE CREEK AT FM 149 APPROX 7.77 MILES SOUTH OF MONTGOMERY TEXAS NEAR KAREN TEXAS	18191	H-GAC	RT	4	4	4	4
1015A	MOUND CREEK 0.10 MILES DOWNSTREAM OF RUN OF THE OAKS 0.84 MILES UPSTREAM OF CONFLUENCE WITH LAKE CREEK	17937	H-GAC	RT	4	4	4	4

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Total Depth, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity*

***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrite+Nitrate, Total Phosphorus, Chloride, Sulfate*

****Bacteria Parameters: E. coli and Enterococci*

Major Watershed Events:

The known or anticipated occurrences that have the potential to either positively or negatively impact this segment include population growth and additional drought.

During 2011, the drought greatly affected Lake Creek causing much of the upper creek to go dry. The rains began in early 2012 and today, stream water levels have returned to normal.

Recommended Actions:

Activity	Responsible Entity(s)
Initiate the development of a WPP to convince area residents to implement their own best management practices before the pollution gets out of control	H-GAC, stakeholders and concerned citizens
Continue collecting water quality data to support actions associated with future WPP development, TMDLs and future modeling efforts	TCEQ, H-GAC and CRP partners
Support, maintain, and/or increase programs that conduct septic system inspections, and oversee maintenance and repairs	County and local agencies and stakeholders
Increase outreach programs to farmers and ranchers regarding best management practices to eliminate or minimize the effects of agricultural activities on water quality	TSSWCB
Educate residents and small commercial property owners on ways to reduce pollutant concentrations in their rainwater runoff	H-GAC, county and local agencies

Figure - 51

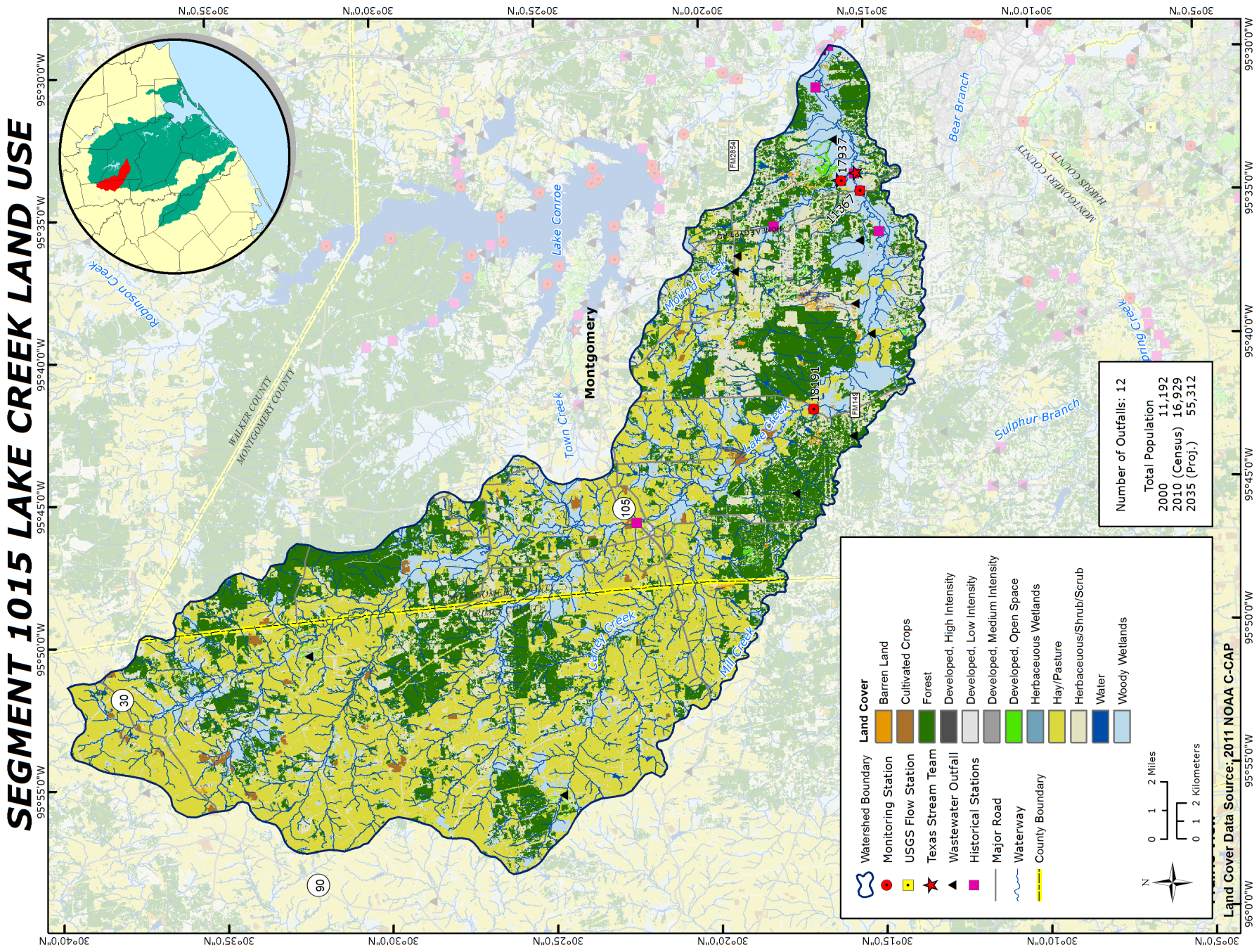

SEGMENT 1015 LAKE CREEK LAND USE
Land Cover
Barren Land
Cultivated Crops
Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Herbaceuous Wetlands
Hay/Pasture
Herbaceuous/Shrub/Scrub
Water
Woody Wetlands
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Waterway
County Boundary
Number of Outfalls: 12
Total Population
2000 11,192
2010 (Census) 16,929
2035 (Proj.) 55,312
0 1 2 Miles
0 1 2 Kilometers
N
Land Cover Data Source: 2011 NOAA C-CAP
Montgomery
Lake Conroe
Robinson Creek
Mound Creek
Town Creek
Lake Creek
Gatlin Creek
Mill Creek
Bear Branch
Sulphur Branch
Spring Creek
WALKER COUNTY
MONTGOMERY COUNTY
HARRIS COUNTY
18191
17937
17367
105
30
90
FM2854
FM149

Figure - 52

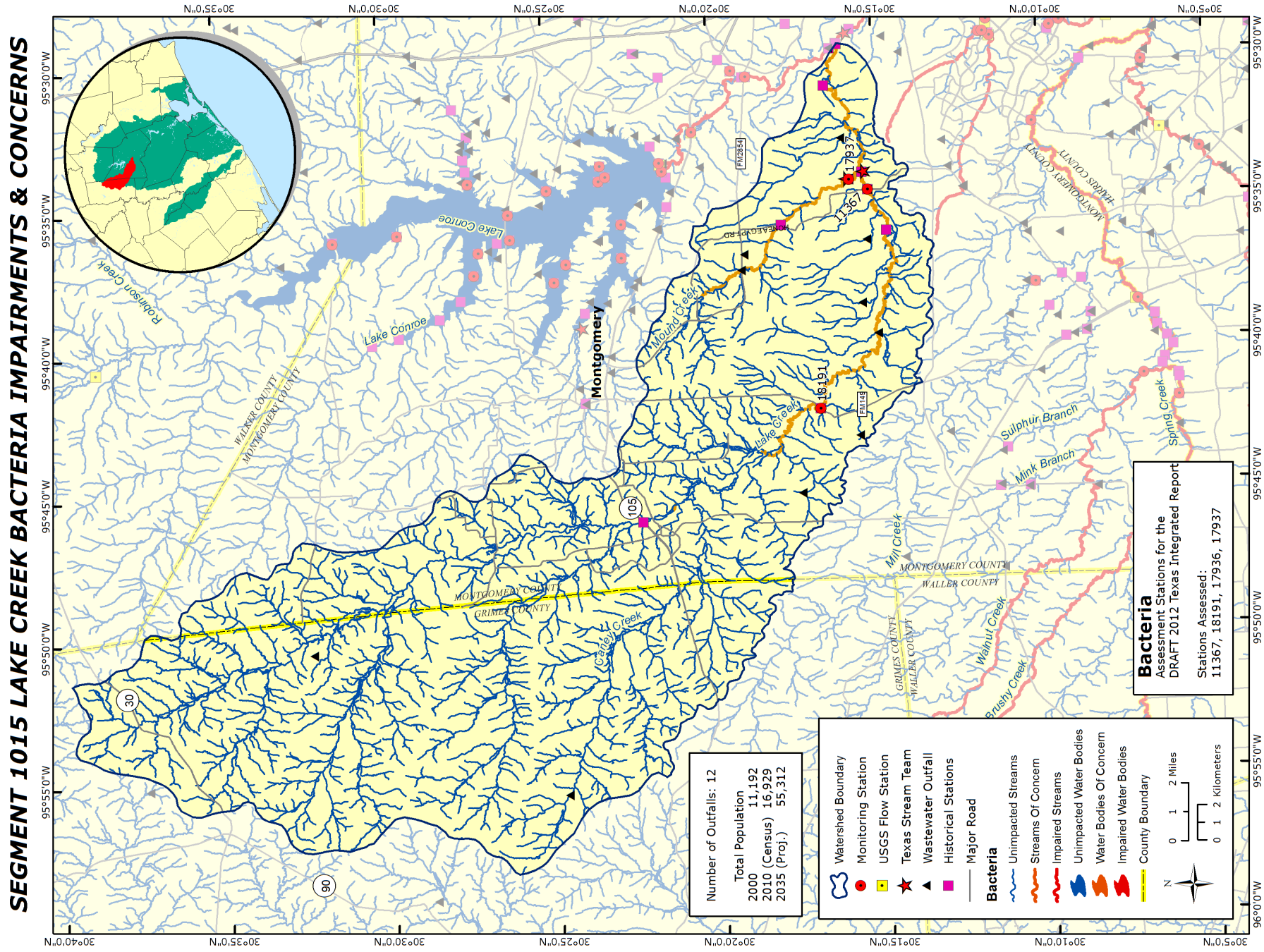
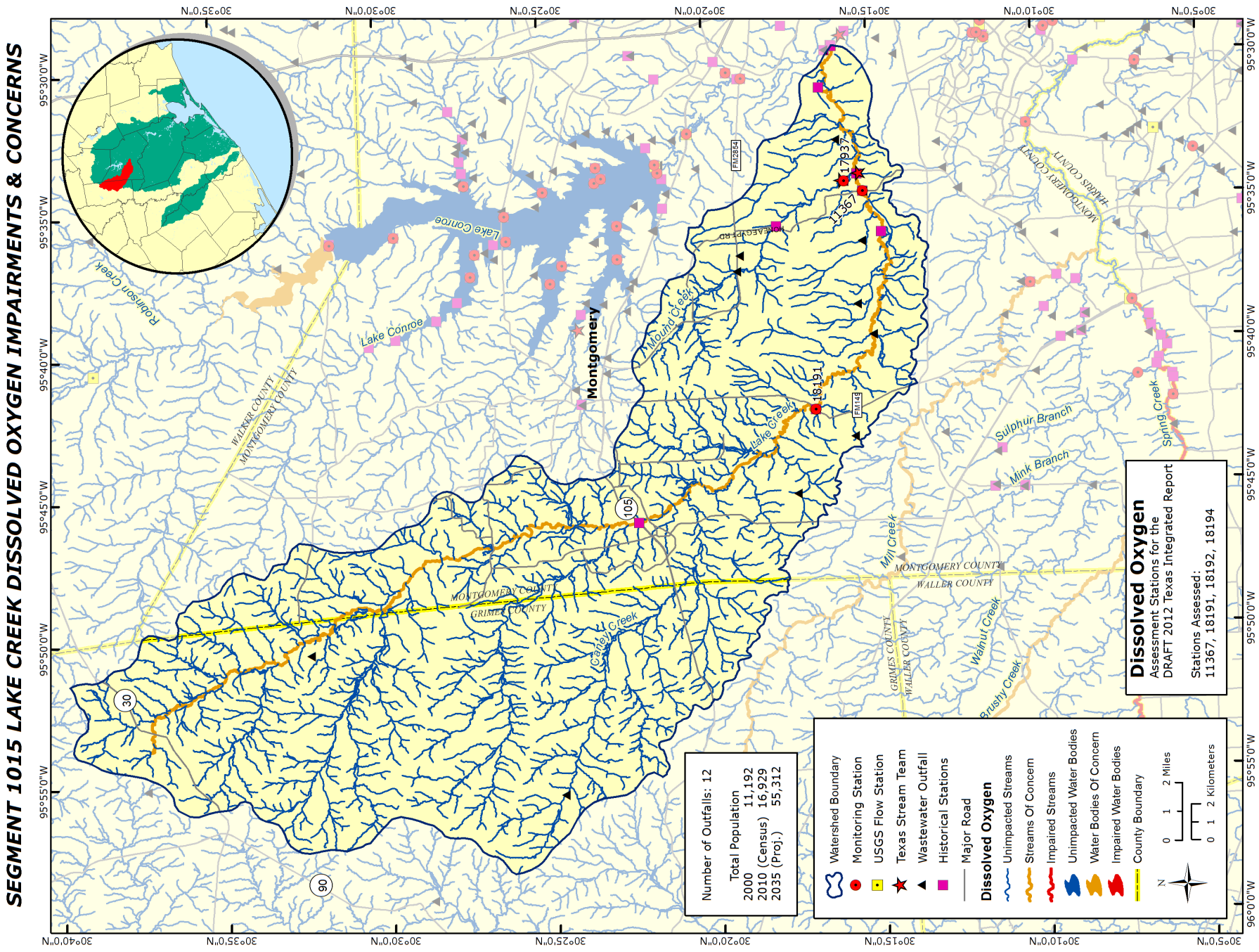
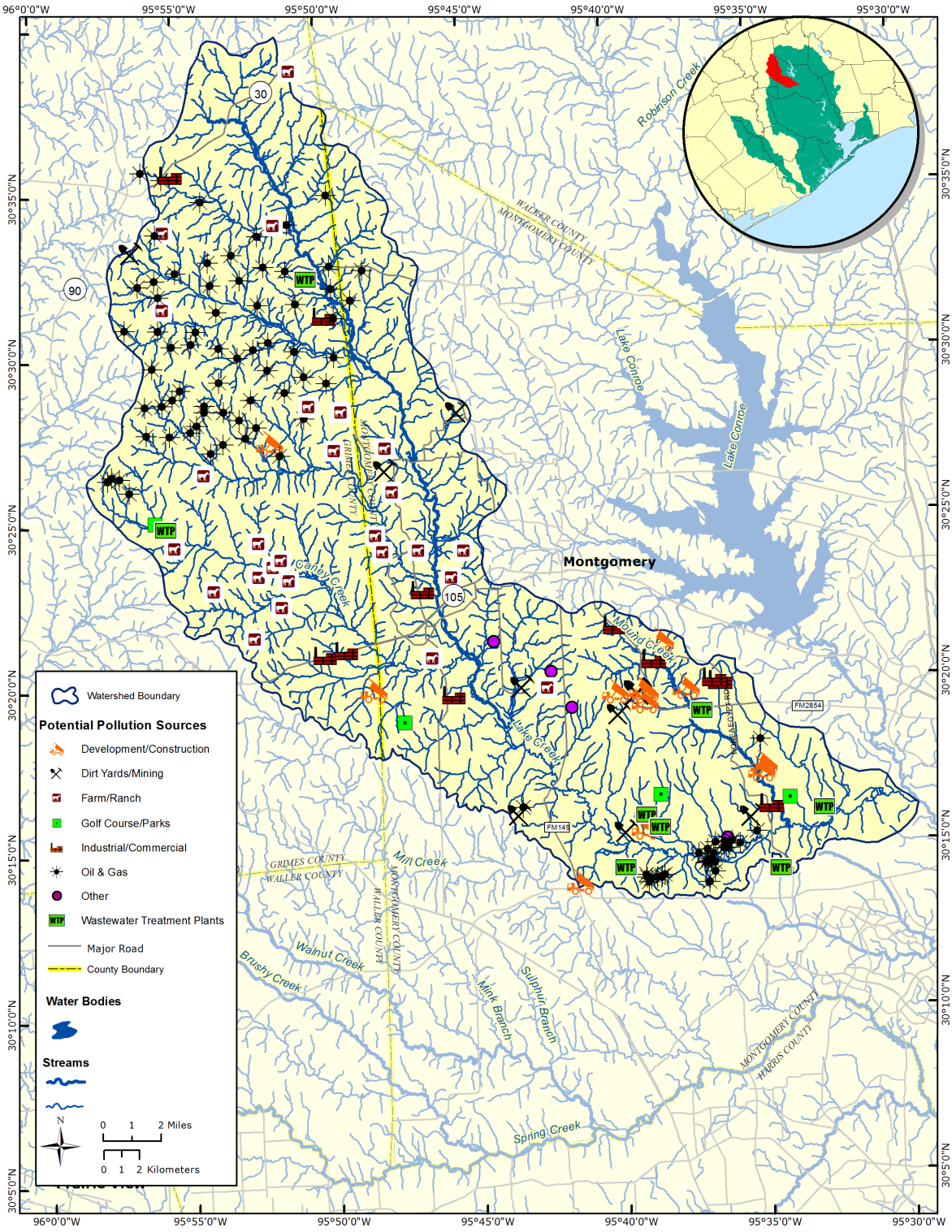

SEGMENT 1015 LAKE CREEK BACTERIA IMPAIRMENTS & CONCERNS
Lake Conroe
Montgomery
Mound Creek
Lake Creek
Caney Creek
Mill Creek
Walnut Creek
Brushy Creek
Sulphur Branch
Mink Branch
Spring Creek
Robinson Creek
MONTGOMERY COUNTY
WALLER COUNTY
GRIMES COUNTY
HARRIS COUNTY
MONTGOMERY COUNTY
HOUSTON
FM2854
HOMEGROWN RD
FM149
11367
17937
18191
105
30
90
Number of Outfalls: 12
Total Population
2000 11,192
2010 (Census) 16,929
2035 (Proj.) 55,312
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Bacteria
Unimpacted Streams
Streams Of Concern
Impaired Streams
Unimpacted Water Bodies
Water Bodies Of Concern
Impaired Water Bodies
County Boundary
0 1 2 Miles
0 1 2 Kilometers
N
Bacteria
Assessment Stations for the
DRAFT 2012 Texas Integrated Report
Stations Assessed:
11367, 18191, 17936, 17937

Figure - 53


SEGMENT 1015 LAKE CREEK DISSOLVED OXYGEN IMPAIRMENTS & CONCERNS
Dissolved Oxygen
Assessment Stations for the
DRAFT 2012 Texas Integrated Report
Stations Assessed:
11367, 18191, 18192, 18194
Number of Outfalls: 12
Total Population
2000 11,192
2010 (Census) 16,929
2035 (Proj.) 55,312
Watershed Boundary
Monitoring Station
USGS Flow Station
Texas Stream Team
Wastewater Outfall
Historical Stations
Major Road
Dissolved Oxygen
Unimpacted Streams
Streams Of Concern
Impaired Streams
Unimpacted Water Bodies
Water Bodies Of Concern
Impaired Water Bodies
County Boundary
2 Miles
2 Kilometers
Lake Conroe
Montgomery
Lake Creek
Mound Creek
Robinson Creek
Sulphur Branch
Mink Branch
Spring Creek
Mill Creek
Walnut Creek
Brushy Creek
Caney Creek
WALKER COUNTY
MONTGOMERY COUNTY
GRIMES COUNTY
WALLER COUNTY
HARRIS COUNTY
11367
18191
FM2854
FM149
105
30
90

SEGMENT 1015 LAKE CREEK POLLUTION SOURCES



Understanding Potential Sources of Pollution

Development/Construction: obvious land clearing and construction sites.

Dirt Yard/ Mining: dirt yards, quarry operations, sand and gravel operations.

Farm /Ranch: obvious livestock watering holes, large commercial farms, such as chicken farms or hog farms, heavy concentrations of cattle, but not the same as a defined CAFO (concentrated animal feeding operation).

Golf Course/Park: golf courses and other parks with ball fields or soccer fields or football fields of natural grass.

Industrial/Commercial: small manufacturing facilities, pipe yards, assembling yards, railroad trestle yards. WWTFs are included in the category. Refer to the land cover map for the actual location of the WWTFs.

Oil & Gas: natural gas well pads, gathering facilities, obvious footprints of units associated with the oil and gas industry.


CAT
CAT

1102 - Clear Creek Above Tidal

Length 31.4 Miles (classified portion)	**Watershed Area** 112 Square Miles
Texas Stream Team Monitors 4	**Permitted Outfalls** 37
Number of Active Monitoring Stations 6	
Designated Uses Contact Recreation; High Aquatic Life	

Segment Description:

Clear Creek is the county line between Harris and Galveston counties and Harris and Brazoria counties. The above tidal segment begins at a point 110 yards upstream of FM 528 in Friendswood in Galveston/Harris County and goes upstream 30 miles to Rouen Road in Fort Bend County. The above tidal segment of the creek drains a watershed of 112 square miles.

In the *Draft 2012 IR*, there are five AUs in segment 1102 and seven additional unclassified water bodies or sub-watersheds in the segment. Those sub-watersheds are:

- 1102A – Cowart Creek (unclassified water body): From the Clear Creek Above Tidal confluence in Galveston County to Texas Highway 35 in Brazoria County
- 1102B – Mary's Creek/ North Fork Mary's Creek (unclassified water body): Perennial stream from the confluence with Clear Creek to the confluence with North and South Fork Mary's Creek near FM 1128, approximately 3.1 miles southwest of Pearland, includes perennial portion of North Fork Mary's Creek to the confluence with an unnamed tributary approximately 1.98 miles upstream of FM 1128
- 1102C – Hickory Slough (unclassified water body): From the Clear Creek Above Tidal confluence to a point 0.43 miles upstream of Mykawa Road
- 1102D – Turkey Creek (unclassified water body): From the Clear Creek Above Tidal confluence to a point 0.61 miles upstream of Scarsdale Boulevard.
- 1102E – Mud Gully (unclassified water body): From confluence with Clear Creek Above Tidal to a point 0.49 miles downstream of Hughes Road
- 1102F – Mary's Creek Bypass (unclassified water body): From the Mary's Creek confluence northeast of FM 518 to a point 0.60 miles upstream to the Mary's Creek confluence (northwest of County Road 126)
- 1102G – Unnamed Tributary of Mary's creek (unclassified water body): From the Mary's Creek confluence 0.84 miles west of FM 1128 to a point 0.75 miles upstream to the confluence of an unnamed tributary

There are six monitoring stations located throughout the segment. Samples are collected on a quarterly basis by TCEQ at two stations and at four stations by H-GAC's CRP partner, EIH. Three of the stations are on the main water body while three are on the downstream end of three major tributaries – Cowart Creek, Mary's Creek and Hickory Slough. See Figure - 60 on page 73 for a full description of all monitoring stations. See Figure - 61 on page 74 for the locations of the stations.

Figure - 55

Summary of Water Quality Impairments and Concerns - Segment 1002 Clear Creek Above Tidal							
Segment ID	**Bacteria**	**Dioxin/PCBs**	**DO**	**Chlorophyll a**	**Nutrients**	**Other***	**Frog(s)****
1102	72.3	100	91.9		91.9	9.9	
1102A	100						
1102B	100				100		
1102C	100		100				
1102D	100		100		100		
1102E			100		100		
1102F			100		100		
1102G	100		100		100		

Indicates general improvement *Indicates general degradation* *Numbers indicate percent of segment impaired*

**Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macro invertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissue and fish contamination.*

***See Ranking Key on page 4 (?= no stations/no data in the assessment unit)*

Hydrological Characteristics:

Besides receiving flow from general runoff, this waterway receives WWTF effluent or stormwater flow from 37 permitted outfalls scattered throughout the segment. The USGS maintains a flow gage on Clear Creek at Mykawa Road which is located at about the mid point in this segment but the gage measures stream flow from only about one-quarter of the total watershed. Gage flows average between 7 CFS and 50 CFS with occasional flows greater than 100 CFS due to heavy rainfall. If all other areas of the watershed were assumed to be equal, flow from the watershed could be roughly estimated at four times the volumes measured at the Mykawa gage or approximately 30 CFS to 200 CFS. This estimate is probably low since there is more urban development downstream of the gage and there are several very high volume WWTF effluents downstream of the gage or on tributaries downstream of the gage.

Land Use & Natural Characteristics:

Approximately half of the Clear Creek Above Tidal segment stretches across the whole northern end of Brazoria County, while another third is located in southern Harris County. Smaller portions lie in far northwest Galveston County and northeast Fort Bend County. FM 518 is the main east-west thoroughfare through the segment and generally tracks the creek through the southern shore.

Past urban development has been concentrated along FM 518, but more recent developments have occurred along the major north-south corridors in the watershed. While there are still large tracts of agricultural lands in the far west, south central and north center areas, subdivisions and commercial properties are being built at an accelerated pace. The Texas Highway 288 corridor near FM 518 has been one of the fastest growing areas in the greater Houston region. In the far eastern area of the watershed there is a large tract of land that is still relatively natural. Wildlife and cattle are the primary uses of the land. See Figure - 61 on page 74 for greater detail.

Description of Water Quality Issues:

A summary of key impairments and concerns appears in Figure - 55 on page 69 for this segment. In segment 1102 (Clear Creek), DO is declining and nutrient concentrations are increasing, but chlorophyll a seems to be going down. In this segment's unclassified water bodies, bacteria concentrations are getting better in Cowart Creek (1002A) but getting worse in Hickory Slough (1002C). Nutrient concentrations are going down in 1102A (Cowart Creek) but going up in Mary's Creek/North Fork Mary's Creek (1102B). The contact recreation designation for segment 1002 and its tributaries is not fully supported. In Clear Creek between Texas Highway 288 and

Figure - 56

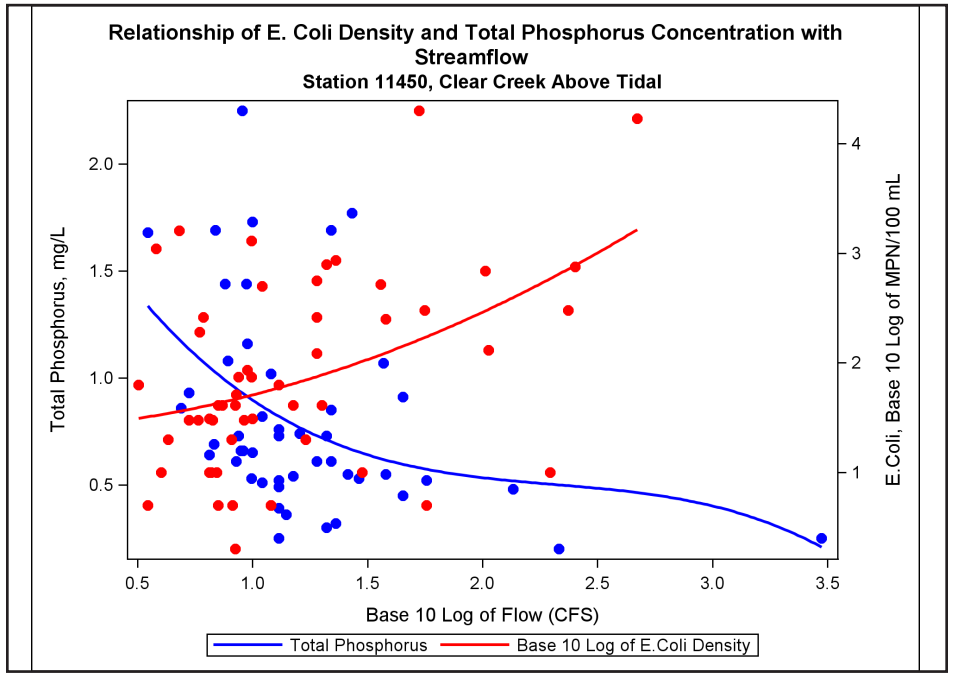
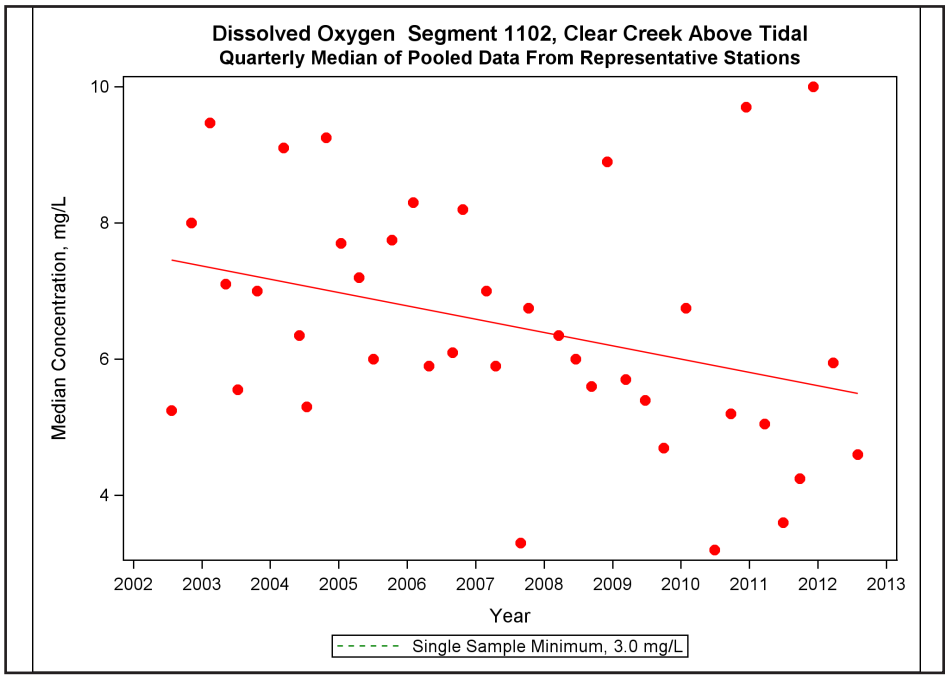


Figure - 57



the confluence with Mary's Creek, the bacteria concentration geometric mean is approximately 250 MPN/ 100 mL while the standard criteria is 126 MPN/100 mL. Five of the seven unclassified water bodies are impaired for bacteria as well. The water body with the most severe impairment is tributary Turkey Creek (1102D) which has a bacteria geometric mean of 4,400 MPN/100 mL. All other impairments had geometric means ranging from 147 to 510 MPN/100 mL. See Figure - 62 on page 75 for the location of these impairments and an illustration of the severity of the impairments. One additional analysis showed that bacteria density increased but total phosphorus concentrations decreased as stream flow increased. This would suggest that point sources (WWTF) are the primary source of the total phosphorus in the waterways, and rainfall significantly increased bacteria contributions from nonpoint sources. Figure - 56 on page 70 illustrates this relationship.

The DO grab screening level shows a concern for depressed DO in the four downstream AUs of the Clear Creek above tidal segment. The *2010 IR* also showed four AUs as having a concern, but AU 1102_01 was identified in the report and was dropped from the *Draft 2012 IR*. AU 1102_05 was added in the *Draft 2012 IR*. This makes only the furthest upstream AU (1102_01), located above Texas Highway 288, fully supporting for DO. A trend analysis of the data collected from the main creek (1102) shows a significant downward trend in DO. Figure - 57 on page 70 shows the quarterly median data in relationship to the screening level of 5 mg/L. In the tributaries, the *2010 IR* identified concerns with depressed DO in Hickory Slough, Mud Gully, and an unnamed tributary to Mary's Creek. In the *Draft 2012 IR*, all the same AUs were identified again plus Mary's Creek Bypass (1102F_01) was also added to the list of concerns for depressed DO. See Figure - 63 on page 76 for the location of these concerns.

The *Draft 2012 IR* identified nine of the 13 AUs monitored in the Clear Creek Above Tidal watershed as having nutrient concerns. See Figure - 64 on page 77 for the locations of nutrient concerns. Of the parameters being monitored – orthophosphorus, total phosphorus, nitrate, and ammonia – only Turkey Creek (1102D) has a concern for all four. Analysis of the quarterly nutrient data showed significant upward trends with total phosphorus, orthophosphorus, and nitrate nitrogen concentrations. In each set of data, there was a dip in concentrations during 2007, but since 2008 concentrations have been going up. See Figure - 58 on page 71 for total phosphorus trends and Figure - 59 on page 71 for nitrate nitrogen trends.

Clear Creek does not support its fish consumption use because all five AUs found in segment 1102 are impaired due to 'PCBs found in edible fish tissue.' The TDSHS issued a restricted and a no-consumption advisory, and TCEQ

Figure - 58

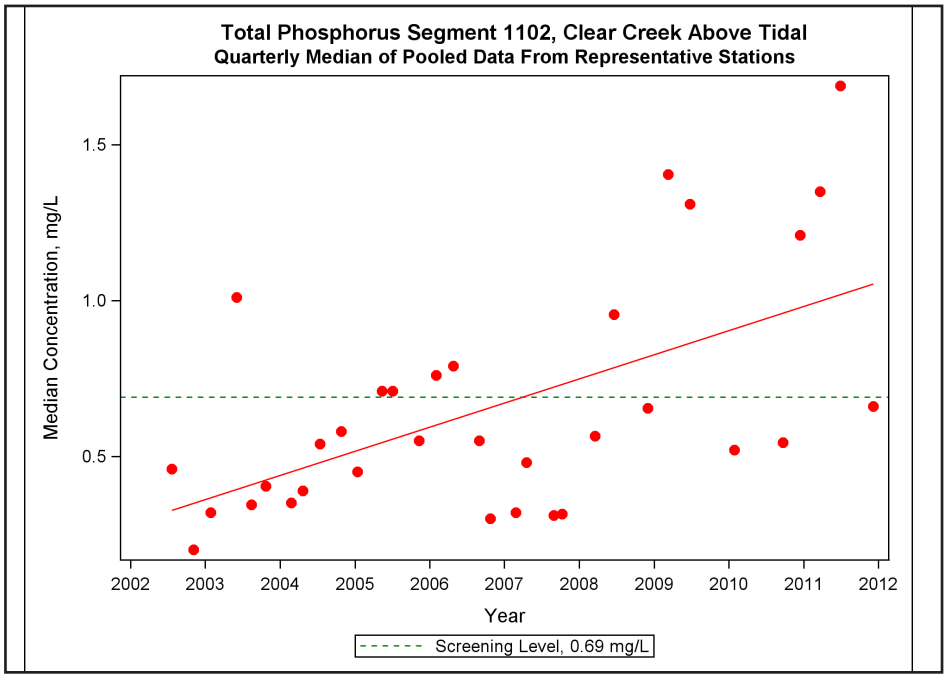
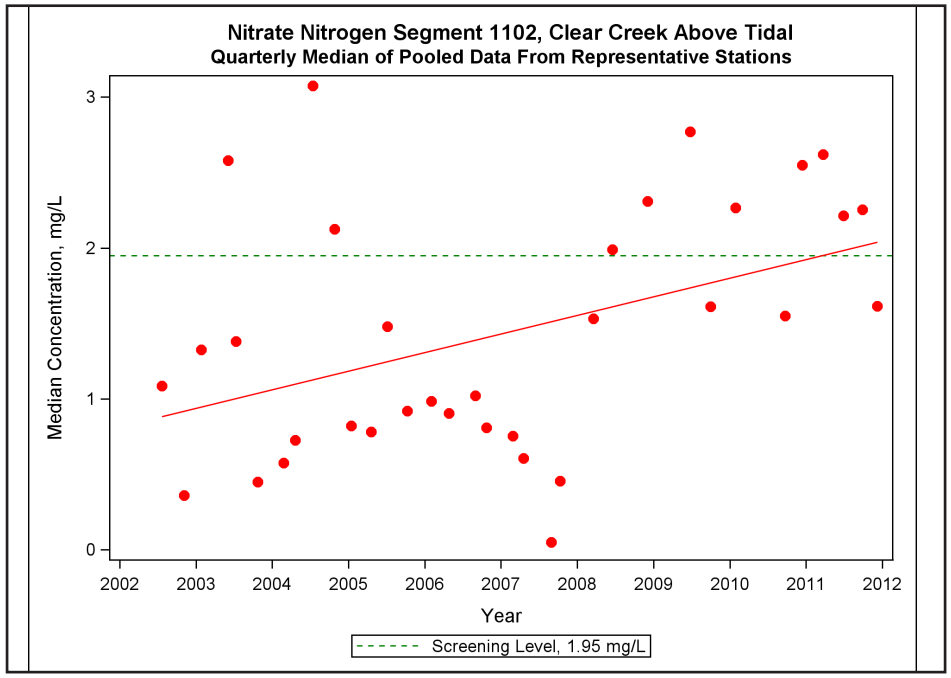


Figure - 59



listed the creek as impaired in 2010. See Figure - 65 on page 78 for the location of this impairment.

The ALU designation for this entire segment is high except for two unclassified water bodies. Cowart Creek (1102A) has a limited ALU, and Mary's Creek/North Fork Mary's Creek (1102B) has an intermediate designation. In the *2010 IR* and the *Draft 2012 IR*, all sections of Clear Creek and its tributaries supported their designation except for one section of Clear Creek. There is a screening level concern that the habitat may be impaired between Texas Highway 288 and the downstream confluence with Hickory Slough (1102_02). This section of the creek has had one or both banks of the stream cleared or channelized, and is currently being maintained by mowing. See Figure - 66 on page 79 for the location of this concern.

Potential Sources of Water Quality Issue(s):

H-GAC reviewed satellite photos to identify a variety of potential sources of pollution or point of interest in this segment. Figure - 67 on page 80 identifies the various categories of sources. Besides the normal pollutants that are commonly washed off the urban and suburban landscape, commercial and residential construction is booming in the watershed-primarily in and around Pearland. Even though WWTFs and large collections systems service large areas of the watershed, there are still hundreds, if not thousands, of OSSFs still being used on the rural homesteads and ranchettes found throughout the watershed.

Sources of bacteria contamination include

- WWTF effluent with inadequate treatment, by-passes and sanitary sewer system overflows;
- hundreds of OSSFs still servicing homesteads and ranchettes;
- cattle grazing operations scattered throughout the watershed; and
- runoff contaminated with waste from pets, and wildlife.

Nutrients are coming from the same sources as well as fertilized yards and other landscapes.

While this watershed supports several golf courses and parks with playing fields, it is interesting to note that these facilities are mostly located adjacent to the various waterways in the segment. While this is not uncommon, these facilities have the potential to contribute nutrients in the form of excess fertilizers.

Potential Stakeholders:

Stakeholders in this segment include:

- Harris, Galveston, and Fort Bend counties;
- Cities of Friendswood, Houston, Pearland, and Brookside Village;
- Harris County Flood Control District;
- area drainage districts and Road and Bridge Departments in Harris, Galveston, Brazoria, and Fort Bend counties;
- Clear Creek ISD and Pearland ISD;
- local colleges;
- Harris-Galveston and Fort Bend subsidence districts;
- Gulf Coast Waste Disposal Authority;
- various utility districts scattered throughout the watershed;
- area home owner's associations; and
- commercial/industrial facilities.

There are representatives of most of these entities currently serving on the BIG Steering Committee.

Ongoing Projects:

The Clear Creek Above Tidal segment was included in a study by EIH to conduct biological assessments of sites that had been previously assessed in 1997 and 1998. The final outcome of the investigation was to provide current data for TCEQ to update their assessment and compare the information to the previous study to determine change over time. All field work was conducted in 2012 with associated reports due by the end of August 2013.

Major Watershed Events:

The known or anticipated occurrences that have the potential to either positively or negatively impact this segment include population growth and additional drought.

Urban development is the primary event occurring in or affecting this segment.

Recommended Actions:

Activity	Responsible Entity(s)
Work to reduce or eliminate bacteria pollution through public outreach and implementation of best management practices	Bacteria Implementation Group (BIG) stakeholders
Continue collecting water quality data to support actions associated with future WPP development and future modeling efforts	TCEQ, H-GAC and CRP partners
Support, maintain, and/or increase programs that conduct septic system inspections, and oversee maintenance and repairs	County and local agencies and stakeholders
Implement Capacity, Management, Operations, and Maintenance (CMOM) programs or similar pollution reduction programs	Cities and utility districts owning and/or operating WWTFs and their related collection systems
Implement public education and outreach programs that address bacteria pollution and other sources of pollution	Stakeholders
Consider collecting samples from Turkey Creek and other sub-watersheds to determine if the concerns and impairments continue and whether those same concerns and impairments are getting better or worse	H-GAC and CRP partners
Work with local governments, organizations, and agencies involved in the maintenance of the waterways to implement practices to prevent or minimize habitat destruction and sedimentation of waterways	H-GAC and CRP partners

Figure - 60

Fiscal Year 2013 Monitoring Sites - Segment 1102- Clear Creek Above Tidal

Segment ID	Site Description	Station ID	Collecting Entity	Monitoring Type	Field Parameters* / Frequency	Conventional Parameters**/ Frequency	Bacteria***/ Frequency	Flow / Frequency
1102	CLEAR CREEK ABOVE TIDAL AT YOST ROAD TERMINUS IN PEARLAND IN BRAZORIA COUNTY	20010	Environmental Institute of Houston (UI)	Routine	4	4	4	4
1102A	COWART CREEK AT FM 518 IN FRIENDSWOOD	11425	Environmental Institute of Houston (UI)	Routine	4	4	4	
1102B	MARYS CREEK AT MARYS CROSSING IN NORTH FRIENDSWOOD	16473	Environmental Institute of Houston (UI)	Routine	4	4	4	4
1102C	HICKORY SLOUGH AT ROBINSON DRIVE IN PEARLAND	17068	Environmental Institute of Houston (UI)	Routine	4	4	4	4

**Field Parameters: Water Temp, Specific Conductance, pH, DO, Total Depth, Secchi Depth, Flow Severity, Days Since Precipitation Event (Days), Wind Intensity, Present Weather, Water Surface, Water Color, Water Odor, Water Clarity, Observed Turbidity*

***Conventional Parameters: TSS, Ammonia-N, Kjeldahl-N, Nitrite+Nitrate, Total Phosphorus, Chloride, Sulfate*

****Bacteria Parameters: E. coli and Enterococci*

Figure - 61

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL LAND USE

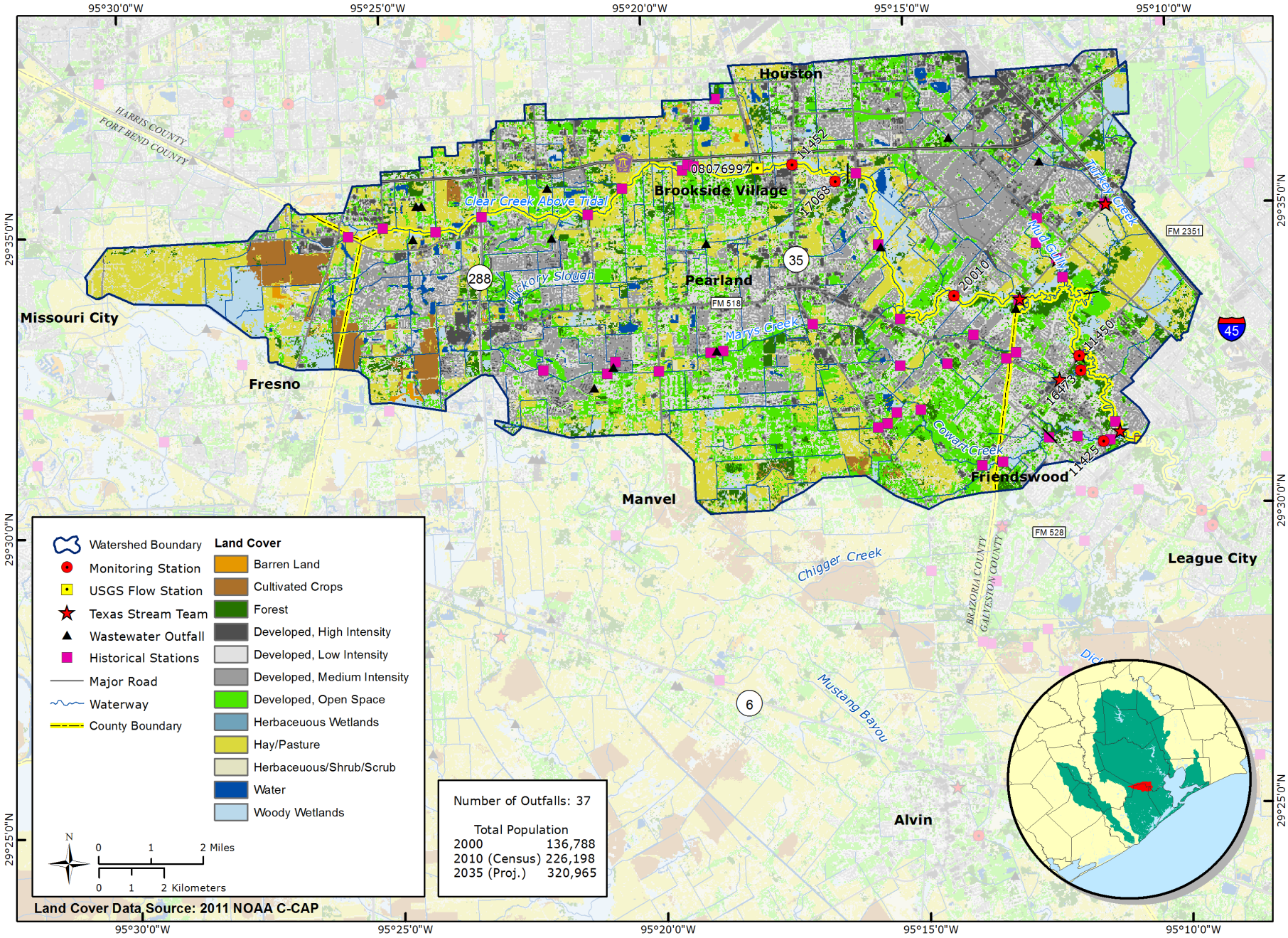


Figure - 62

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL BACTERIA IMPAIRMENT & SEVERITY

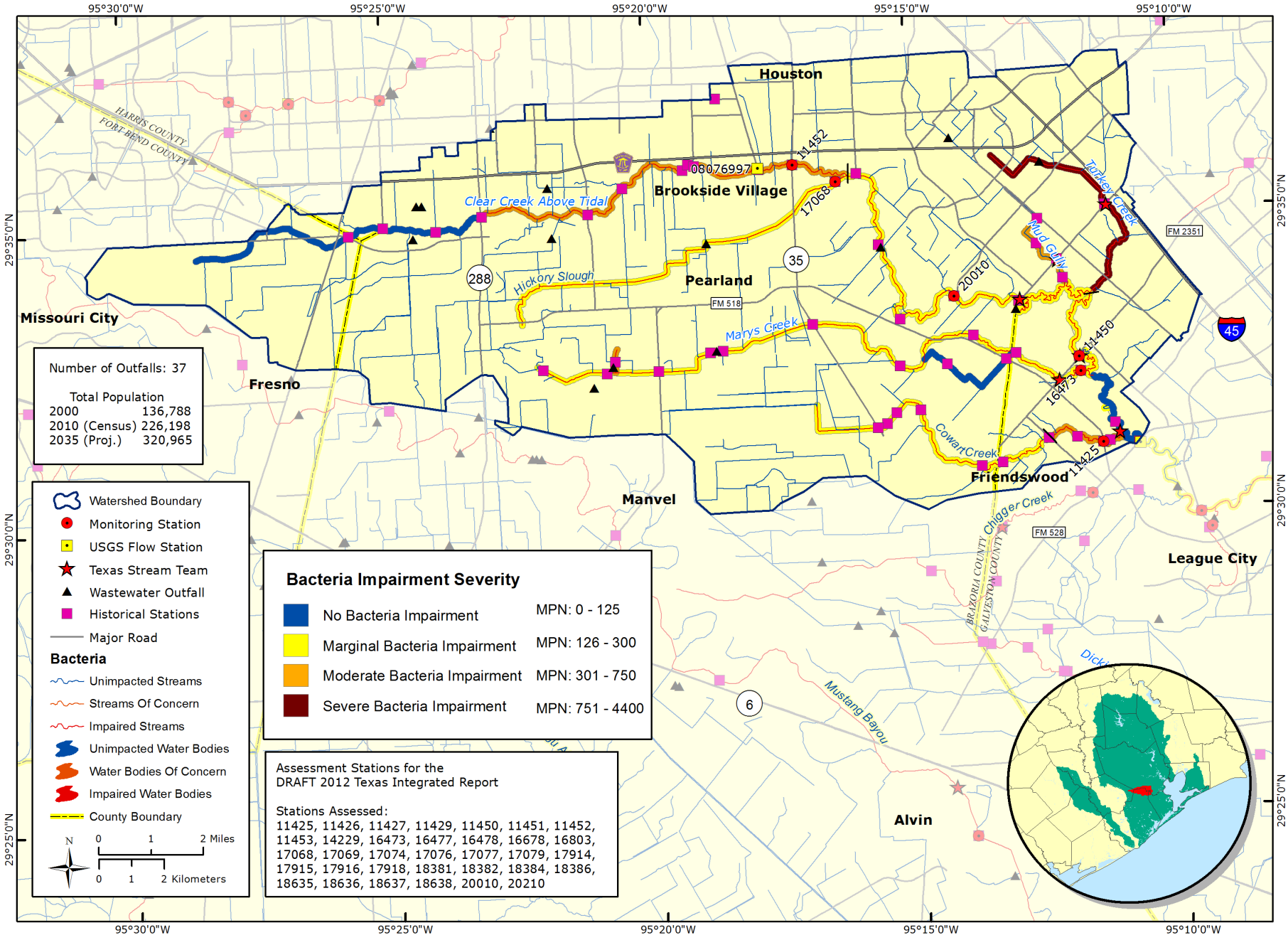


Figure - 63

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL DISSOLVED OXYGEN IMPAIRMENTS & CONCERNS

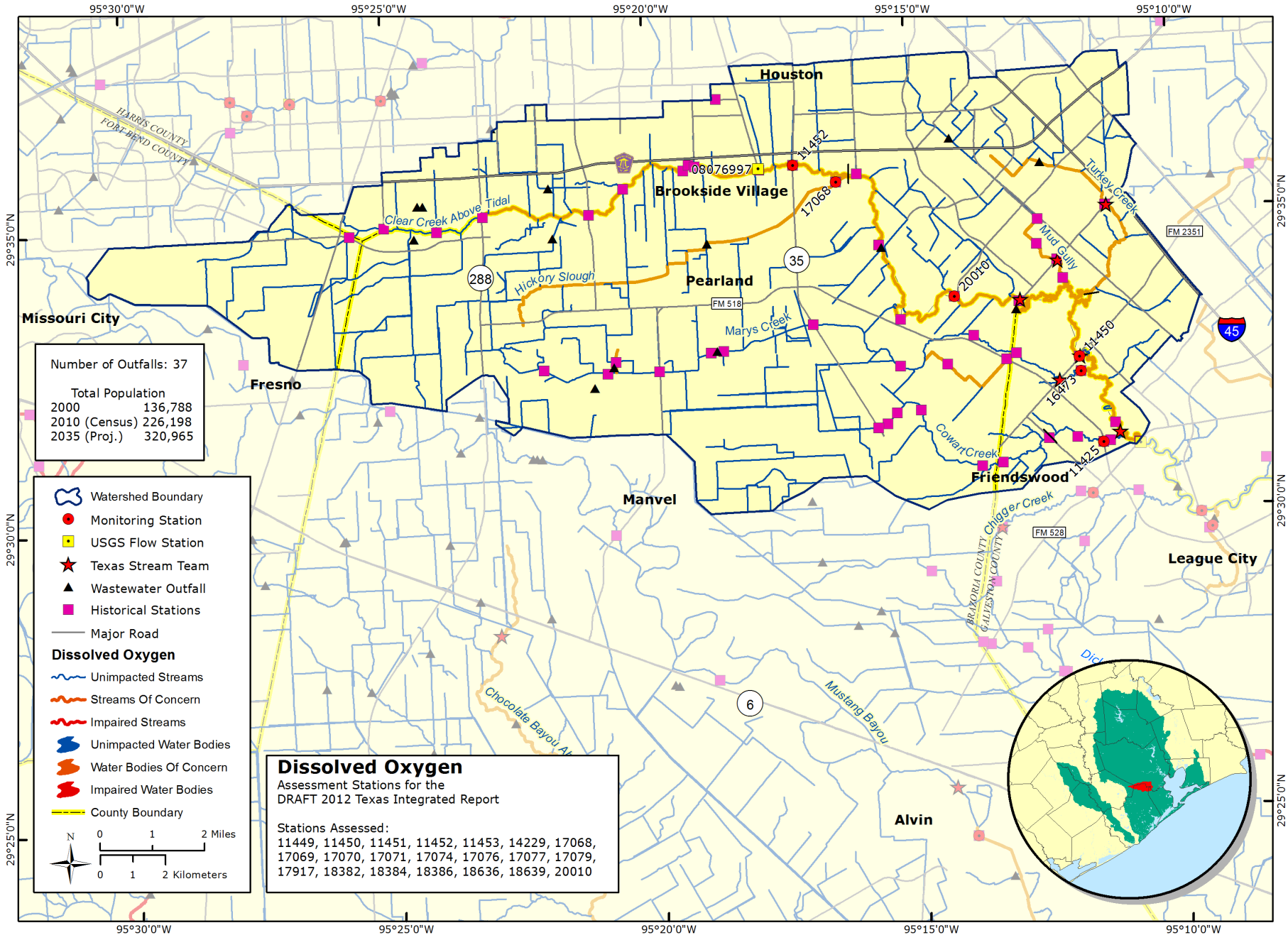


Figure - 64

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL NUTRIENT CONCERNS

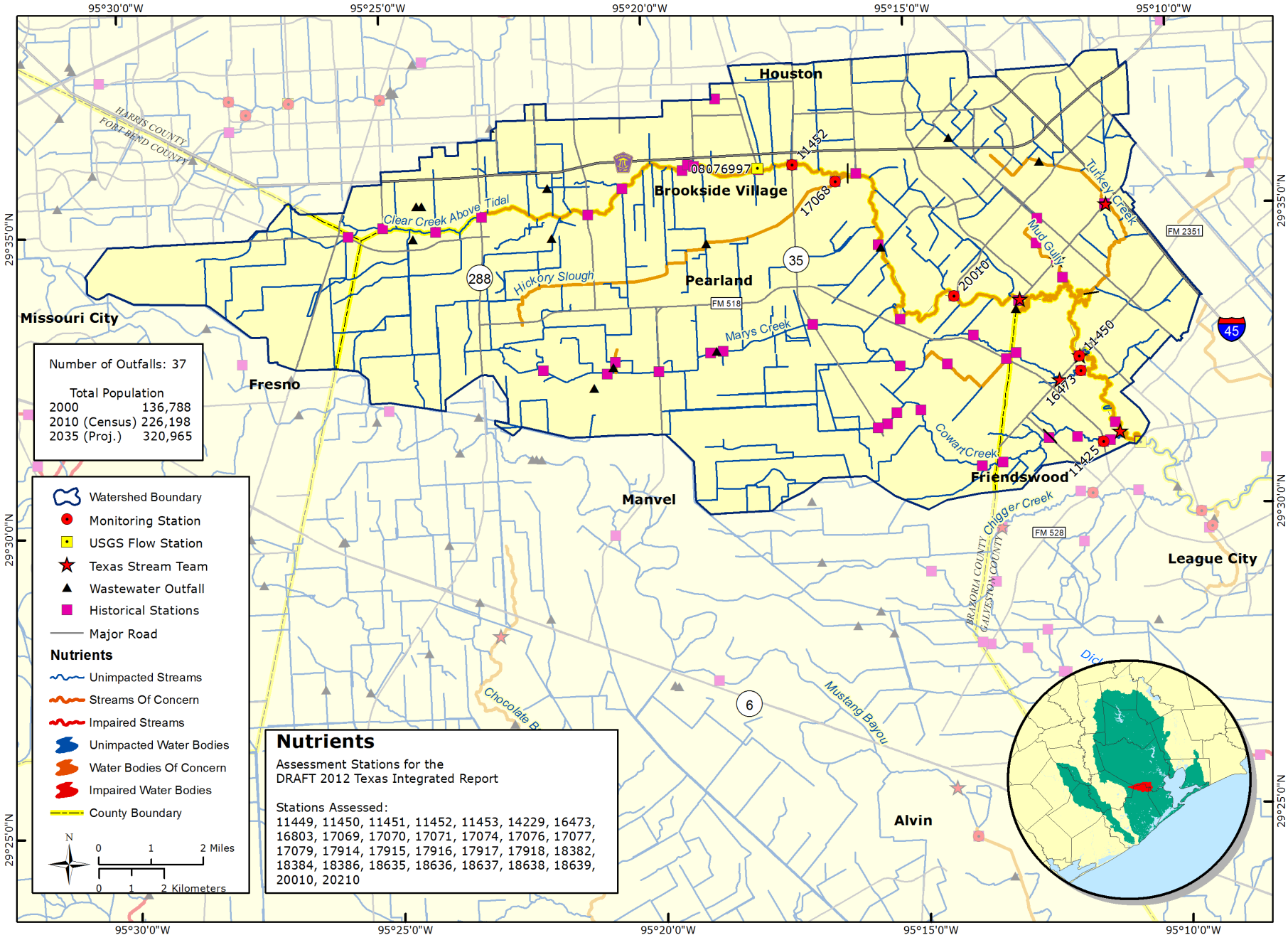


Figure - 65

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL FISH CONSUMPTION IMPAIRMENTS

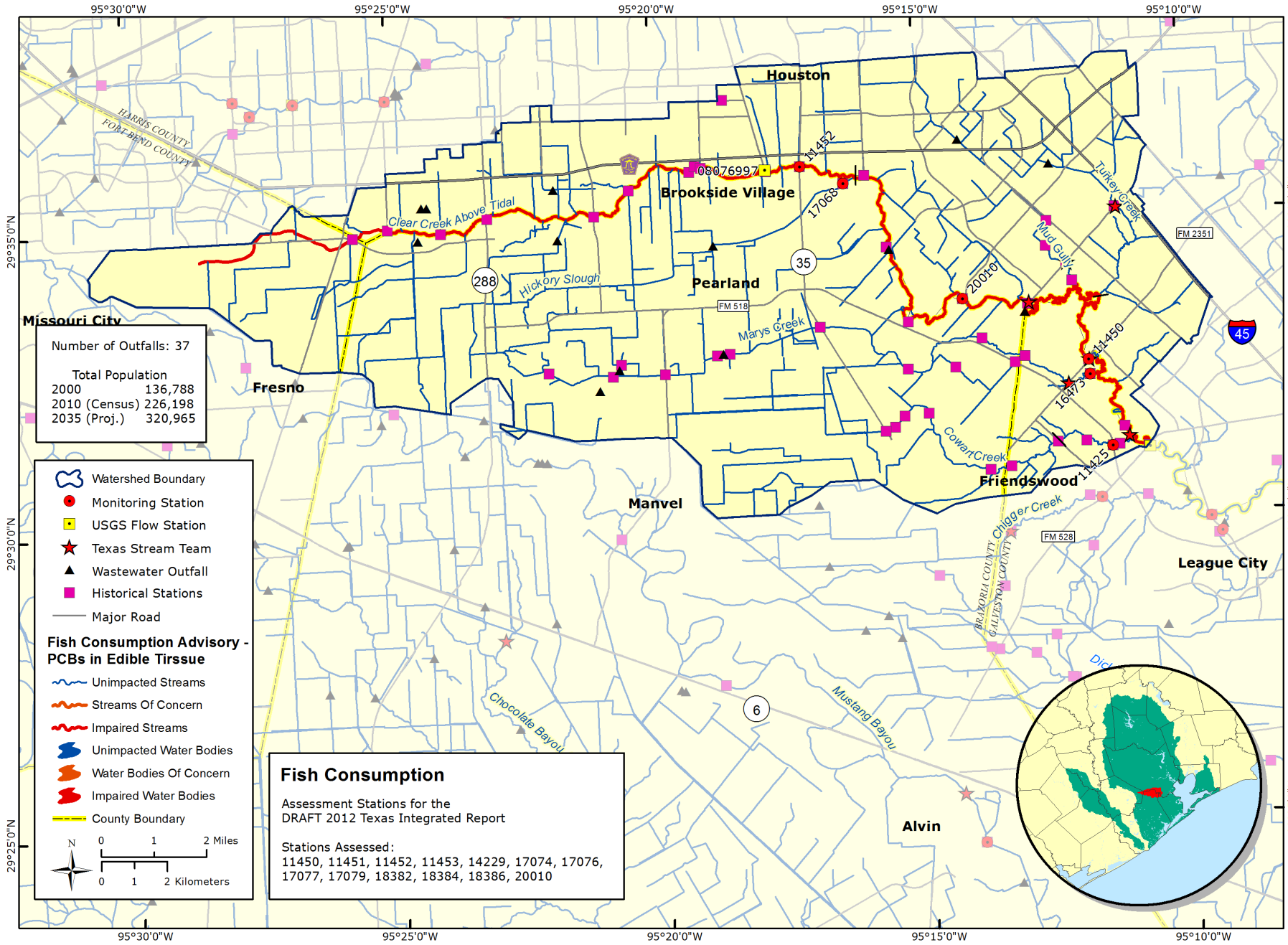


Figure - 66

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL HABITAT CONCERNS

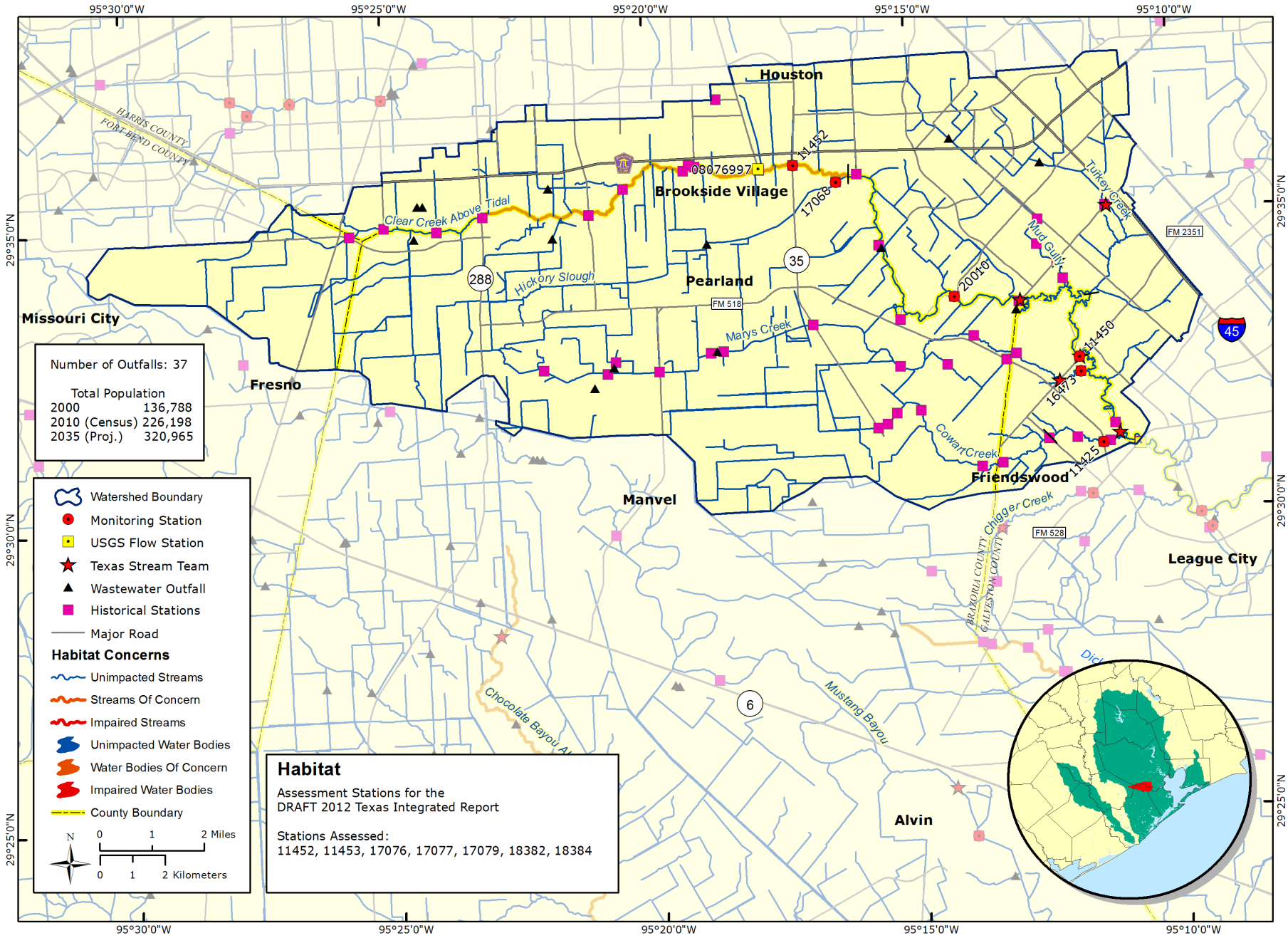
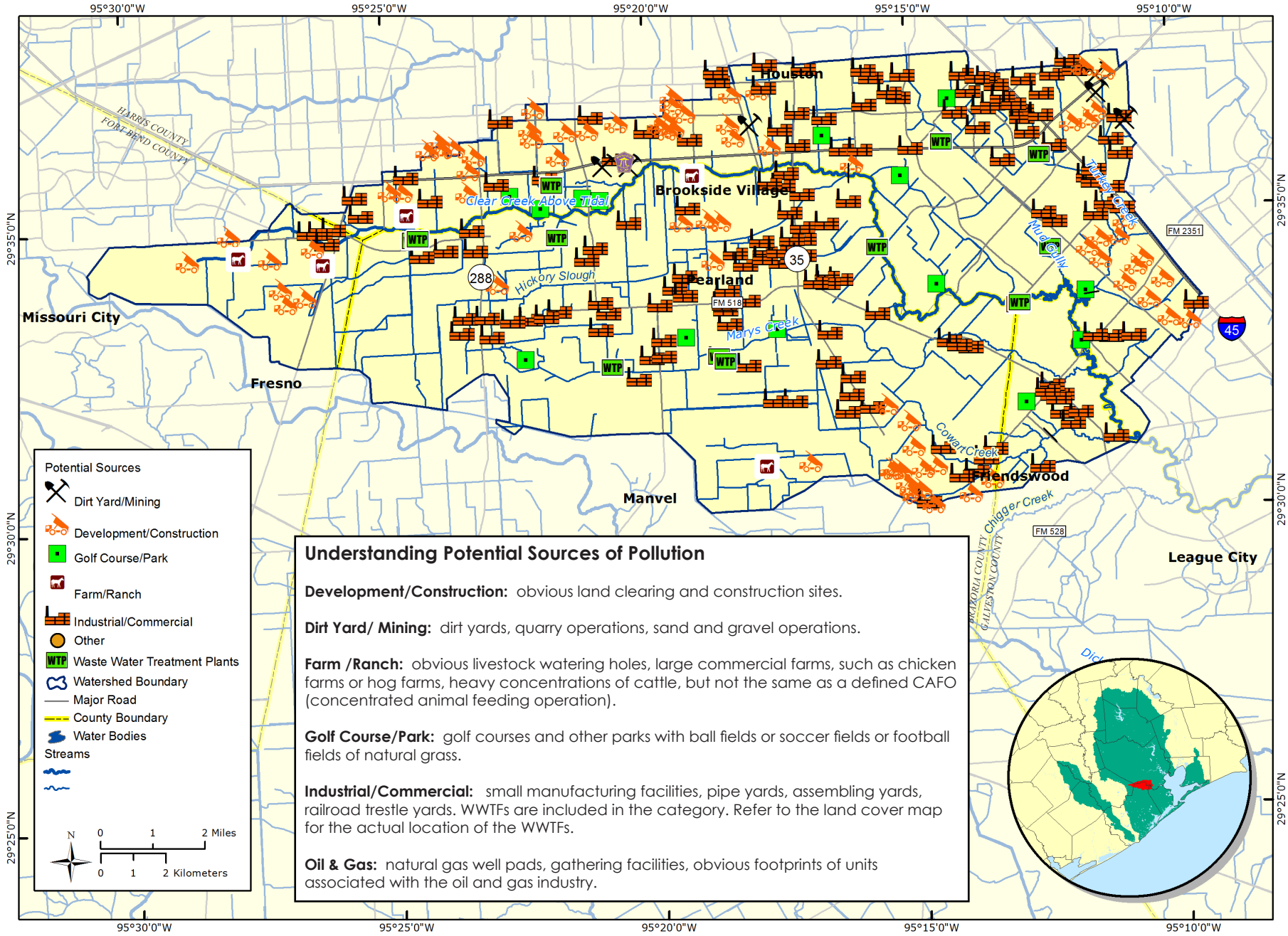


Figure - 67

SEGMENT 1102 CLEAR CREEK ABOVE TIDAL POLLUTION SOURCES



Understanding Potential Sources of Pollution

Development/Construction: obvious land clearing and construction sites.

Dirt Yard/ Mining: dirt yards, quarry operations, sand and gravel operations.

Farm /Ranch: obvious livestock watering holes, large commercial farms, such as chicken farms or hog farms, heavy concentrations of cattle, but not the same as a defined CAFO (concentrated animal feeding operation).

Golf Course/Park: golf courses and other parks with ball fields or soccer fields or football fields of natural grass.

Industrial/Commercial: small manufacturing facilities, pipe yards, assembling yards, railroad trestle yards. WWTFs are included in the category. Refer to the land cover map for the actual location of the WWTFs.

Oil & Gas: natural gas well pads, gathering facilities, obvious footprints of units associated with the oil and gas industry.

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Cover photo by Jan Edwards

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