2019 CYPRESS CREEK BASIN SUMMARY REPORT

Northeast Texas Municipal Water District

Water Monitoring Solutions
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Texas Commission on Environmental Quality

The Texas Clean Rivers Program

FOREWORD

The Clean Rivers Program (CRP) is a water quality monitoring, assessment, and public outreach program administered by the TCEQ and funded by state collected fees. The Northeast Texas Municipal Water District (NETMWD) coordinates the CRP for the Cypress Creek Basin. As a participant in the Clean Rivers Program, NETMWD submits its Basin Summary Report to the TCEQ and CRP partners.

This report and others submitted throughout the State are used to develop and prioritize programs that will protect the quality of healthy waterbodies and improve the quality of impaired waterbodies. Under the CRP, biologists and field staff collect water quality and biological samples, field parameters and measure flow at sites throughout the Cypress Creek Basin.

Monitoring and analysis are the basis for maintaining good water quality within the Cypress Creek Basin. Within a cooperative program directed by the Northeast Texas Municipal Water District (NETMWD) these activities are an integral part of the State's Clean Rivers Program. Cypress Creek Basin CRP stakeholders include:

- Caddo Lake Institute
- U. S. Steel Tubular Products, Inc.
- Northeast Texas Community College
- Luminant
- Pilgrim's Pride Corporation
- AEP SWEPCO
- Titus Co. Fresh Water Supply District #1
- City of Marshall
- Texas Parks and Wildlife Department
- United States Geological Survey
- Franklin County Water District
- East Texas Baptist University

NETMWD contracts with Water Monitoring Solutions, Inc. (WMS) to fulfill the sampling and reporting requirements of the CRP.

Cover photo: View of the headwaters of Lake O' the Pines from US 259

GET INVOLVED!

Each spring, NETMWD provides a venue for local stakeholders to learn about water quality issues affecting their region and to provide input on projects in their communities. The Cypress Creek Steering Committee meetings allow stakeholders to have input on addressing water quality concerns and to prioritize water quality monitoring within the Cypress Creek Basin. NETMWD and its Clean Rivers Program partners continue to reach out to the public to educate and help resolve local water quality issues. Members of the public, water supply corporations, permitted dischargers, councils of government, and city and county officials are invited annually to become steering committee members. A CRP Steering Committee meeting was held in March 2018 at the NETMWD executive offices in Hughes Springs. Topics included paddlefish restoration research by US Fish and Wildlife Service, Texas Water Resources Institute water monitoring project in Camp County, an invasive species update from Texas Parks and Wildlife Department (TPWD), Caddo Lake Institute (CLI) program activities, and an update on the Integrated Report.

NETMWD plans and coordinates monitoring efforts with other basin entities, the TCEQ monitoring staff, CLI, and other interested participants annually within the Cypress Creek Basin. All entities collecting water quality data in the Cypress Creek Basin are encouraged to coordinate their efforts with the NETMWD and participate under the NETMWD QAPP. Currently, the CLI monitors Caddo Lake on a monthly basis under the NETWMD QAPP.

Visit NETMWD to join the Clean Rivers Program Steering Committee or contact Robert Speight at 903-639-7538 or rspeightnetmwd@aol.com.

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LIST OF ACRONYMS AND ABBREVIATIONS

cfs	Cubic feet per second (measurement of stream flow)
CLI	Caddo Lake Institute
CMS	Coordinated Monitoring Schedule
CR	County Road
CRP	Clean Rivers Program
CWA	Clean Water Act
DO	Dissolved Oxygen
DSHS	Department of State Health Services
EPA	Environmental Protection Agency
FM	Farm-to-Market Road
FY	Fiscal Year
HQI	Habitat Quality Index
IBI	Index of Biotic Integrity
IR	Integrated Report
I-Plan	TMDL Implementation Plan
mg/L	milligrams per liter
MPN/100 mL	Most Probable Number per 100 milliliters (bacteria measurement units)
NETMWD	Northeast Texas Municipal Water District
PCB	Polychlorinated biphenyls
QAPP	Quality Assurance Project Plan
RBA	Rapid Bioassessment
RUAA	Recreational Use Attainability Analysis
SH	State Highway
s.u.	standard units (measurement of pH)
SWQM	TCEQ Surface Water Quality Monitoring team
SWQMIS	Surface Water Quality Monitoring Information Systems
TCEQ	Texas Commission on Environmental Quality
TCFWSD	Titus County Fresh Water Supply District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TPLA	Total Phosphorus Load Agreement
TPWD	Texas Parks and Wildlife Department
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
TWRI	Texas Water Resources Institute
UAA	Use Attainability Analysis
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMS	Water Monitoring Solutions, Inc.
WWTP	Wastewater Treatment Plant
§303(d) List	Impaired water bodies in Section §303(d) of the Federal Clean Water Act

EXECUTIVE SUMMARY

The Texas Clean Rivers Program (CRP) is a statewide water quality monitoring and assessment program that provides funding and resources for regional watershed protection efforts. The program is administered by the Texas Commission on Environmental Quality (TCEQ) in partnership with river authorities and other regional governments with the goal of maintaining and improving water quality in each river basin in the state.

As the coordinating agency in the Cypress Creek basin, the Northeast Texas Municipal Water District (NETMWD) works with federal and state agencies, municipalities, water suppliers, and private companies to accomplish water quality monitoring and watershed protection objectives. Monitoring priorities are established through stakeholder input and coordination with other organizations working in the basin. Coordinating entities in attendance often include the TCEQ, Caddo Lake Institute (CLI), Texas Parks and Wildlife Department (TPWD), U. S. Geological Survey (USGS), Texas State Soil and Water Conservation Board (TSSWCB), and Texas A&M University – Agrilife/ Texas Water Resources Institute.

Every five to six years, a Basin Summary Report is written. This technical report is used to provide an in-depth review of historical and recent data, and an analysis of water quality trends occurring throughout the watershed. The objectives of the Basin Summary Report are to:

- Discuss water quality issues and their potential sources,
- Identify statistically significant water quality trends,
- Compare the *Draft 2016 Texas Integrated Report* with current data, and
- Examine the effects of water quality impairments on the biotic community structures.

The Cypress Creek watershed encompasses approximately 6,000 square miles. Its major tributaries – Big Cypress Creek, Little Cypress Creek, James' Bayou, Harrison Bayou, and Black Cypress Bayou – drain into Caddo Lake on the Texas/Louisiana border. The watershed has a diverse ecology. The headwaters of Big Cypress Creek, above Lake Cypress Springs, is intermittent. Releases into Big Cypress Creek from Lake Bob Sandlin runs through flat to rolling terrain surfaced by sandy and clay loams that support water-tolerant hardwoods, conifers, and grasses before entering Lake O' the Pines. Below Lake O' the Pines, Big Cypress Creek (Bayou) flows into Caddo Lake through bottomland thick with hardwood and cypress trees.

The watershed originates in the southern portions of Hopkins and Franklin Counties. Headwaters flow south eastwardly into Camp, Titus, Morris, Cass, Marion, and Harrison Counties. Reservoirs in the basin include: Monticello Reservoir, Lake Cypress Springs, Lake Bob Sandlin, Lake Gilmer, Lake Daingerfield, Ellison Creek Reservoir, Lake O' the Pines, and Caddo Lake. The major tributaries of Caddo Lake include Big Cypress Creek, Little Cypress Creek (Bayou), Black Cypress Bayou, James Bayou, and Harrison Bayou.

The basin experienced a pervasive drought that began around 1999 and extended through 2014. During this period, the drought was punctuated with large rainfall events. In 2011 and 2012, the drought reached comparable levels with the drought of record which ended with the near-historic flooding in 2015 and 2016.

Annual precipitation averages around 52 inches in the basin. At slightly over 25 inches of precipitation, 2005 was the driest year on record and was also the first year that no water was released from Lake Bob Sandlin.

Releases from Lake Bob Sandlin play an important role in the water quality of Big Cypress Creek and Lake O' the Pines. Since there are no instream flow requirements in Big Cypress Creek, water is only released from Lake Bob Sandlin to maintain freeboard of the Fort Sherman Dam. A record amount of water was released from the Fort Sherman Dam in 2015 through April 2016. The amount of water released could fill Lake Bob Sandlin more than twice. By comparison, about 60% of the combined releases from 1999 to 2014 was released from 2015 through 2018.

Dissolved oxygen, *E. coli*, and mercury in fish tissue remained the most common impairments in the Cypress Creek Basin. Due to data meeting the pH criterion, the Goose Prairie Arm of Caddo Lake was removed from the *Draft 2016 Texas §303(d) List* for pH. As a result of changes to the Texas Surface Water Quality Standards, some assessment units of Big Cypress Creek below Lake O' the Pines and James Bayou were delisted for pH while some assessment units in Black Cypress Creek, Little Cypress Creek, and James Bayou were delisted for DO. New impairments on the §303(d) List were high pH in Lake O' the Pines and high pH and Nutrient Reservoir Criteria in Lake Cypress Springs. Segment 0408 – Lake Bob Sandlin was the only segment in the Cypress Creek Basin with no impairments or concerns.

Impairments and concerns for low dissolved oxygen were found in most segments of the basin with the exception of Lake Bob Sandlin. In the stream segments, low dissolved oxygen readings were often associated with low flow, especially in the intermittent streams of Black Bayou,

James Bayou, and Segment 0410A of Black Cypress Creek. The pervasive drought most likely exacerbated the low dissolved oxygen conditions leading to these concerns and impairments.

The arms of Caddo Lake are shallow, swamp-like, and from May to October, the water surface is often completely covered by non-native vegetation preventing sunlight from entering the water column. Low dissolved oxygen was common in these areas, especially for samples collected during the summer months. Despite regularly recording low dissolved oxygen at the four stations in the upper portion of Caddo Lake (stations 14236, 15249, 10286, 10288), low dissolved oxygen were rarely recorded at the mid-lake station, 10283.

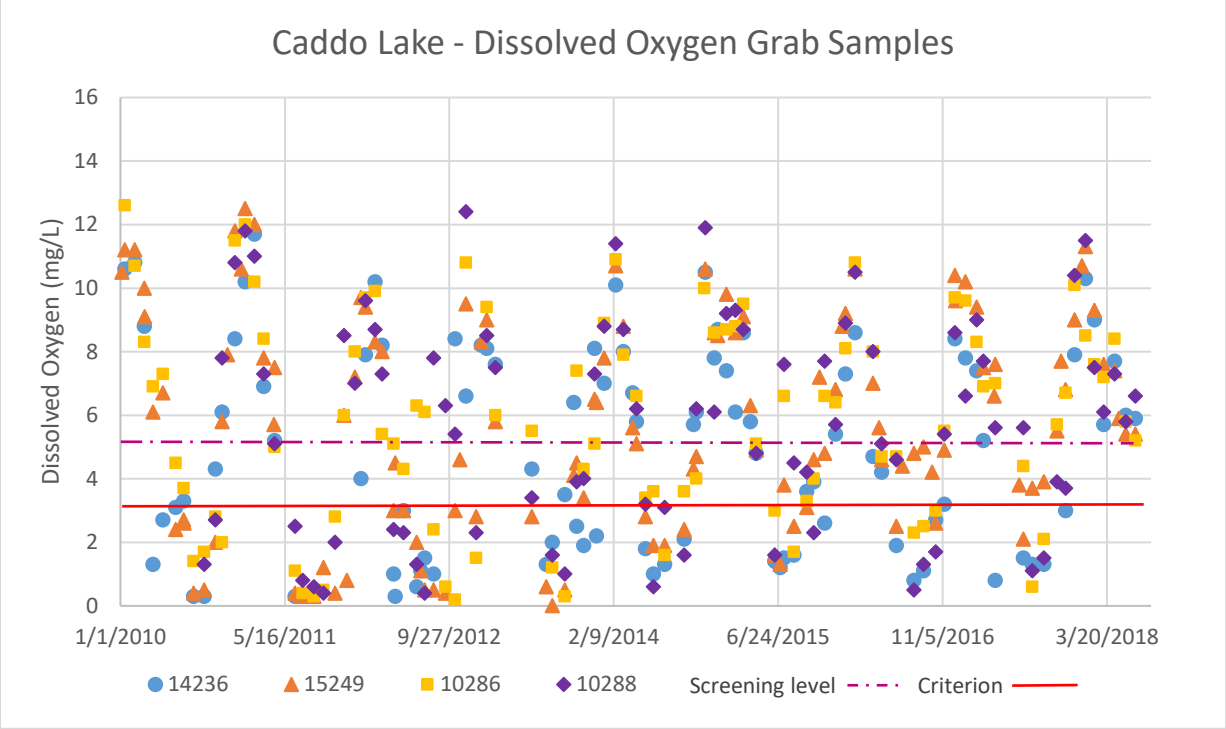

Figure 1: Graph of dissolved oxygen grab sample results in Caddo Lake

Elevated bacteria levels appears to be a significant threat to the water quality of the Cypress Creek Basin. Impairments for *E. coli* were shown in many stream segments in the watershed. *E. coli* listings included Big Cypress Creek and its tributaries, Tankersley Creek and Hart Creek; Little Cypress Creek and its tributaries, Lilly Creek and South Lilly Creek; Black Cypress Creek; Black Bayou; and James Bayou. Sources of bacteria include livestock, pets, wildlife, and improperly treated human waste, such malfunctioning on-site septic systems.

A Comprehensive Recreational Use Attainability Analysis (RUAA) was conducted in Big Cypress Creek, Tankersley Creek, and Hart Creek to address these impairments. The project was conducted to discover whether these streams were being used for primary contact recreation

or if secondary contact recreation was a more appropriate use standard. The comprehensive RUAA found no evidence of primary contact recreation occurring within the study area. Similarly, an RUAA was conducted in Little Cypress Creek, Lilly Creek, and South Lilly Creek, but the results have not been released. A Comprehensive RUAA should be conducted in stream segments to address the remaining *E. coli* impairments.

Nutrient and sulfate concentrations in Tankersley Creek, Hart Creek, and Big Cypress Creek below Lake Bob Sandlin were inversely correlated to stream flow suggesting that the primary contributor of these constituents was from point-sources. A multi-million dollar upgrade to the Pilgrim's Pride WWTP, completed in 2015, measurably reduced the amount of phosphorus entering Tankersley Creek and Big Cypress Creek. Although nitrate and sulfate were lower in these streams after the plant upgrades were completed, these reductions may have been the result of higher stream flows and releases from Lake Bob Sandlin. The graph below shows nitrate results in the upper reach of Big Cypress Creek from station 10310 (US 271), located below the confluence with Tankersley Creek; and from station 10308 (SH 11), located further downstream after the confluence with Hart Creek and other tributaries.

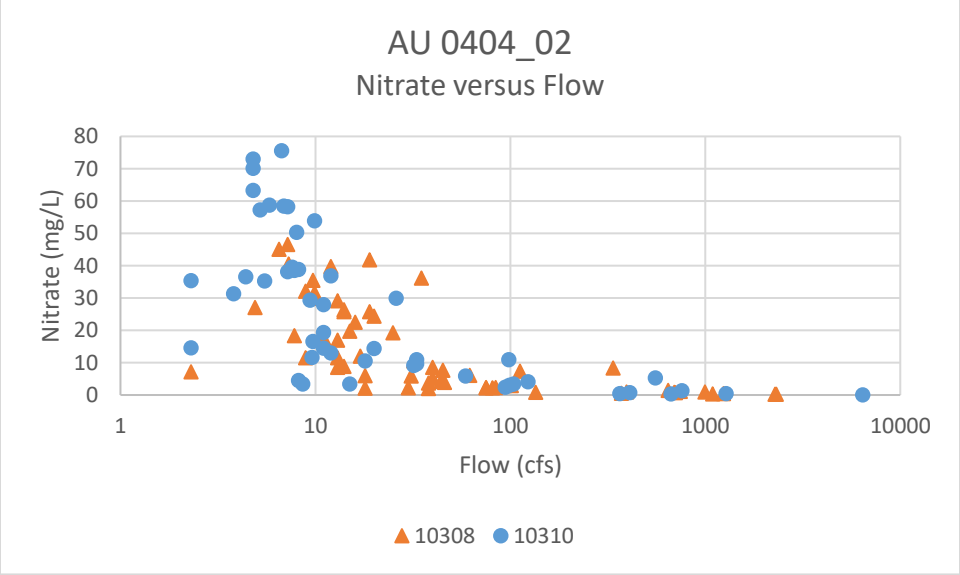

Figure 2: Graph of nitrate versus flow in AU 0404_02

The 2014 Cypress Creek Basin Summary Report found statistically significant increasing nutrient trends in Big Cypress Creek below Lake Bob Sandlin and subsequently increasing chlorophyll *a* trends in Lake O' the Pines. As a result of the lack of freshwater inflow into Big Cypress Creek, due to the pervasive drought and reduced releases from Lake Bob Sandlin, the stream became dominated by effluent. Statistically significant increasing Specific Conductance/Total Dissolved Solids trends in Big Cypress Creek below Lake Bob Sandlin further supported this reasoning.

Despite the past four years of near historic rainfall and releases from Lake Bob Sandlin, recent data suggest that the process of eutrophication is occurring throughout the upper portion of the Cypress Creek Basin. Eutrophication is a process where a body of water becomes overly enriched with nutrients which induces excessive algae growth and harmful algae blooms. The eutrophication process may result in the depletion of oxygen at night which may result in fish kills. During the day, excessive algal growth can also lead to fish kills due to elevated oxygen concentration. The eutrophication conclusion was evidenced by statistically significant increasing pH trends in Lake Bob Sandlin, Lake O' the Pines, and Big Cypress Creek below Lake O' the Pines. Increasing chlorophyll *a* levels and strong correlations between pH and dissolved oxygen percent saturation readings in Lake Cypress Springs and in Lake O' the Pines along with the decreasing transparency trend in Lake O' the Pines lend further credence to this assertion.

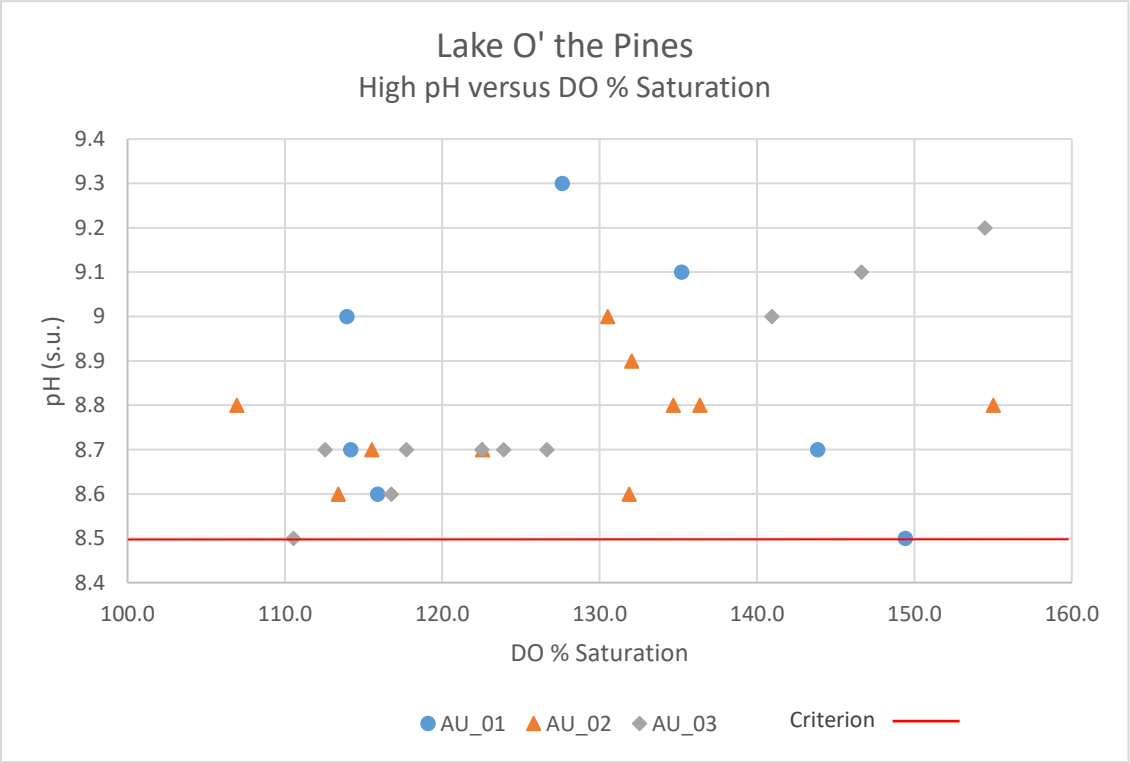

Figure 3: Graph of high pH versus DO saturation in Lake O' the Pines

Although elevated chlorophyll *a* and high pH were poorly correlated, excessive algal production should not be discounted as the basis for increasing pH in these water bodies. Grab samples are collected at 0.3-meter below the water surface, and the diurnal movement of phytoplankton vertically within the water column is well-documented. As a result, algal populations may have been above or below the 0.3-meter depth at the time of sampling. Since most samples were collected during the time of peak productivity, the percent saturation of dissolved oxygen

provided a reasonable surrogate parameter for chlorophyll *a*. In nearly all cases where high pH was measured, dissolved oxygen was also reported above 100% saturation.

Eutrophication is the most significant threat to water quality in the Cypress Creek Basin. The *Draft 2016 Integrated Report* classified Lake Cypress Springs as being an eutrophic reservoir. A review of the current data suggest that Lake Bob Sandlin and Lake O' the Pines are becoming eutrophic, as well. The effects of eutrophication may reduce the aesthetics of the reservoir, reduce its biological diversity, and increase the cost of drinking water treatment.

Efforts to reduce nutrient loadings through the implementation of best management practices, such as those used in the Lake O' the Pines TMDL, should be considered across the entire Cypress Creek Basin.

Figure 4: Clean Rivers Program Steering Committee Meeting, March 2018

INTRODUCTION

The Texas Clean Rivers Program (CRP) is a statewide water quality monitoring and assessment program that provides funding and resources for regional watershed protection efforts. The program is administered by the Texas Commission on Environmental Quality (TCEQ) in partnership with river authorities and other regional governments with the goal of maintaining and improving water quality in each river basin in the state.

As the coordinating agency in the Cypress Creek basin, the Northeast Texas Municipal Water District (NETMWD) works with federal and state agencies, municipalities, water suppliers, and private companies to accomplish water quality monitoring and watershed protection objectives. Monitoring priorities are established through stakeholder input and coordination with other organizations working in the basin. Water quality sampling regimens are established though an annual Coordinated Monitoring Meeting with the objective of ensuring that resources and efforts are not duplicated or overlapped. Coordinating entities in attendance often include the TCEQ, Caddo Lake Institute (CLI), Texas Parks and Wildlife Department (TPWD), U. S. Geological Survey (USGS), Texas State Soil and Water Conservation Board (TSSWCB), and Texas A&M University – Agrilife/ Texas Water Resources Institute.

Each year, a Basin Highlight Report is authored, presented at stakeholder meetings, and posted to the NETMWD website. The report is typically of a non-technical nature intended to provide a high-level overview of recent activities and water quality issues within the basin. Every five to six years, a Basin Summary Report is written. This technical report is used to provide an in-depth review of historical and recent data, and an analysis of water quality trends occurring throughout the watershed. The objectives of the Basin Summary Report are to:

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THE CYPRESS CREEK BASIN

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The basin experienced a pervasive drought that began around 1999 and extended through 2014. During this period, the drought was punctuated with large rainfall events. In 2011 and 2012, the drought reached comparable levels with the drought of record from the 1950's. The near-historic flooding in 2015 and 2016 ended the pervasive drought.

Each Tuesday, the U. S. Drought Monitor is updated with information and maps about drought conditions across the country. Information is provided for each Hydrologic Unit Code (HUC) and a drought classification is assigned. Classifications are coded 0 - no drought; D0 - Abnormally Dry; D1 - Moderate Drought; D2 - Severe Drought; D3 - Extreme Drought, D4 - Exceptional Drought. As shown in the graph below, much of the past two decades fell within the D0 to D4 categories.

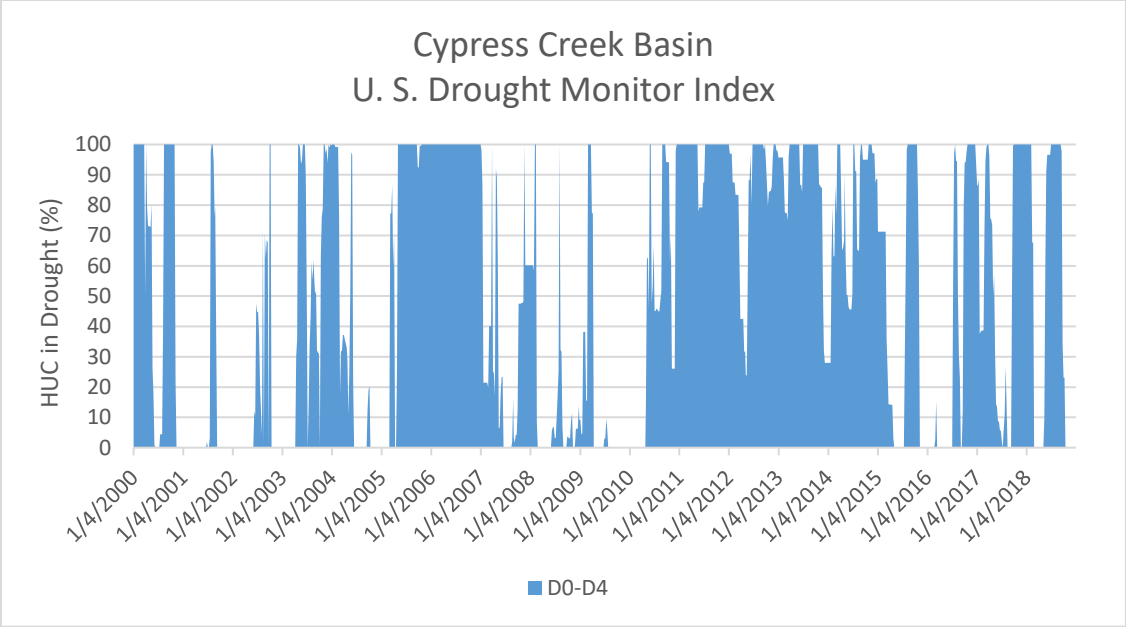

Figure 5: Graph of US Drought Monitor Index for the Cypress Creek Basin

Rainfall records at the Fort Sherman Dam, located in the upper portion of the basin, have been maintained since its completion in 1978. Over the forty-year period, precipitation has averaged around 52 inches annually. However, from 1979 to 1998, the average was 54 inches per year, as compared to 50 inches from 1999 to 2018. During the 1999 - 2014 drought, an annual average of 48 inches of rain was reported. At slightly over 25 inches of precipitation, 2005 was the driest year on record and was also the first year that no water was released from Lake Bob Sandlin.

Releases from Lake Bob Sandlin play an important role in the water quality of Big Cypress Creek and Lake O' the Pines. There are no instream flow requirements in Big Cypress Creek, so water is only released by the Titus County Freshwater Supply District #1 to maintain freeboard of the Fort Sherman Dam. From 2000 through 2014, a combined total of 939,956 acre-feet of water was released from the reservoir. As a result of pervasive drought, there were zero releases during seven out of those fifteen years. No releases occurred in 2005 through 2007 and again from 2011 through 2014.

A record amount of water was released from the Fort Sherman Dam in 2015, at over 280,000 acre-feet. An additional 150,000 acre-feet was released by the end of April 2016. This amount of water could fill Lake Bob Sandlin more than twice. A total of 677,968 acre-feet was released in 2015 through 2018, or about 60% of the combined releases of the previous fifteen years.

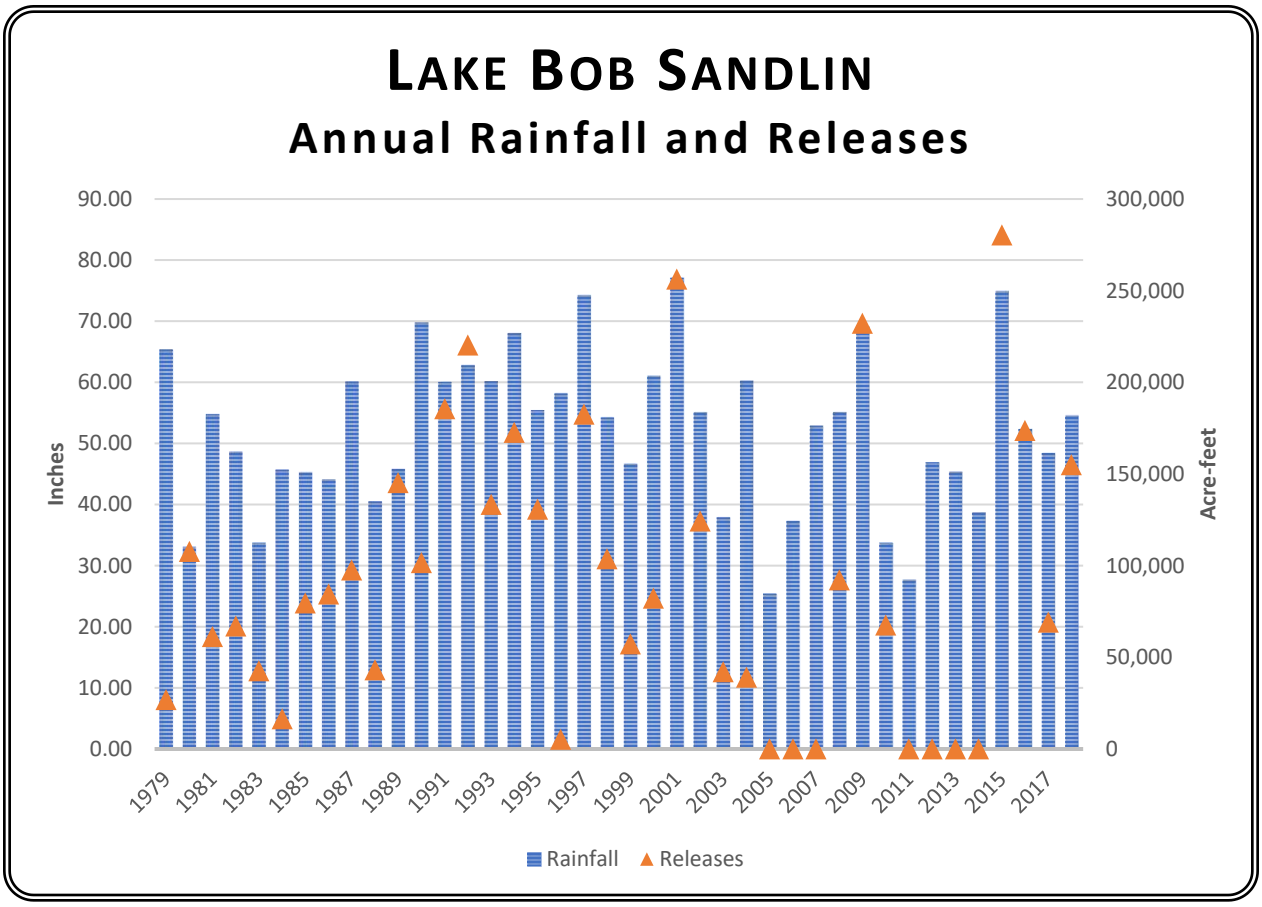

Figure 6: Graph of annual rainfall and releases form Lake Bob Sandlin

Similarly, Caddo Lake surpassed its flood stage of 172.0 feet seven times over the past 46 months. Further, during the thirteen-month period of March 2015 to April 2016, Caddo Lake reached flood stage five times including the fourth highest water level ever recorded at 179.95 feet. For a perspective of the magnitude of the recent flooding, during the 93-year period of 1921 to 2014, the Caddo Lake spillway reached its flood stage 29 times for an average of once per every 3.2 years. Over sixty percent of these record events occurred prior to the impoundment of Big Cypress Bayou that created Lake O' the Pines, which was constructed as a flood control structure in response to the historic flooding of Jefferson in 1945. The only other decades that Caddo Lake reached flood stage five times was during the 1930's and 1940's, prior to the construction of Lake O' the Pines.

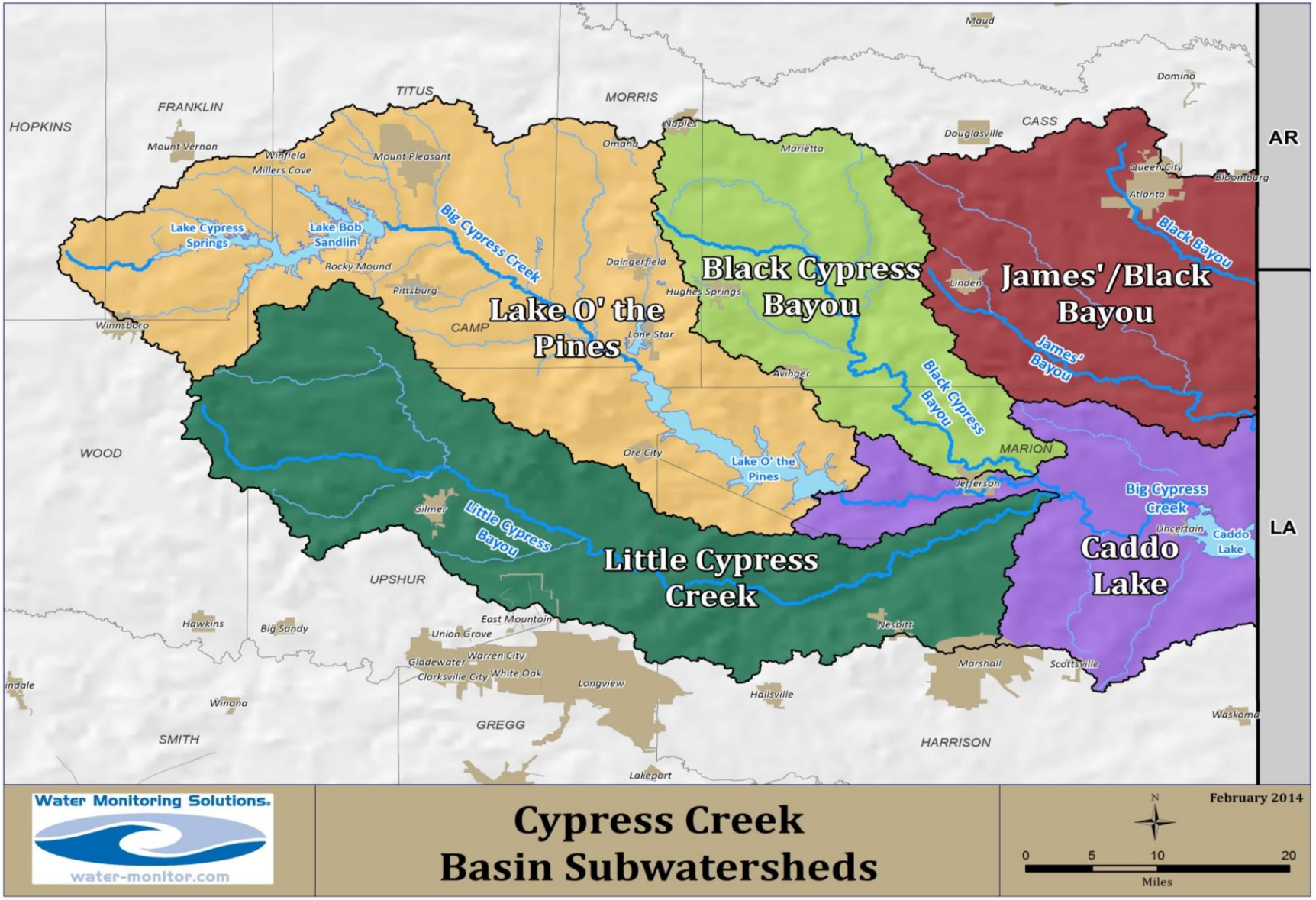

Figure 7: Map of the Cypress Creek Basin watersheds

WATER QUALITY MONITORING

Clean Rivers Program partners collect monitoring data following a TCEQ-approved Quality Assurance Project Plan (QAPP). The QAPP references procedures and methods for sample collection and handling. The TCEQ Surface Water Quality Monitoring (SWQM) team have produced two procedures manuals that detail the methods for collecting water, sediment, and biological samples. All CRP partners follow these methods of data collection and quality assurance.

WMS collects, analyzes, and assimilates water quality data in the Cypress Creek Basin and submits the resulting data to the TCEQ for inclusion in the state water quality database - Surface Water Quality Monitoring Information Systems (SWQMIS). After a thorough review and approval by TCEQ, these data are made available for public access via the NETMWD and TCEQ websites. NETMWD/WMS, TCEQ (Region 5 - Tyler), and the CLI collected water quality data from 53 sites in the Cypress Creek basin during Fiscal Year (FY) 2018. A similar monitoring effort is scheduled for FY 2019. The Coordinated Monitoring Schedule (CMS) is presented at the end of each segment discussion.

Physical and chemical measurements of water quality are typically made at each station. Common parameters include dissolved oxygen, pH, suspended sediments, nutrients, bacteria, and stream flow or lake level. Biological assessments include the collection of fish, aquatic insects, and habitat assessments to assess the overall health of streams. Water quality monitoring is often described in the general terms of field parameters, conventional laboratory parameters, diel studies (data collected over a 24-hour period), stream flow, and biological sampling.

The following provides definitions of the common parameters for each group.

FIELD PARAMETERS

Field parameters include those obtained using a water quality sonde such as temperature, dissolved oxygen, pH, specific conductance (sometimes referred to as "temperature-compensated conductivity"), and salinity. Other field parameters include transparency, stream flow, air temperature, and general field observations.

Temperature – Water temperature affects the oxygen content of the water, with warmer water unable to hold as much oxygen. When water temperature is too cold, cold-blooded organisms may either die or become weaker and more susceptible to other stresses, such as disease or parasites. Colder water can be caused by reservoir releases. Warmer water can be caused by removing trees from the riparian zone, soil erosion, or use of water to cool manufacturing equipment.

Dissolved Oxygen (DO) – The concentration of dissolved oxygen is a characteristic of water that correlates with the occurrence and diversity of aquatic life. A water body that can support diverse, abundant aquatic life is a good indication of high water quality since all aerobic aquatic organisms require oxygen to live. Modifications to the riparian zone, decreases in stream flow, increases in water temperature, increases in organic matter, bacteria, and over abundant algae may lead to lower DO concentrations in water.

Specific Conductance – Conductivity is a measure of the water body's ability to conduct electricity and indicates the approximate levels of dissolved salts, such as chloride, sulfate, and sodium in the stream. Elevated concentrations of dissolved salts can impact the water as a drinking water source and as suitable aquatic habitat.

Salinity – Salinity is commonly calculated by the water quality sonde using an algorithm based upon conductivity and temperature, and is typically only recorded at coastal and tidally influenced stations. Salinity plays a role in determining estuarine sites and the composition of saline water diluted by freshwater from streams and rivers.

pH – is a measure of the acidity or basicity of a solution. The pH scale is a logarithmic (base 10) scale. A change of one pH unit means that the water has become ten times more acidic or basic. Most aquatic life is adapted to live within a relatively narrow pH range, but tolerant species can adjust to varying pH ranges. However, pH levels below 4 (acidity of orange juice) or above 12 (basicity of ammonia) are lethal to most fish species. Industrial and wastewater discharge, runoff from quarry operations, and accidental spills are examples of factors that

can change the pH composition of a water body. For many water bodies in East Texas, the pH tends to be naturally low (acidic) due to soil composition.

Transparency – Transparency is a measure of the depth to which light is transmitted through the water column and thus the depth at which aquatic plants can grow. Transparency is measured using a secchi disk. Transparency is an important secondary parameter for assessing eutrophication, the natural aging process in reservoirs and lakes, and for determining trends in water clarity.

Stream Flow – Flow is an important parameter affecting water quality. Low flow conditions, common in the warm summer months, create critical conditions for aquatic organisms. At low flows, the stream has a lower assimilative capacity for waste inputs from point and non-point sources. Streams have critical low flows calculated by TCEQ. When stream flows drop below these (known as 7Q2) calculations, some water quality standards do not apply. For example, low DO is often a result of low flows. As a result, flow is often evaluated in conjunction with DO by the assessors to determine if a site is meeting its Aquatic Life Use designation.

Flow Method – The method used to measure flow is also recorded to provide information as to how the flow was determined. Flow is often reported using a USGS gage or measured in wadeable streams using a Doppler or electronic flow meter.

Flow Severity – Flow severity is a parameter recorded at freshwater (non-tidally influenced) stream sites. It is an observational measurement that is highly dependent upon the sampler's knowledge of the water body. Flow severity is reported as either dry, no flow (pooled), low, normal, high, or flood. This parameter is often used as a supporting detail of conditions present during sampling when assessing a water body.

CONVENTIONAL LABORATORY PARAMETERS

Laboratory analysis of "conventional" parameters generally includes solids, salts, nutrients, and bacteria. Conventional parameters analyzed by a laboratory include:

Solids: Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) – High solids may affect the aesthetic quality of the water, interfere with washing clothes, and corrode plumbing fixtures. High total dissolved solids in the environment can also affect the permeability of ions in aquatic organisms. Mineral springs, carbonate deposits, salt deposits, and sea water intrusion are sources for natural occurring high concentration solids levels. Other sources can be attributed to oil and gas exploration, drinking water treatment chemicals, storm water and agricultural runoff, and point/non-point wastewater discharges. Elevated levels of dissolved solids such as chloride and sulfate can cause water to be unusable, or simply too costly to treat for drinking water uses. Changes in dissolved solids concentrations also affect the quality of habitat for aquatic life.

Total Hardness – Hardness is a composite measure of ions in the water, and is primarily composed of calcium and magnesium. The hardness of the water is critical due to its effect on the toxicity of certain metals. Higher hardness concentrations in the receiving stream can result in reduced toxicity of heavy metals.

Chloride – Chloride is an essential element for maintaining normal physiological functions in all organisms. Elevated chloride concentrations can disrupt osmotic pressure, water balance, and acid/base balances in aquatic organisms which can adversely affect survival, growth, and/or reproduction. Natural weathering and leaching of sedimentary rocks, soils, and salt deposits can release chloride into the environment. Other sources can be attributed to oil and gas exploration and storage, sewage and industrial discharges, run off from landfills, and saltwater intrusion.

Sulfate – Effects of high sulfate levels in the environment have not been fully documented. However, sulfate contamination may contribute to the decline of native plants by altering chemical conditions in the sediment. Due to abundance of elemental and organic sulfur and sulfide mineral, soluble sulfate occurs in almost all natural water. Other sources are the burning of sulfur-containing fossil fuels, steel mills, wastewater treatment plant discharges, and fertilizers.

***E. coli* (Bacteria) –** Occurring naturally in the digestive system of warm blooded animals, *Escherichia coli* (*E. coli*) bacteria are commonly found in surface water. Although not all bacteria are harmful to human beings, the presence of is an indication of recent fecal matter contamination, and that other pathogens dangerous to human beings may be present. Bacteria are measured to determine the relative risk of contact with pathogens through swimming or other contact recreation activities. Sources may include inadequately treated sewage; waste from livestock, pets, waterfowl, and wildlife; or malfunctioning/failing septic systems.

Chlorophyll *a* – High levels of chlorophyll can indicate algal blooms, decrease water clarity, and cause swings in pH and dissolved oxygen concentrations due to photosynthesis and respiration processes. An increase in nutrients can lead to excessive algal production. Chlorophyll *a* concentrations are used as an indication of eutrophication in lakes and reservoirs.

Turbidity – Turbidity is a measure of the water clarity or light transmitting properties of water. Increases in turbidity are caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. High turbidity can affect the growth of aquatic plants, decrease species diversity, and increase water treatment costs.

Nutrients (Ammonia, Nitrate, Phosphorus) – Nutrients are essential for life. However, elevated concentrations of nutrients can cause excessive growth in aquatic vegetation and may lead to algal blooms. Bloom conditions may cause wide variations in pH and dissolved oxygen within a water body. Common sources of nutrient pollution are treated effluent, malfunctioning septic systems, and agricultural non-point sources. Soil erosion and runoff from farms, lawns, and gardens can add nutrients to the water. Some nutrient loading may also occur naturally through biotic decomposition. In aquatic systems, when plants and algae die, the bacteria that decompose them use oxygen, thereby reducing the amount of dissolved oxygen in the water column which may lead to fish kills and decreased species diversity.

Elevated amounts of nitrogen in the environment can adversely affect fish and invertebrate reproductive capacity and reduce the growth of young. High levels of nitrates and nitrites can produce nitrite toxicity, or “brown blood disease.” It can contribute to Blue Baby Syndrome in humans, a disease which reduces the ability of blood to transport oxygen throughout the body.

Ammonia is excreted by animals and is produced during the decomposition of organic matter. Municipal and industrial wastewater treatment plant discharge is another common source of ammonia.

Phosphorus is one of the most abundant elements on the planet; however, most natural phosphate compounds are very insoluble and not biologically available. Most water bodies are phosphorus-limited, meaning that algal production is limited to the amount of soluble phosphorus available in the water column. Common contributors of soluble phosphorus are non-point sources such as human and animal waste as well as commercial fertilizers. Commercial fertilizers are a more soluble form that can readily be used by plants, but this property also makes the phosphorus more susceptible to runoff.

Metals - High concentrations of metals such as cadmium, mercury, and lead pose a threat to drinking water supplies and human health. Eating fish contaminated with metals can cause these toxic substances to accumulate in human tissue, posing a long-term significant health threat. Metals also pose a threat to livestock and aquatic life. Potentially dangerous levels of metals and other toxic substances are identified through chemical analysis of water, sediment, and fish tissue. Bioaccumulation of mercury in the edible tissues of many fish species to the point of becoming a human health concern has prompted the Department of State Health Services (DSHS) to issue fish consumption advisories around the basin. Mercury in edible fish tissue has been identified in fish tissue in water bodies throughout East Texas.

Organics - Toxic substances from pesticides and industrial chemicals pose the same concerns as metals. PCBs, for example, are industrial chemicals that are toxic and probably carcinogenic. Although banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed.

A Summary of Regulatory Framework for Texas Surface Water Quality

In order to protect water quality, we must define and measure it. The state of Texas has established standards that protect the purposes for which the streams, lakes, and estuaries in the state will be used, and defined measurements that determine whether the water quality is good enough to attain those uses. The **Texas Surface Water Quality Standards (TSWQS):**

- designate the uses, or purposes, for which the state's waterways should be suitable;
- establish numerical and narrative criteria for water quality throughout the state;
- provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals (criteria) for water quality.

Water quality criteria are designed to be protective of uses. Substantial deviations from criteria indicate that related uses might be impaired. For example, the concentration of dissolved oxygen is one criterion for determining the attainment of the aquatic life use. Where oxygen concentrations are low, the use of the water body to support aquatic life may be impaired. However, since other factors affect the health of an aquatic environment, additional data, such as the presence of a high number and variety of species, may show that the use is fully attained, even if oxygen concentrations are lower than the criterion.

Five major "use" categories for water are defined in the *Texas Surface Water Quality Standards*:

- **Aquatic Life Use**
  The standards associated with this use are designed to protect aquatic species, and to protect the propagation of both aquatic and terrestrial species. They establish optimal conditions for the support of aquatic life and define indicators used to measure whether these conditions are met. Some pollutants or conditions that may violate this standard include low levels of dissolved oxygen, or high concentrations of toxics such as metals or pesticides dissolved in water.

- **Contact Recreation**
  The standard associated with this use measures the level of certain bacteria in water that indicate the relative risk of swimming or other water sports involving direct contact with the water. Texas protects the quality of the state's surface waters to make them safe for recreational uses such as swimming, wading, or other activities during which a person might ingest natural waters. Criteria that are also defined in the TSWQS are used to evaluate the suitability and safety of streams, lakes, and estuaries for contact

recreation. The four contact recreation use categories are Primary Contact Recreation, Secondary Contact Recreation 1, Secondary Contact Recreation 2, and Non-contact Recreation. Almost all water bodies in Texas are designated for Primary Contact Recreation.

- **Public Water Supply**
  Standards associated with this use indicate whether water from a lake or river is suitable for use as a source for a public water supply system. Source water is treated before it is delivered to the tap. A separate set of standards governs treated drinking water. Indicators used to measure the safety or usability of surface water bodies as a source for drinking water include the presence or absence of substances such as metals or pesticides. Concentrations of salts, such as sulfate or chloride, are also measured, since treatment to remove elevated levels of salts from drinking water may be expensive.

- **Fish Consumption**
  The standards associated with this use are designed to protect the public from consuming fish or shellfish that may be contaminated by pollutants in the water. The standards identify levels at which there is a significant risk that certain toxic substances dissolved in water may accumulate in the tissue of aquatic species. Because toxic substances in water may exceed these levels while no accumulation in fish tissue is observable, the state conducts tests on fish and shellfish tissue to determine if there is a risk to the public from consuming fish caught in state waters. The standards also specify bacterial levels in marine waters to assure that oysters or other shellfish subject to commercial harvest and marketing are safe for public sale and consumption.

- **General Use**
  General uses are indicators of water quality that are not tied to specific uses. General uses include dissolved solids, nutrients, and toxic substances in sediment. These uses are also described in the standards.

The standards define an anti-degradation policy of the Clean Water Act to protect existing uses and water quality of less impacted water bodies. Some water quality standards are applied generally across the State while other criteria are site-specific. Site-specific standards are often revised when new data become available. Initially, site-specific standards were set for individual water bodies in the State using limited data to establish uses and criteria. Many of

the subsequent changes in water quality standards have involved revisions to the initial standards based upon additional data and evaluations. As new data were collected, a subsequent evaluation found that a revised criterion was appropriate.

A “Segment” provides a basic unit of a water body for assigning these standards. A “Classified Segment” is a waterway or portion of a waterway that is individually defined in the TSWQS. Classified segments include most perennial streams, rivers, lakes, and reservoirs in Texas. However, not all waterways in Texas are classified in the TSWQS. Water bodies, such as tributaries, may not be part of the system of classified segments; these water bodies are referred to as “Unclassified Segments”. Water quality standards and assessment are conducted on the “Assessment Unit” (AU) level. Assessment units are sub-units of a segment and are defined as hydrologically distinct areas of streams, rivers, and reservoirs. Some segments may only have a single assessment unit while others may consist of several assessment units.

When assessment units are discussed in this report, they are designated by the letters AU followed by the segment number and assessment unit number. For example, Lake O’ the Pines is segment number 0403. The lowest assessment unit, near the dam, is numbered 01. When discussing the water quality of this assessment unit, the discussion will include “AU 0403_01” to identify the segment and assessment unit. The headwater of Lake O’ the Pines is in assessment unit 04; discussions about the upper portion of the reservoir are identified as “AU 0403_04”. All reservoirs in the basin follow this naming convention where assessment unit 01 is nearest the dam. Similarly, the lowest portion of stream segments are also numbered 01 and the highest numbered AU is located in the headwaters.

DRAFT 2016 TEXAS INTEGRATED REPORT OF SURFACE WATER QUALITY

Based upon these standards, the TCEQ, in concert with other federal, regional, and local organizations, carries out a regular program of monitoring and assessment to determine which water bodies are meeting the standards set for their use, and which are not. Every two years, the TCEQ produces an assessment report, the *Texas Water Quality Integrated Report for Clean Water Act Sections §305(b) and §303(d)*, which compares water quality conditions to established standards, as required by the federal Clean Water Act.

The most recent assessment is the *Draft 2016 Texas Integrated Report* which compared all available quality-assured data collected from December 1, 2007, through November 30, 2014 with the TSWQS. For parameters with no established numerical criteria, the data were compared to screening levels. The TCEQ Commissioners approved the *Draft 2016 Texas Integrated Report* on October 17, 2018. The Environmental Protection Agency is currently reviewing the document which will remain as a "Draft" until it is approved.

The Integrated Report (IR) defines the status of each water body as one of the following:

- **Meets or Supports:**
  Sufficient data were available to assess the water body and it meets all applicable surface water quality standards and fully supports its uses.

- **Concern:**
  a) *Sufficient data are not available to perform a full assessment and the limited data indicate surface water quality standards are not being met, or*
  b) *Sufficient data are available to perform a full assessment but the number of samples exceeding the standards are less than that needed to establish that the standards are not being met, or*
  c) *Surface water quality standards have not yet been established. If water quality data indicate a concern, resources are allocated to collect more data to verify the concern.*

- **Impaired:**
  Sufficient data are available and show that the water body does not meet surface water quality standards. If monitoring data indicate a water body does not support one or more of its designated uses, then it is said to be impaired. Details of the impairment are

published in the Draft 2016 Texas Integrated Report. Water bodies that are impaired are shown on the Draft 2016 Texas §303(d) List.

The *Draft 2016 Texas §303(d) List*, a subset of the report, identified:

- water bodies that do not attain one or more of the standards set for their use, or are expected not to meet one or more uses in the near future;
- which pollutants or conditions are responsible for the failure of a water body to attain standards;

Common limitations in water quality include:

- bacteria levels that exceed the criterion established to assure the safety of contact recreation
- dissolved oxygen levels that are lower than the criterion established to assure optimum conditions for aquatic life
- total dissolved solids, sulfate, and chloride that exceed the criteria established to safeguard general water quality uses
- contaminants in fish tissue that pose a risk to consumers

Some water bodies also have:

- toxic substances in water that exceed the criterion to protect aquatic life
- conditions of acidity (measured as pH) and high temperature that exceed the criteria to safeguard general water quality uses

Impairments shown on the §303(d) List are assigned one of three subcategories to each impaired parameter to provide information about water quality status and management activities on that water body. All of the impairments in the Cypress Creek Basin were included in Category 5 meaning that the water body did not meet applicable water quality standards for one or more designated uses by one or more pollutants. The subcategories are:

- *5a* - TMDLs are underway, scheduled, or will be scheduled for one or more parameters.
- *5b* - A review of the standards for one or more parameters will be conducted before a management strategy is selected, including the possible revision to the TSWQS.
- *5c* - Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

If not enough data were collected to fully assess a parameter, the assessor may carry-forward the listing into the next assessment. The assessor will identify whether an impairment or concern was based upon having adequate data (AD) which was ten or more samples depending upon the parameter; limited data (LD), four to nine samples; or inadequate data (ID), less than four results. These details are included on tables of impairments and concerns in the segment narratives section of this report.

Changes to the list of impairments shown in the *Draft 2016 Texas §303(d) List* included the addition of Lake Cypress Springs (Segment 0405) for excessive algae growth using the Nutrient Reservoir Criteria method. Reservoir nutrient criteria is a new method in the 2016 assessment. For several years, the TCEQ has been working to develop nutrient criteria for reservoirs. At present, Lake Cypress Springs is the only reservoir in the Cypress Creek Basin to have nutrient criteria approved by EPA. The new criteria were developed to assess reservoir nutrients based on the changes in the revision of the TSWQS in 2010 which were approved by EPA in 2013. The nutrient criteria uses a multiple lines of evidence approach with criteria thresholds developed from sampling results obtained over the data record for chlorophyll *a* and other parameters. Chlorophyll *a*, total nitrogen, total phosphorus, dissolved oxygen, and secchi measurements are all used to assess reservoirs for excessive algal growth. In addition to the reservoir nutrient criteria, the changes to the TSWQS in 2010 included using a regression equation to calculate the dissolved oxygen criterion based upon flow in the lower stream segments of the Cypress Creek Basin. Based upon historic data, the minimum pH was reduced from 6.0 s.u. to 5.5 s.u. in the lower portion of the basin. The changes to TSWQS were deemed to more appropriately apply to these water bodies.

Fish Consumption Advisories and Closures

The Texas Department of State Health Services conducts chemical testing of fish tissue to determine whether there is a risk to human health from consuming fish or shellfish caught in Texas streams, lakes, and bays. Fish seldom contain levels of contaminants high enough to cause an imminent threat to human health, even to someone who eats fish regularly. When a fish consumption advisory is issued, a person may legally take fish or shellfish from the water body, but fish advisories may recommend an amount of fish that should be consumed. When a fish consumption closure is issued for a water body, the taking of fish or shellfish is legally prohibited.

RESTORING IMPAIRED WATERBODIES

The TCEQ watershed action planning process helps identify and prioritize watershed restoration projects for impaired water bodies. As part of the watershed action planning process, stakeholders and monitoring agencies provide input about local water quality problems. Information about potential sources of pollution, geographic factors in the watershed, and community interest is stored in the state watershed action planning strategy table and used to implement the following water quality protection strategies:

Total Maximum Daily Loads

The first step toward restoration is to determine the source(s) of pollution. One way to determine the source is to develop a scientific model called a total maximum daily load (TMDL). A TMDL involves a historical water quality data review, targeted monitoring, detailed water quality analysis, and determination of the amount or "load" of a pollutant that a water body can receive and still support its designated uses. Once the load is calculated among all potential sources of pollution, an implementation plan, or I-Plan is developed to outline strategies that reduce pollutant loads.

Watershed Protection Plans

A Watershed Protection Plan (WPP) is another way to restore impaired water bodies. Unlike the TMDL, a Watershed Protection Plan is non-regulatory. Stakeholders develop the plans to address causes of the identified impairments. Like a TMDL, a Watershed Protection Plan uses monitoring data and local input to outline strategies that reduce pollutant loads.

Use Attainability Analyses

Another option for addressing impaired water bodies is a use attainability analysis (UAA). While a TMDL and Watershed Protection Plan are designed to improve water quality by limiting pollutants, a UAA is designed to evaluate TSWQS and, if appropriate, establish standards that meet the actual use(s) of the waterbody. Similarly, a Recreational Use Attainability Analysis (RUAA) is a study that confirms the level of contact recreation that occurs within a waterway.

Water quality monitoring and reporting is the heart of the CRP program. NETMWD / Water Monitoring Solutions, Inc. (WMS), TCEQ Region 5 – Tyler (R5), and the Caddo Lake Institute (CLI) routinely collect water quality data. Monitoring is conducted at fifty sites located in ten designated segments and 41 sub-segments within the Cypress Creek basin. These data are used by the TCEQ to assess the basin.

During the most recent assessment, the TCEQ evaluated 31 classified and unclassified water bodies in the basin. The results reported in the *Draft 2016 Texas Integrated Report* indicated that over half of these water bodies did not meet surface water quality standards for one or more parameters. Low concentrations of dissolved oxygen, high levels of bacteria, and mercury in fish tissue were the most common impairments. Figure 7 details the segments and parameters shown on the *Draft 2016 Texas §303(d) List*. The §303(d) List identified nine classified and seven unclassified water bodies that were non-supporting of water quality criteria for one or more parameters. Details about these impairments and water quality concerns are discussed within the segment narratives that follow this section of the report.

As a result of the changes to the TSWQS, the water bodies in the table below were delisted in the *Draft 2016 Texas §303(d) List*:

Segment Description	Parameter
Big Cypress Creek below Lake O' the Pines (Segment 0402)	DO
James Bayou (Segment 0407)	DO, pH
Little Cypress Creek (Segment 0409)	DO
Black Cypress Creek (Segment 0410)	DO

The Goose Prairie arm of Caddo Lake was also delisted for low pH. Data collected during the assessment period were above the pH criterion.

The *Draft 2016 Texas §303(d) List* for the Cypress Creek Basin includes the impairments shown in the table below:

Segment ID	Description	Parameter
0401	Caddo Lake (entire)	Mercury in fish tissue
0401	Caddo Lake	DO 24-HR Average
0401	Caddo Lake	DO 24-HR Minimum
0402	Big Cypress Creek Below	Mercury in fish tissue
0402	Lake O' the Pines	DO 24-HR Average
0403	Lake O' the Pines	High pH
0403	Lake O' the Pines	DO 24-HR Minimum
0404	Big Cypress Creek below	*E. coli*
0404	Lake Bob Sandlin	Sulfate
0404A	Ellison Creek Reservoir	Sediment Toxicity (LOE)
0404A	Ellison Creek Reservoir	Dioxin in fish tissue
0404A	Ellison Creek Reservoir	PCBs in fish tissue
0404B	Tankersley Creek	*E. coli*
0404C	Hart Creek	*E. coli*
0404N	Lake Daingerfield	Mercury in fish tissue
0405	Lake Cypress Springs	High pH
0405	Lake Cypress Springs	Nutrient Reservoir Criteria
0405A	Big Cypress Creek above	DO Grab Minimum
0405A	Lake Cypress Springs	*E. coli*
0406	Black Bayou	DO Grab Minimum
0406	Black Bayou	*E. coli*
0407	James' Bayou	Fish Community
0407	James' Bayou	Macrobenthic Community
0407	James' Bayou	DO 24-HR Average
0407	James' Bayou	DO 24-HR Minimum
0407	James' Bayou	*E. coli*
0409	Little Cypress Creek	DO 24-HR Average
0409	Little Cypress Creek	*E. coli*
0409A	Lilly Creek	*E. coli*
0409B	South Lilly Creek	*E. coli*
0410	Black Cypress Creek	Mercury in fish tissue
0410	Black Cypress Creek	Copper in water
0410	Black Cypress Creek	DO 24-HR Average
0410	Black Cypress Creek	DO 24-HR Minimum
0410	Black Cypress Creek	DO Grab Minimum
0410	Black Cypress Creek	*E. coli*
0410A	From Kelly Creek	DO 24-HR Average
0410A	upstream to FM 250	DO 24-HR Minimum

Figure 8: Table of Impairments

TREND ANALYSIS AND METHODOLOGY

A comprehensive review of records extending over the past two decades in the Cypress Creek Basin was performed, with some samples collected as recently as August 2018. The twenty-year record was selected in order to encompass data collected through the recent pervasive drought, recent historic flooding, and to identify these impacts on water quality throughout the basin.

All data used for trend analyses were obtained from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS) database and were conducted by following the TCEQ CRP guidance document for FY 2018 - 2019. Trend analyses were conducted on an assessment unit level, and where appropriate, the trends identified in this study were compared with those identified in previous reports.

Trend analyses were conducted in assessment units that had at least ten years of data, had regular sampling, and had a minimum of twenty sample results. Note that in some cases, trend analyses were not conducted using all data due to infrequent sampling.

Statistical analyses were calculated using a linear regression with a ninety percent confidence interval. For the purposes of this report, a trend was defined as “statistically significant” when meeting five criteria:

- T-stat greater than the absolute value of two,
- p-value less than 0.1,
- R-squared greater than 0.1,
- K-Norm less than 2, and
- S-Norm less than 3.

The “T-statistic” (T-stat) is the coefficient divided by its standard error. The standard error is an estimate of the standard deviation of the coefficient, the amount it varies across cases. The T-stat can be thought of as a measure of the precision with which the regression coefficient is measured.

The “p-value” is the level of significance within a statistical hypothesis test representing the probability of the occurrence of a given event. The “p-value” is used as an alternative to rejection points to provide the smallest level of significance at which the null hypothesis would be rejected.

The statistical measure of how close the data are to the fitted regression line are known as an "R-squared". For example, an R-squared of 0% indicates that the model explains none of the variability of the response data around its mean, while 100% indicates that the model explains all the variability of the data around its mean.

Skewness (S-Norm) and Kurtosis (K-Norm) identifies the shape of the data distribution under a bell curve. Skewness measures the relative size of the two tails on the bell curve, while Kurtosis refers to the pointedness of a peak in the distribution curve. If the Kurtosis is greater than 3, then the dataset had heavier tails than found under a normal distribution mean that the data were skewed towards the tails.

Where applicable, contributing factors such as flow, flow severity, recent significant rainfall, and other parameters were reviewed for anomalies and/or to determine the possibility of targeted sampling and their impacts on the resulting trend. In cases where the trends did not pass these evaluations, they were not discussed in this report.

Results Reported Below Limits

Laboratory results reported below the limit of quantitation (LOQ) occur when the sample concentration is less than the test method or instrument can reliably measure. Trend analyses were not performed on data sets with more than half of the results reported below the LOQ. For the purposes of trend analyses, all results reported as less than the LOQ were adjusted to one-half of that value. This approach assumed that the actual sample concentration was somewhere between zero and the LOQ. In all cases where the results were at or above the LOQ, those values remained unchanged.

It should also be noted that when comparing laboratory results with varying methods or reporting limits, the reliability of the data may be impacted. Variations in test methodologies or LOQ were another possible source of error. Unless the datum was marked in SWQMIS or guidance was provided by TCEQ, all data used for trend analyses were assumed to be valid and accurate.

The results of trend analysis revealed statistically significant trends within most segments of the Cypress Creek Basin. In the table below, trends that were highlighted in green were good water quality trends; yellow were cautionary trends; and red for negative water quality trends. Trends for specific conductance and pH were the most commonly identified parameters. Of particular interest were the trends for increasing pH as this may be an indication of eutrophication. The relationship between pH and eutrophication, as well as all trends, are discussed in more detail in the segment narratives following this section of the report. The results of all statistically significant trends are summarized in the Appendix.

Segment	Station	Secchi	DO	Sp. Cond	pH	Alkalinity	TKN	Bacteria	TDS
0402	15511			↑	↑	↑			
0403	10296	↓							↑
0403	16156				↑				
0403	10297				↑				
0404A	14473		↑						
0405	10312			↑					
0405	10313			↑					
0405	17548					↑	↑		
0408	16158			↑	↑	↑			
0409	10332							↓	

Figure 9: Table of statistically significant trends

REPORT FORMAT

The segment narratives are discussed in order from the upper portion of the Cypress Creek Basin and following the flow of Big Cypress Creek into Caddo Lake. The segment narratives discuss:

- An overview of the segment
- *Draft 2016 Texas Integrated Report* impairments and/or concerns
- Other parameters of interest
- Possible sources of impairments and/or concerns
- Water quality trends
- Monitoring Activities

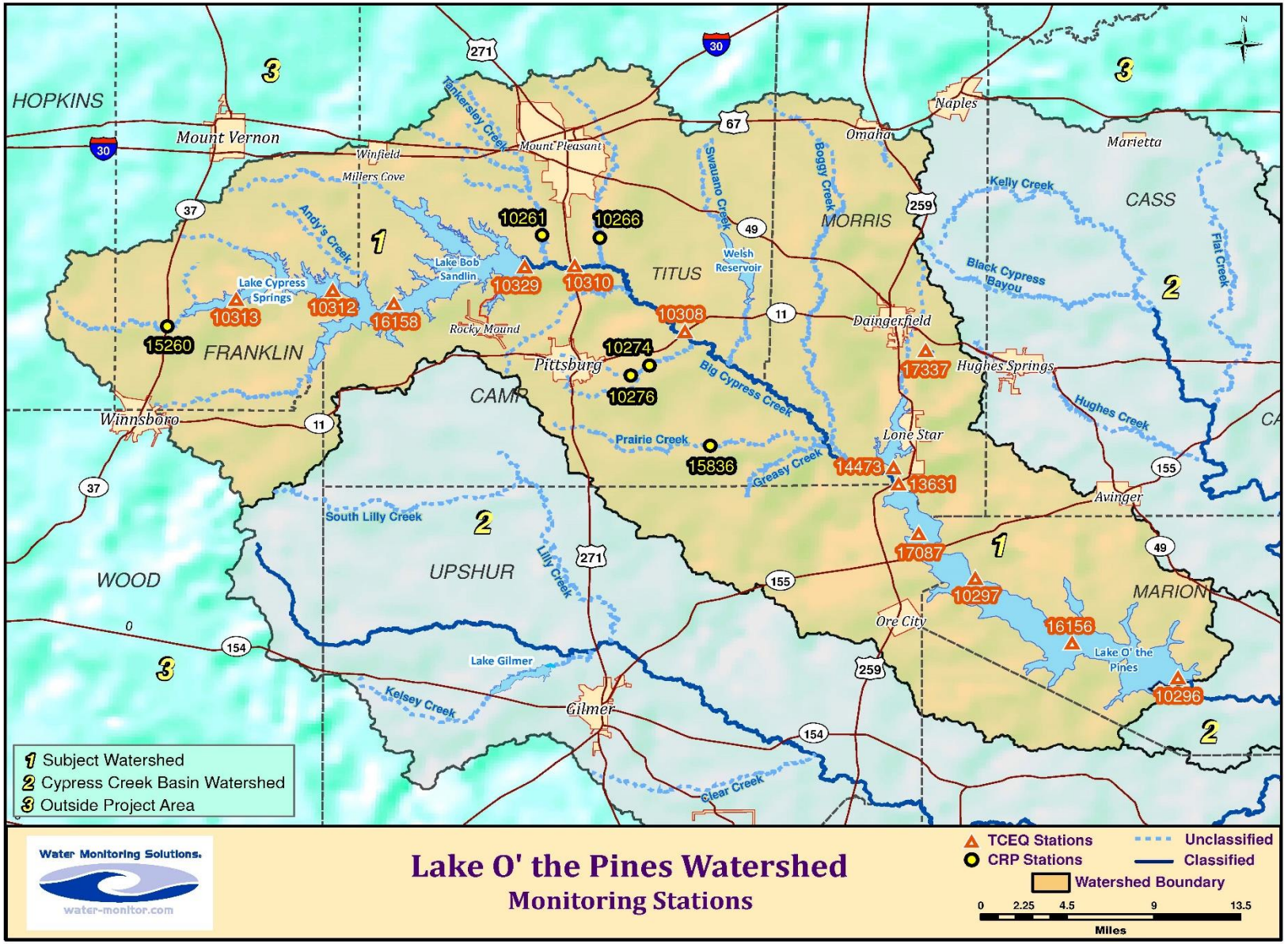

Figure 10: Map of the Lake O' the Pines watershed

LAKE O' THE PINES WATERSHED

Segment narratives for the Lake O' the Pines watershed begins in the headwaters of Big Cypress Creek and follows the waterway into Lake O' the Pines. Population centers include Mt. Pleasant (pop. 16,273), Pittsburg (pop. 4,707), Daingerfield (pop. 2,460), and Ore City (pop. 1,204).

The watershed is composed of four segments:

- Segment 0405 Lake Cypress Springs
- Segment 0408 Lake Bob Sandlin
- Segment 0404 Big Cypress Creek below Lake Bob Sandlin
- Segment 0403 Lake O' the Pines

Major tributaries to Lake O' the Pines include Big Cypress Creek (0404), Tankersley Creek (0404B), Hart Creek (0404C), Dry Creek (0404E), Sparks Branch (0404F), and Prairie Creek (0404J). Reservoirs in the Lake 'O the Pines Watershed include Lake 'O the Pines (0403), Ellison Creek Reservoir (0404A), Welsh Reservoir (0404D), Lake Dangerfield (0404N), Lake Monticello (0408A), Lake Cypress Springs (0405), and Lake Bob Sandlin (0408).

Figure 11: Stream flow measurement at station 15260 in Segment 0405A

SEGMENT 0405 – LAKE CYPRESS SPRINGS

Segment 0405 includes the uppermost reach of Big Cypress Creek and Lake Cypress Springs. The riparian zone of the headwaters of Big Cypress Creek is primarily agricultural including dairy, poultry, cow/calf operations, and hay meadows.

SEGMENT 0405A – BIG CYPRESS CREEK

Big Cypress Creek originates in Hopkins County near the Franklin County line and flows southeast into Lake Cypress Springs. Station 15260, located on SH 37 between Mount Vernon and Winnsboro, was the only station sampled in this reach of the stream.

WATER QUALITY

Regular sampling at station 15260 began in FY 2009. Prior to that, no samples had been collected since 2002. Segment 0405A was listed in the *Draft 2016 Texas §303(d) List* for bacteria and dissolved oxygen. The geometric mean of the samples collected during the assessment period was 654 MPN/100 mL, well over the 126 MPN/100 mL geometric mean criterion. About 20% of the dissolved grab samples were below the 2 mg/L criterion with an average of 1.46 mg/L.

The *Draft 2016 Texas Integrated Report* also includes concerns for screening level for dissolved oxygen, ammonia, and chlorophyll *a*. Approximately a quarter of the dissolved oxygen grab samples were below the 3.0 mg/L screening level while over 40% of the ammonia, and almost 70% of the chlorophyll *a* results exceeded the screening levels of 0.33 mg/L and 14.1 µg/L, respectively. A review of the data in SWQMIS suggest that these listings and concerns will persist into future assessments.

The ammonia results are of particular interest since levels of ammonia above 2 mg/L is acutely toxic to many aquatic organisms. **The average of all ammonia samples collected since 2008 was approximately 0.81 mg/L or about 2.5 times the screening level**. The highest result was 8.98 mg/L, collected in July 2011, a concentration that far exceeds the acute toxicity level for nearly all aquatic organisms. Since then, only three samples exceeded the screening level with a mean of 0.47 mg/L. These high results were possibly due to runoff from the application of commercial fertilizers, and animal waste from livestock and wildlife.

Chlorophyll *a* results range from below the LOQ to 94.3 µg/L, also collected in July 2011. Eleven of the samples in the current assessment period exceeded the screening level with an average of 32.34 µg/L. Since July 2011, five samples have exceeded the screening level with a mean of 45.42 µg/L.

Due to the typically low flow at the location, most low dissolved oxygen values were often associated with low flow measurements. Stream flow under 1 cfs was reported for over a one-third of the site visits, and less than 2 cfs were measured at nearly half. Discussions about the representativeness of station 15260 has been held at coordinate monitoring meetings. As a result, routine sampling was dropped by NETMWD/WMS after FY 2018; however, Region 5 is scheduled to collect *E. coli* samples and measure flow at this station on a monthly basis in 2019.

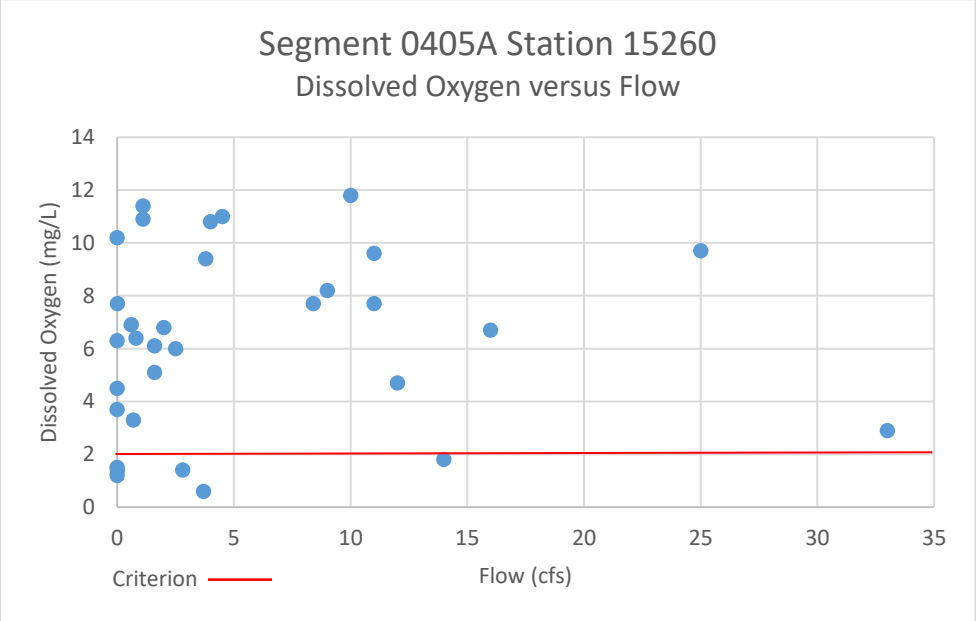

Figure 12: Graph of dissolved oxygen versus flow

TRENDS

There were no trends observed in this reach of Big Cypress Creek.

SEGMENT 0405B – PANTHER CREEK

Panther Creek rises near Purley in Franklin County. The stream, which is intermittent in its upper reaches, originally ran southeast for 6.5 miles to it confluence with Big Cypress Creek before Lake Cypress Springs was impounded in 1970. The *Draft 2016 Texas Integrated Report* shows a concern for impaired habitat. No sampling has been conducted since 2002 in this stream, and

none is presently scheduled. Trend analysis was not conducted since there were no recent data available to review.

SEGMENT 0405 – LAKE CYPRESS SPRINGS

Lake Cypress Springs is located in Franklin County, south of the City of Mount Vernon. Lake Cypress Springs is managed by the Franklin County Water District and is a popular recreational reservoir. The watershed is primarily rural though many new homes have been constructed along the shoreline over the past decade. The Franklin County Dam has a fixed spillway structure, which means that water is discharged only when the lake level exceeds the normal conservation pool of 378 feet mean sea level. The structure has no valves or gates to adjust the rate of releases from Lake Cypress Springs. As a result, flooding in the watershed in December 2015 caused damage to homes and property along the shoreline. Water exiting the spillway flows directly into Lake Bob Sandlin.

Figure 13: Photo of Lake Cypress Springs

WATER QUALITY

Lake Cypress Springs is comprised of three assessment units:

- AU 0405_01 Station 10312 Mid-lake near dam
- AU 0405_02 Station 10313 FM 155
- AU 0405_03 Station 17548 Panther Arm

All assessment units were included on the *Draft 2016 Texas §303(d) List* for high pH and excessive algal growth. Approximately 20% of the surface pH measurements made at all stations in Lake Cypress Springs during the assessment period exceeded the 8.5 s.u. criterion. **The highest pH value was 9.5 s.u., reported in August 2013 at station 10312 and at station 17548.** For station 10313, a value of 9.1 s.u. was recorded that day, and its highest pH was collected in May 2010 at 9.4 s.u. The median pH for samples collected from February 2007 to April 2018 was 7.6 s.u. at station 10312; 8.2 s.u. at station 10313; and 7.9 s.u. at station 17548. These data indicate that the high pH listing will continue in future assessments.

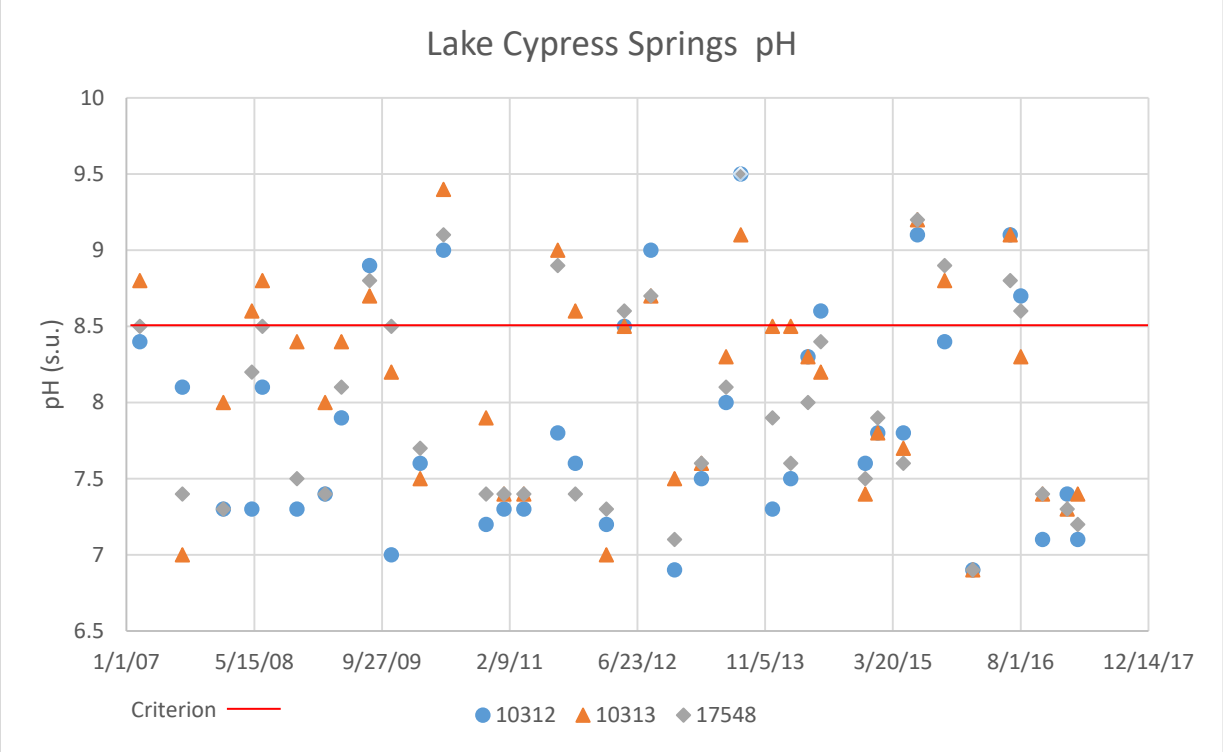

Figure 14: Graph of pH in Lake Cypress Springs

The *Draft 2016 Texas Integrated Report* classified Lake Cypress Springs as eutrophic, and ranked the reservoir in the top forty percent of reservoirs statewide for chlorophyll *a* despite having

relatively low phosphorus concentrations. Values for chlorophyll *a* exceeded the 26.7 µg/L screening level in over 40% of all samples analyzed from February 2007 through April 2018. **The mean chlorophyll concentration of all samples was only slightly below the screening limit at 26.5 µg/L. Almost 60% of the samples collected at station 10313 exceeded the screening limit** during this period, and the highest result in Lake Cypress Springs was collected there in February 2010 at 73.6 µg/L. Of note was that the chlorophyll *a* concentrations for other stations on that date were also very high with 64.8 µg/L at station 17548 and 51.0 µg/L at station 10312. These results were the highest chlorophyll *a* value on record at both stations and suggest that the listing for excessive algal growth listing will continue.

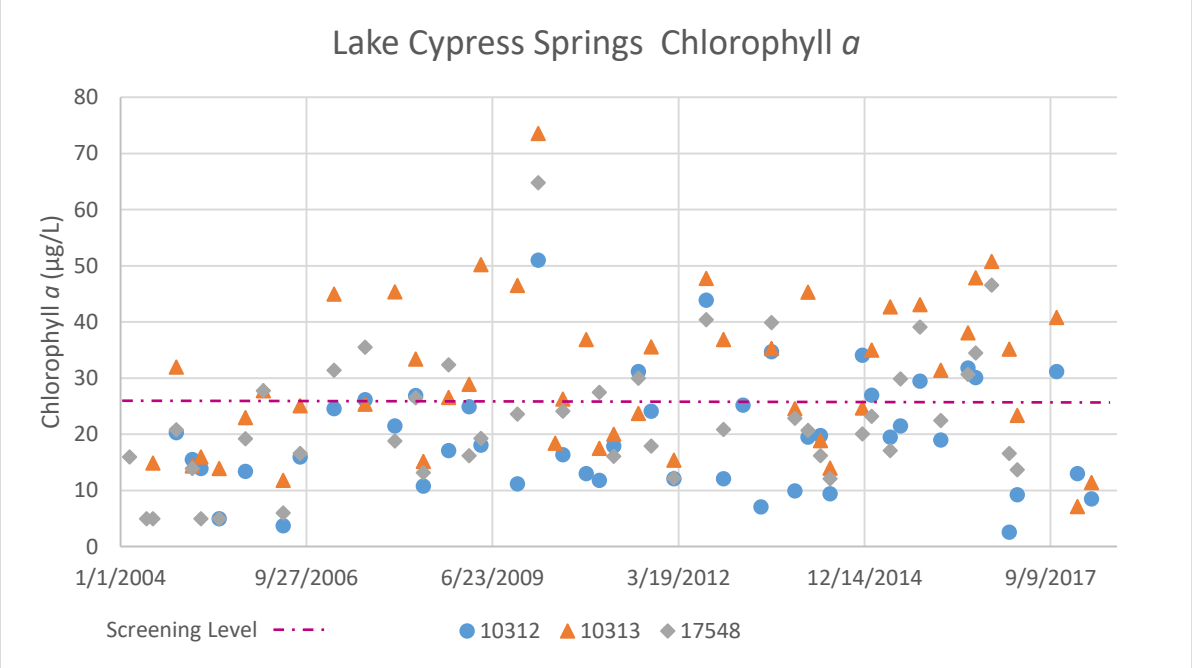

Figure 15: Graph of chlorophyll in Lake Cypress Springs

When the DO percent saturation is super-saturated (exceeds 100%), other contributors of oxygen into the water column, such as phytoplankton and aquatic plants are common sources. While DO concentration (mg/L) is used for assessment purposes, DO percent saturation is a useful indication of phytoplankton productivity. DO concentration is a calculated parameter based upon DO percent saturation, temperature, and salinity. Since TCEQ does not report DO percent saturation to SWQMIS, WMS reversed the algorithm to calculate DO saturation from concentration.

After calculating DO percent saturation, these results were compared with the high pH readings in Lake Cypress Springs reported from 2007 through 2017. All but one of the high pH measurements coincided with dissolved oxygen saturation values above 100%. That lone

reading was 99.9% DO saturation. For all sites in the reservoir, the correlation between pH and DO percent saturation ranged from 0.81 at station 17548 to 0.83 at station 10313.

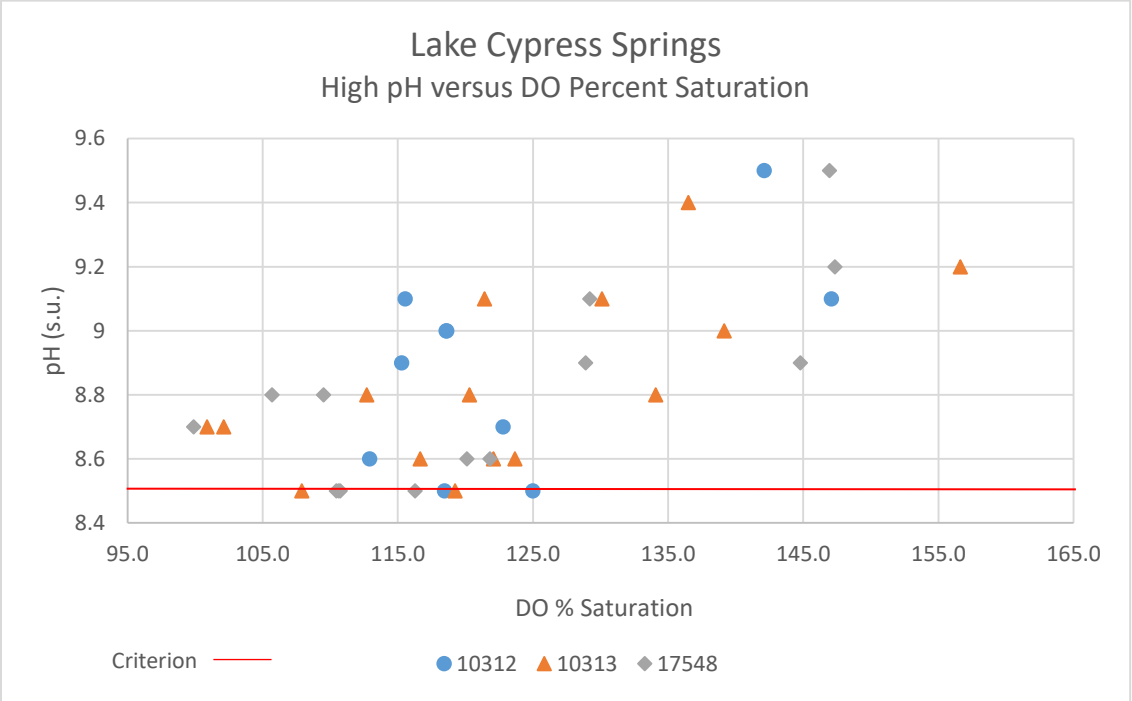

Figure 16: Graph of high pH versus DO saturation in Lake Cypress Springs

The correlation between pH and chlorophyll *a* was not robust and only ranged from 0.17 to 0.37. The correlation between DO percent saturation and chlorophyll *a* was slightly lower. Although the correlations were low, these results do not necessarily negate that the cause of high pH was eutrophication. By following the TCEQ SWQM procedures manual, all surface water grab samples in lakes and reservoirs are collected at 0.3-meter below the surface. While most other laboratory parameters are subject to diffusion, moving from high concentration to low concentration, phytoplankton are motile organisms. Movement of phytoplankton vertically through the water column occurs on a diel cycle. Phytoplankton movement to a depth that is most suitable for photosynthesis and reproduction to occur is well-documented. This depth may be well above or below 0.3 meter.

In eutrophic reservoirs, algae and other primary producers will consume the available carbon dioxide (CO_2) during the process of photosynthesis. Once the available carbon dioxide is exhausted, a CO_2 molecule will be broken away from the weak covalent bond of carbonic acid, thereby increasing the pH in the water column. After sunlight is no longer available for photosynthesis, CO_2 released through respiration, will bond with hydrogen to form carbonic acid, thereby decreasing pH. This pH cycling phenomenon can be assumed in Lake Cypress

Springs since all of the grab samples were collected between 10 AM and 2 PM, the peak hours of primary productivity. However, without diel data, pH cycling cannot be demonstrated, nor the pH range calculated. The pH cycle is especially pronounced in waters with low alkalinity, such as that of Lake Cypress Springs and other reservoirs in the Cypress Creek Basin.

In addition to high pH, super-saturated dissolved oxygen concentrations are alarming. Large diel changes in both dissolved oxygen and pH can stress the organisms within the water body. During peak hours of photosynthesis, dissolved oxygen may become super-saturated at levels high enough to cause fish kills. Also in eutrophic waters, oxygen is consumed through respiration at night at rates that the dissolved oxygen may fall to levels low enough to cause fish kills.

TRENDS

Increasing trends for specific conductance were identified at stations 10312 and 10313 in both the 2009 and 2014 basin summary reports. Due to the extended drought and lack of freshwater inflow during this period, the concentration of salts in the reservoir was assumed to cause the trends. Despite the near historic flooding in 2015 and 2016, these trends continued into the current analysis. However, after reviewing the data more closely, specific conductance values have noticeably shifted lower since the flooding in 2015 and 2016. Although statistically significant, a graph of the data showed much lower conductance results during years of heavy rainfall including 2001, 2009, 2015, and 2016 (Figure 14). The graph demonstrates the assertion that these specific conductance trends were a result of the pervasive drought period beginning around 1999 through 2014.

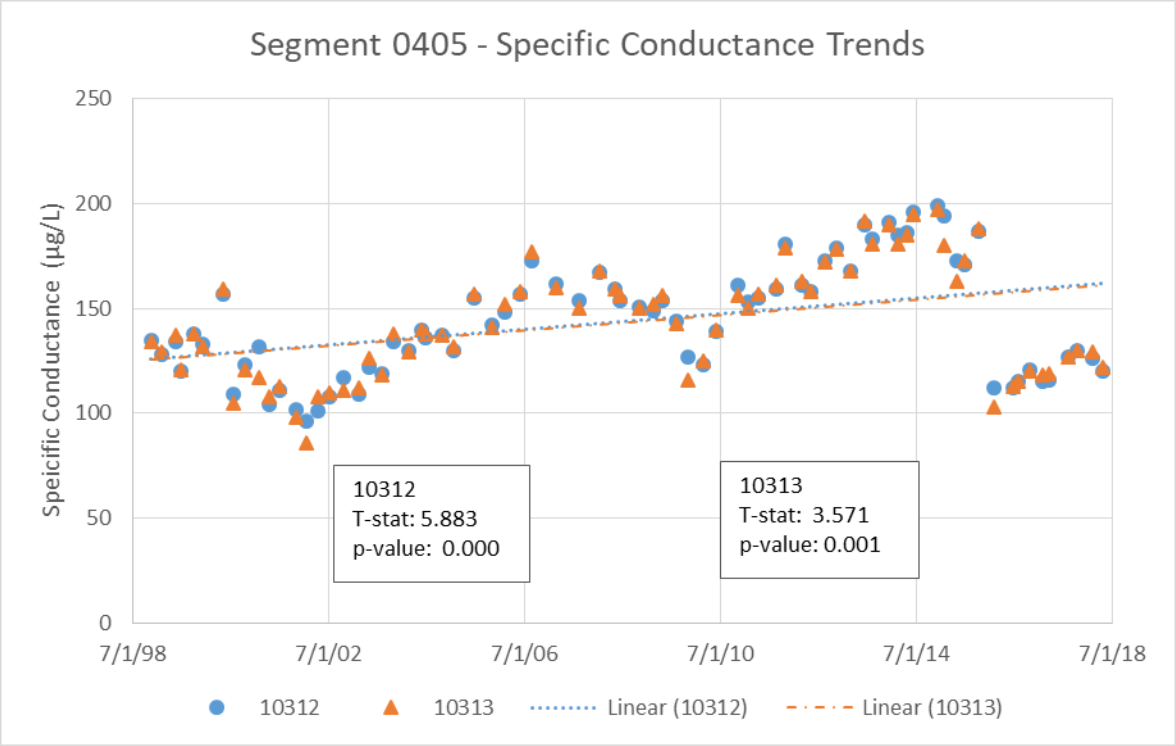

Figure 17: Graph of specific conductance trend in Lake Cypress Springs

TCEQ Region 5 is scheduled to collect bacteria, conventionals, and field parameters on a quarterly basis at stations 10312 and 10313 in 2019.

SEGMENT 0408 – LAKE BOB SANDLIN

Lake Bob Sandlin is located immediately below Lake Cypress Springs and Lake Monticello, located in the upper reaches of the reservoir. Completed in 1977, the Fort Sherman Dam impounds over 8,700 surface acres with a capacity of almost 191,000 acre-feet of water. The reservoir is a popular recreational and fishing lake and is regulated by the Titus County Freshwater Supply District #1. In recent years, many new homes have been constructed along the shoreline.

Water is released from Lake Bob Sandlin into Big Cypress Creek, and these releases highly influence the water quality in the receiving stream. Since there are no in-stream flow requirements below the reservoir, water is released only to maintain freeboard.

Figure 18: Water being released from the Fort Sherman Dam at Lake Bob Sandlin

As discussed in the introduction, a total of 939,956 acre-feet of water was released from the reservoir from 2000 through 2014. Due to the pervasive drought, there were zero releases during seven of those fifteen years causing the stream flow of Big Cypress Creek to become dominated by effluent flows. The most releases from Lake Bob Sandlin occurred in 2015 due to extensive flooding that year. A record amount of water was released from the Fort Sherman Dam in 2015 at more than 280,000 acre-feet. An additional 150,000 acre-feet was released by

the end of April 2016. This amount of water could fill Lake Bob Sandlin more than twice. Combining the releases for 2015 through 2018, a total of 677,968 acre-feet was released, or about 60% of the total releases for the previous fifteen years combined.

WATER QUALITY

The *Draft 2016 Integrated Report* showed that Lake Bob Sandlin was one of the least polluted reservoirs in the state. The reservoir has some of the clearest water in the state with an average transparency depth of 1.68 meters, enough to put it in the top 15%. The reservoir is ranked number eleven out of 137 reservoirs for the lowest amount of phosphorus, with a mean of only 0.02 mg/L. Lake Bob Sandlin is in the top 30% for the lowest concentration of chlorophyll *a*, with a mean of 8.8 µg/L

Lake Bob Sandlin is monitored at two locations in FY 2019:

- AU 0408_01 Station 10329 Midway of dam
- AU 0408_03 Station 16158 FM 21

Through FY 2017, regular sampling had been conducted in AU 0408_01 at station 17059 at the City of Mount Pleasant raw water intake and at station 17060 at the City of Pittsburg raw water intake. In FY 2018, both stations were dropped by TCEQ, and sampling was moved to its present location midway of the dam and near the spillway (station 10329).

There were no impairments or concerns for Lake Bob Sandlin shown in the *Draft 2016 Texas Integrated Report*.

Despite low chlorophyll concentrations across the reservoir, pH was recorded above the criterion on several occasions since 2009. From 2007 to 2018, over 20% of the surface pH values reported at stations 16158, 17059, and 17060 were above the 8.5 s.u. criterion.

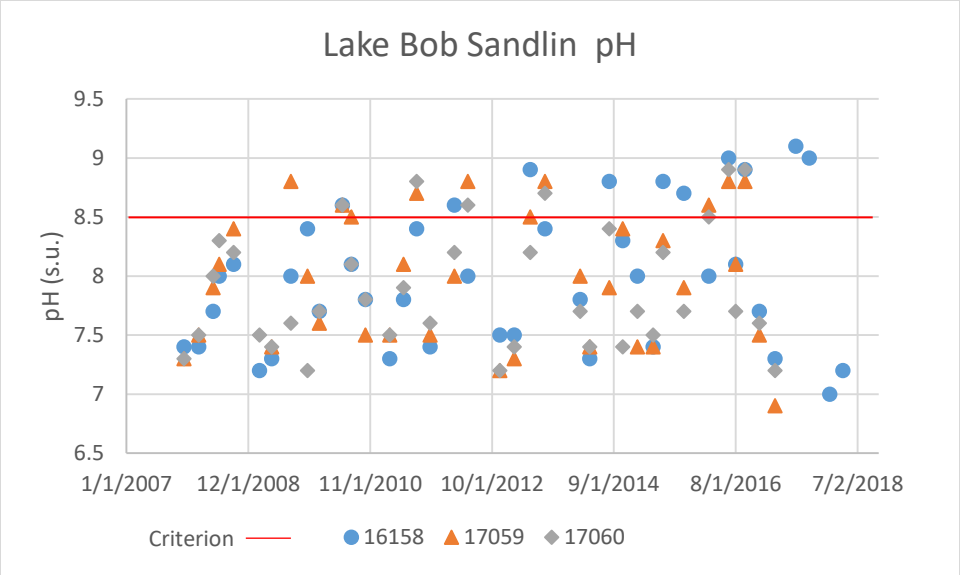

Figure 19: Graph of pH in Lake Bob Sandlin

The correlation between pH and DO percent saturation ranged from 0.71 as station 16158 to 0.76 at station 17060. All high pH values were associated with super-saturated DO. These high pH readings and strong correlation with DO percent saturation may be an indicator of eutrophication occurring in Lake Bob Sandlin. Although all but four chlorophyll values were below the screening level in the reservoir, phytoplankton are motile and may concentrate above or below the 0.3 meter grab sampling depth.

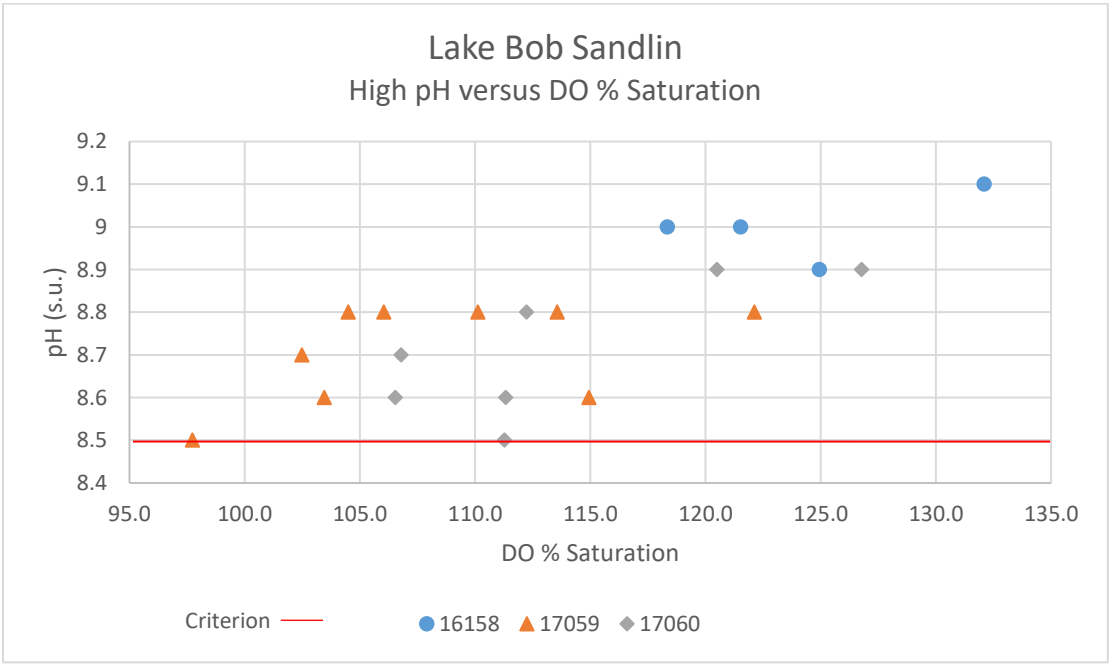

Figure 20: Graph of high pH versus DO saturation in Lake Bob Sandlin

TRENDS

An increasing trend for specific conductance at station 16158 was identified in the 2009 and the 2014 basin summary reports. This trend continued into the current analysis along with increasing trends for pH and alkalinity. An increasing trend for pH was also noted at this station in the 2009 report.

Unlike Lake Cypress Springs, chlorophyll *a* concentrations were typically low with only a few samples above the screening level. However, pH cycling may still be the cause of increasing pH in the assessment unit. The mean of the chlorophyll *a* samples collected at station 16158 over the past decade was 13.9 µg/L with only two samples exceeding the screening level, at 27.8 and 28.6 µg/L. Alkalinity is a measure of the buffering capacity of water from changes in pH. In low alkalinity waters, pH can change quickly. Of note was that the alkalinity trend was increasing at a similar rate as the pH trend. The higher alkalinity was another possible reason for higher pH; however, the source of the higher alkalinity has not been identified.

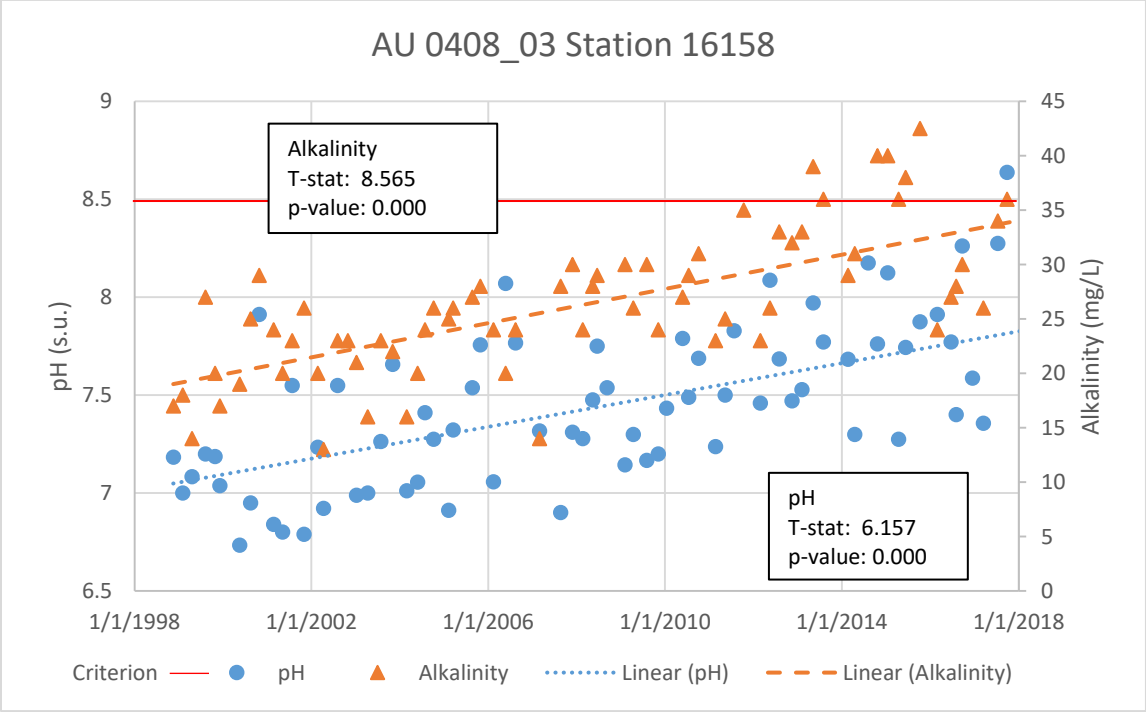

Figure 21: Graph of pH and alkalinity trends in AU 0408_03

Similar to Lake Cypress Springs, an increasing trend for specific conductance was discovered in Lake Bob Sandlin in the 2009, 2014, and current analysis. This trend was also a result of the pervasive drought as there was a prominent shift in the conductance readings after the heavy rainfall in 2015 and 2016. Quarterly samples for bacteria, conventionals, and field parameters are scheduled to be collected by TCEQ Region 5 at stations 16158 and 10329 in 2019.

SEGMENT 0404 – BIG CYPRESS CREEK BELOW LAKE BOB SANDLIN

Segment 0404 is the most urban-influenced segment in the Cypress Creek basin. Population centers include Mount Pleasant, Pittsburg, and Daingerfield. The segment begins at the release from Fort Sherman Dam on Lake Bob Sandlin and continues about 60 kilometers (38 miles) to the headwaters of Lake O' the Pines. Stream flow in this reach of Big Cypress Creek is highly influenced by releases from Lake Bob Sandlin. Since there are no in-stream flow requirements in Big Cypress Creek, water is only released from Lake Bob Sandlin to maintain freeboard. During periods of drought or low flow, the stream flow is primarily composed of treated municipal and industrial wastewater effluent.

There are eight permitted wastewater treatment plants in the Lake O' the Pines watershed, with the half of the plants located in Segment 0404. The two largest plants are the City of Mount Pleasant and Pilgrim's Pride, permitted at 3.0 million gallons per day each. Both plants are located near the City of Mount Pleasant. Pilgrim's Pride discharges into Segment 0404B – Tankersley Creek and the City of Mount Pleasant discharges into Segment 0404C – Hart Creek. The City of Pittsburg operates two plants with one on Segment 0404E - Dry Creek and another on Segment 0404F - Sparks Branch. The remaining plants in the Lake O' the Pines watershed include the cities of Daingerfield, Lone Star, Omaha, and Ore City.

LAKE O' THE PINES TMDL IMPLEMENTATION

Monitoring data indicated that the low dissolved oxygen in Lake O' the Pines resulted from high nutrient levels, and phosphorus was identified as the limiting factor in the reservoir. The Lake O' the Pines I-Plan was developed to reduce phosphorus loading into Lake O' the Pines which was approved on July 9, 2008.

Stakeholder meetings were held throughout the basin. As a result, milestones were developed by individuals with an interest in improving water quality. The I-Plan detailed priority controls that included descriptions of the control measures, responsible parties, and timeline along with goals to measure, track, evaluate, and report progress. The scope of the I-Plan included an adaptive approach to phosphorus reduction allowing for updates that may later be identified in the project.

Stakeholders specified voluntary actions aimed at reducing non-point source contributions, like stormwater runoff. Technical and financial programs were created for agricultural producers; and local/county programs were created for on-site sewage facilities, marine sanitation, and education. Loading from point sources were addressed through the limitation of phosphorus in discharges from wastewater facilities.

Phosphorus reduction is being accomplished through a Total Phosphorus Load Agreement (TPLA) between NETMWD and entities operating permitted waste water treatment plants within the Lake O' the Pines watershed. In 2014, a multi-million dollar upgrade to the Pilgrim's Pride WWTP was initiated in order to reduce its contribution of phosphorus into the watershed. In 2018, the plant discharged only 17% of its annual phosphorus allocation. For all systems combined in 2018, about 31% of the total annual allocation was discharged into the Lake O' the Pines watershed. Since the TPLA program began in 2015, the total amount of phosphorus discharged was less than 92,000 pounds, or about 40% of the annual allocations combined. The table below shows the total pounds of phosphorus discharged by each wastewater treatment plant in 2018 versus its annual allocation.

WWTP	Annual Allocation	Actual Discharge	Difference
Daingerfield	510	805	295
Lone Star	450	1,505	1,055
Mt. Pleasant	2,180	4,457	2,277
Omaha	260	544	284
Ore City	1,000	726	(274)
Pilgrim's Pride	53,200	9,544	(43,656)
Pittsburg/Dry Creek	570	209	(361)
Pittsburg/Sparks Branch	1,780	1,351	(429)
Total	**59,950**	**19,141**	**(40,809)**

Figure 22:Table of TPLA Total phosphorus tracking

WATER QUALITY

The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0404.

Segment AU	Description	Parameter	Support	Data
0404_01	From the	DO 24-HR Avg.	CN	ID
0404_01	confluence with	DO 24-HR Min.	CN	ID
0404_01	Lake O' the Pines	Sulfate	**NS**	AD
0404_01	upstream 24 km	Chlorophyll *a*	CS	AD
0404_01	(14.9 mi)	Nitrate	CS	AD
0404_02	From the	*E. coli*	**NS**	AD
0404_02	confluence with	Sulfate	**NS**	AD
0404_02	an unnamed tributary	Nitrate	CS	AD
0404_02	upstream 37.2 km	Total Phosphorus	CS	AD
0404A	Ellison Creek Reservoir	Sediment Toxicity (LOE)	**NS**	ID
0404A	Ellison Creek Reservoir	Cadmium	CS	ID
0404A	Ellison Creek Reservoir	Iron	CS	ID
0404A	Ellison Creek Reservoir	Lead	CS	ID
0404A	Ellison Creek Reservoir	Manganese	CS	ID
0404A	Ellison Creek Reservoir	Nickel	CS	ID
0404A	Ellison Creek Reservoir	Zinc	CS	ID
0404A	Ellison Creek Reservoir	dioxin in fish tissue	**NS**	OE
0404A	Ellison Creek Reservoir	PCBs in fish tissue	**NS**	OE
0404B	Tankersley Creek	Habitat	CS	ID
0404B	Tankersley Creek	*E. coli*	**NS**	AD
0404B	Tankersley Creek	Ammonia	NC	LD
0404B	Tankersley Creek	Nitrate	CS	LD
0404B	Tankersley Creek	Total Phosphorus	CS	LD
0404C	Hart Creek	*E. coli*	**NS**	AD
0404C	Hart Creek	Nitrate	CS	LD
0404E	Dry Creek	Nitrate	CS	ID
0404J	Prairie Creek	DO 24-HR Avg.	CN	ID
0404J	Prairie Creek	DO 24-HR Min.	CN	ID
0404N	Lake Daingerfield	Mercury in tissue	**NS**	OE

Figure 23: Table of Draft 2016 Texas Integrated Report for Segment 0404

Common impairments in Segment 0404 were *E. coli* and sulfate, while nutrients were the most common concerns identified in the *Draft 2016 Integrated Report*. Segment 0404 was listed for bacteria in 2002 and for sulfate in 2014. The sulfate listing was for both assessment units while the bacteria impairment was in the upper assessment unit. The geometric mean of the *E. coli*

samples collected during the assessment period was 228 MPN/100 mL exceeding the 126 MPN/100 mL geometric mean criterion. The geometric mean of the samples collected since 2014 was 221 MPN/100 mL indicating that the bacteria impairment will continue into the next assessment period.

Figure 24: Photo of Big Cypress Creek at station 10308

Sulfate concentrations in the lower assessment unit has an historical average of 43.1 mg/L based upon 185 samples collected from 1979 through 2018. The sulfate criterion for Big Cypress Creek is 100 mg/L. At station 13631, located at US 259, the highest sulfate result of 171 mg/L was collected in September 2011. Other samples with high sulfate concentrations were 160 mg/L collected in October 2010; 144 mg/L, November 2011; and 133 mg/L, September 2012. All of these samples were collected during the period of near-record drought. No sulfate samples have exceeded 85 mg/L since September 2012, and the average of the sulfate samples collected since 2015 was 28 mg/L. There were few flow values recorded at this station, but the sulfate results appeared to be inversely related to stream flow since some of the lowest values were reported during the flooding and high release periods of 2015 and 2016.

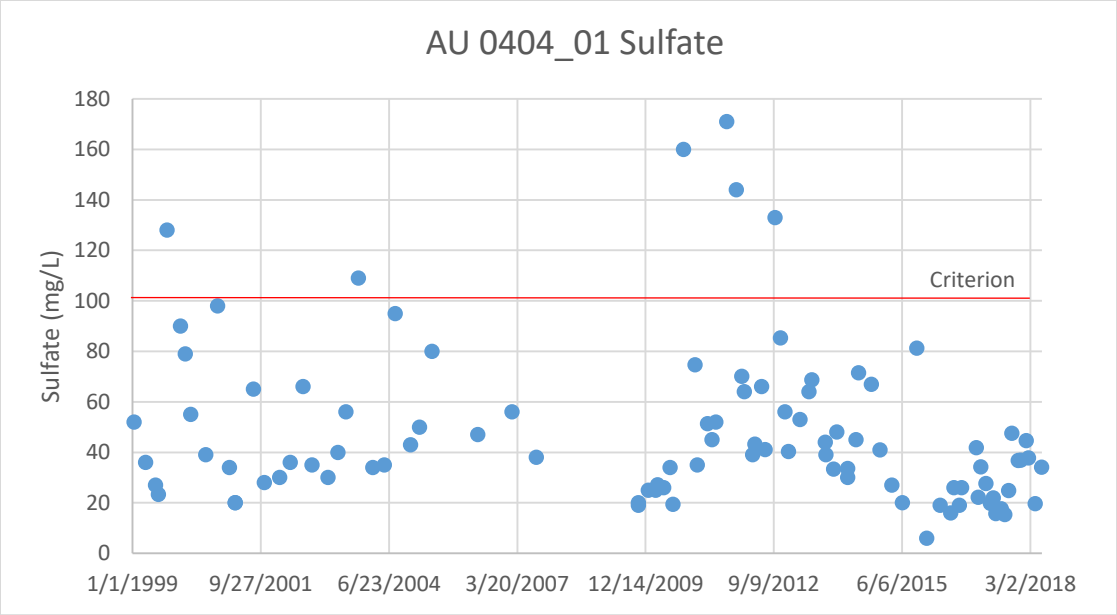

Figure 25: Graph of sulfate samples in AU 0404_01

There are two stations routinely monitored in the upper assessment unit of Big Cypress Creek:

- Station 10310 at US 271
- Station 10308 at SH 11

Station 10310 is downstream of the confluence with Tankersley Creek while Station 10308 is after the confluence with several streams including Hart Creek and Walkers Creek. Station 10308 has a data record dating back to 1968, while monitoring began at Station 10310 in 1983. The maximum sulfate result for 10310 was 490 mg/L, collected in June 2014, compared to 293 mg/L at Station 10308, collected in July 2012. Station 10310 had a much higher average sulfate concentration at 155 mg/L compared to Station 10308 at 67.4 mg/L.

Of note is that the average sulfate concentration has declined at both stations since 2014. For 10310, the average sulfate sample collected from 2015 through 2018 was 83 mg/L while it was 55 mg/L at Station 10308. The decline was likely a result of higher flows as a result of releases from Lake Bob Sandlin, thus diluting the sulfate concentration at both stations. High sulfate concentrations clustered at lower flows indicating that point sources were the source of the excess sulfate.

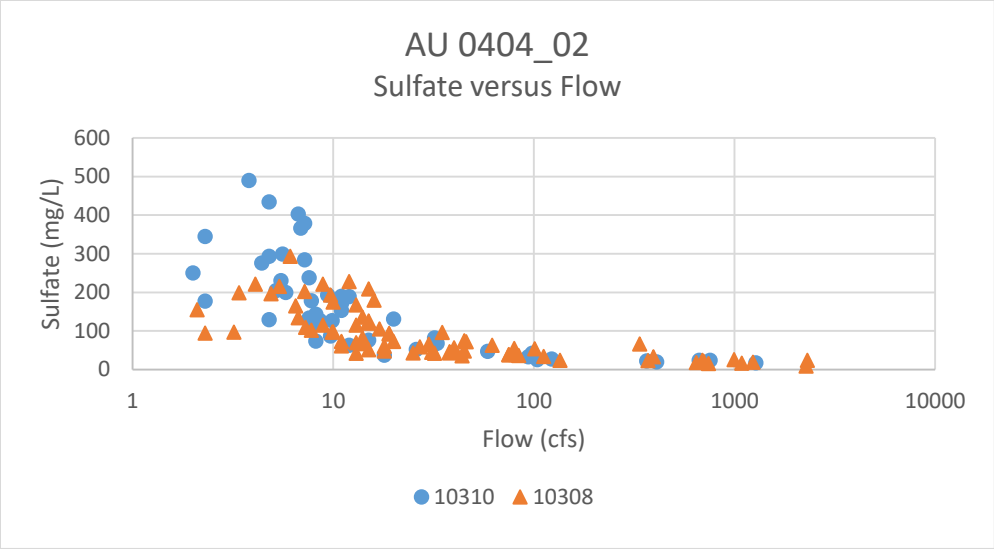

Figure 26: Graph of sulfate versus flow in AU 0404_02

Nutrients and chlorophyll *a* were included on the *Draft 2016 Integrated Report* as concerns in this segment. High nitrate was a concern in both assessment units. Total phosphorus was a concern only in the upper reach while chlorophyll *a* was a concern in the lower reach. Similar to sulfate, nitrate and phosphorus were markedly higher at Station 10310 than at station 10308. The screening levels for both total phosphorus (0.69 mg/L) and nitrate (1.95 mg/L) were exceeded at both stations. The average total phosphorus concentration for station 10310 was 2.2 mg/L while nitrate was 24.59 mg/L. For station 10308, the averages were 1.09 mg/L and 9.69 mg/L, respectively.

Since the Pilgrim's Pride wastewater treatment plant upgrade was completed in early 2015 (discussed in more detail in the Tankersley Creek section), the phosphorus concentrations have noticeably declined. Since the March 2015, the mean total phosphorus result at 10310 was 0.41 mg/L and 0.17 mg/L at 10308. Similar to sulfate, the highest concentrations of nitrate were collected at lower stream flows indicating that point sources were likely contributors of the excess nutrient.

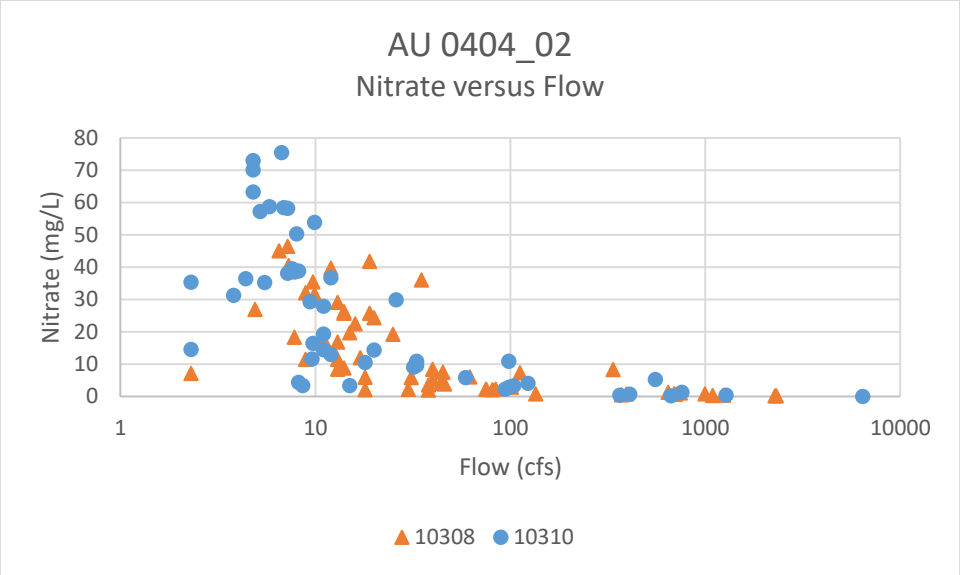

Figure 27: Graph of nitrate versus flow in AU 0404_02

The high nutrient concentrations in Big Cypress Creek resulted in a concern for chlorophyll *a* in the lower assessment unit. One-third of the samples collected during the assessment period exceeded the 14.7 µg/L screening level with an average of the exceedances at 17.68 µg/L. The excessive nutrients continued into Lake O' the Pines and have degraded its water quality. These effects are discussed in further detail in Lake O' the Pines section of the report.

TRENDS

There were no trends identified in Segment 0404.

In FY 2019, TCEQ Region 5 is scheduled to monitor monthly at stations 10308, 10310, and 13631 for flow, bacteria, and for field and conventional laboratory parameters.

SEGMENT 0404B – TANKERSLEY CREEK

Tankersley Creek arises in Titus County northwest of the city of Mount Pleasant. The stream flows in a southeasterly direction for approximately two miles before it enters Tankersley Lake. Downstream of the impoundment, the stream flows about eight miles to its confluence with Big Cypress Creek at the Titus-Camp county line. Tankersley Creek is the receiving water for the Pilgrim's Pride wastewater treatment plant, located on FM 127, west of Mount Pleasant.

Figure 28: Photo of Tankersley Creek at station 10261

WATER QUALITY

Tankersley Creek had an impairment for bacteria in the *Draft 2016 Integrated Report*. The geometric mean was 305 MPN/100 mL, **more than double the criterion** of 126 MPN/100 mL. Tankersley Creek was first listed as impaired for bacteria in 2000. Data collected since the last assessment indicated that the bacteria concentrations on Tankersley Creek have continued to exceed the water quality standard at a similar level. Due to the listing, a bacteria study, *The Assessment of Contact Recreation Use Impairments and Watershed Planning for Big Cypress Creek and Tributaries (Hart and Tankersley Creeks)*, was funded by the Texas State Soil and Water Conservation Board. The study was conducted from 2009 through 2011 and included a Recreation Use Attainability Analysis (RUAA). The purpose of the RUAA was to determine if primary contact recreation was the appropriate use designation of the stream. The results were

submitted to the TCEQ, and they will use the information to determine the best strategy to address the impairment.

Concerns for screening levels of ammonia, nitrate, and total phosphorous were identified in the *Draft 2016 Integrated Report*, but these concerns were based upon limited data. Routine conventionals sampling began at Station 10261 (FM 3417) in FY 2013 since only a few samples had been collected in 1984 and in FY 2003.

Since regular sampling began in FY 2013, half of the 22 ammonia samples collected were reported below the Limit of Quantitation (LOQ) of 0.1 mg/L. All samples were below the 0.33 mg/L screening level, with the highest result at 0.3 mg/L. Prior to upgrading the Pilgrim's Pride wastewater treatment plant, **phosphorus results regularly exceeded the 0.69 mg/L screening level with an average concentration of 3.37 mg/L, about five times the screening level**. **Since the plant upgrades were completed in the spring of 2015, the mean result was 0.31 mg/L with no samples exceeding the screening level**. Similar to Segment 0404, sulfate was another parameter of interest. The maximum sulfate value collected in Tankersley Creek was 508 mg/L collected in July 2013 while the mean was 138 mg/L. Since the plant upgrades were completed, the average sulfate concentration declined to 82 mg/L, well below the 100 mg/L criterion. Since the region began receiving higher rainfall amounts in 2015 than in previous years, the decline in sulfate values may be a result of dilution due to higher stream flows or a combination of flow and plant upgrades.

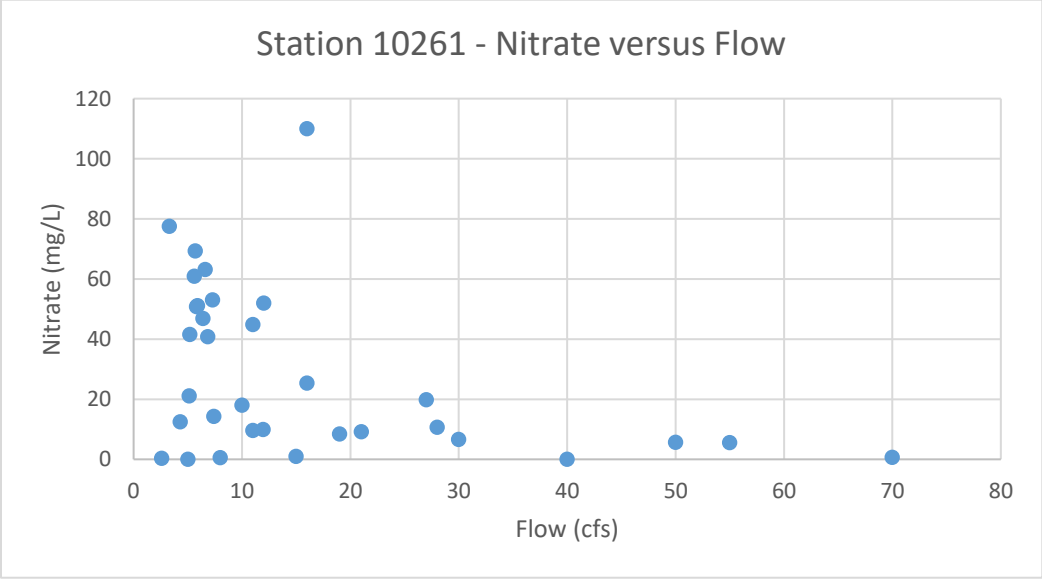

Figure 29: Graph of nitrate versus flow at station 10261

The plant upgrades have had no noticeable effect on nitrate values. Nitrate results tended to inversely correlate with stream flow, meaning that nitrate levels tended to be highest during periods of low flow. **The average nitrate result was 29 mg/L with a maximum concentration of 110 mg/L collected in July 2015.** These results indicate that point sources are the likely contributors of excess nitrate.

As a result of the high nitrate results, a nitrate special study was funded by CRP. Monthly samples for ammonia, nitrite, nitrate, Total Kjeldahl Nitrogen (TKN), and total phosphorus are collected at three stations in Tankersley Creek in order to identify potential nitrogen sources. WMS monitors Tankersley Creek at FM 899, FM 127, and at FM 3417. Samples are also collected at two stations in Hart Creek for a comparison. Special study monitoring began in July 2018 and is scheduled to be completed in June 2019. The results will be discussed in a future basin highlights report.

In addition to the monthly special study sampling, quarterly monitoring for flow, bacteria, and for field and conventional parameters continue at station 10261 (FM 3417) in FY 2019.

SEGMENT 0404C – HART CREEK

Hart Creek, an unclassified water body, rises 4.5 miles north of Mount Pleasant and runs southeast for twelve miles to its confluence with Big Cypress Creek. It receives surface drainage from two small tributaries to the east of Mount Pleasant, Hayes Creek and Evans Creek. The City of Mount Pleasant WWTP outfall is located on Hart Creek approximately 2 kilometers upstream of station 10266, located on County Road 4550.

WATER QUALITY

The *Draft 2016 Integrated Report* included an impairment in Hart Creek for bacteria. The geometric mean was 385 MPN/100 mL, **more than three times the criterion** of 126 MPN/100 mL. Hart Creek was first identified as not meeting the water quality standard for bacteria in 2006. Data collected since the last assessment indicated that bacteria concentrations on Hart Creek continued to exceed the criterion. Due to the listing, Hart Creek was included in the contact recreation study and RUAA funded by the Texas State Soil and Water Conservation Board. The TCEQ will use information obtained from a bacteria study, completed in 2011, to determine the best management strategy to address this impairment.

The *Draft 2016 Integrated Report* also showed a concern for nitrate that was based upon limited data. Routine conventionals sampling began at Station 10266 (at CR 4550) in FY 2013 to obtain recent data for the stream. Prior to FY 2013, no samples had been reported to SWQMIS since 2003. After regular sampling resumed, **the mean nitrate concentration was 4.99 mg/L, approximately 2.5 times the screening level**, with the highest result collected in July 2013 at 15.4 mg/L. Sixteen of the 22 recent samples reported exceeded the 1.95 mg/L screening level. These data support the concern for nitrate.

Due to the high nitrate levels, Hart Creek was included as part of the nitrate special study also being conducted in Tankersley Creek. Monthly samples for ammonia, nitrite, nitrates, TKN, and total phosphorus are collected at two stations in Hart Creek in order to identify potential sources. Monitoring is conducted at station 10272 (SH 49) and at station 10266 (CR 4550). The special study monitoring is scheduled to be completed in June 2019, and the results will be discussed in a future basin highlights report.

Unlike Tankersley Creek and Big Cypress Creek, phosphorus and sulfate were below the screening levels in Hart Creek. Since regular sampling resumed in FY 2013, the mean total phosphorus result was 0.19 mg/L while sulfate averaged 43.83 mg/L. None of the results exceeded the screening level for either parameter.

In addition to the monthly special study sampling, WMS is scheduled to collect samples for flow, bacteria, field, and conventional parameters quarterly at station 10266 (CR 4550) in 2019.

SEGMENT 0404K – WALKERS CREEK

Walkers Creek arises in Camp County northwest of Pittsburg. The stream flows generally to the north east to its confluence with Big Cypress Creek. Walkers Creek was included in the contact recreation study in 2009 to 2011. The bacteria results were below the criterion indicating that the stream supported its contact recreation designation.

Diel sampling was conducted at station 16454 at US 271 from 2008 through 2012. The diel data met the 24-Hour dissolved oxygen criteria suggesting that the stream supported its aquatic life use designation. Due to meeting standards, stakeholders agreed to discontinue monitoring at this station in FY 2013 in order to address water quality concerns elsewhere in the basin.

SEGMENT 0404E – DRY CREEK

The headwaters of Dry Creek are located south of Pittsburg, Texas. The stream serves as a receiving water for the City of Pittsburg wastewater treatment plant. Dry Creek flows toward the east to its confluence with Big Cypress Creek in northeast Camp County. Sampling in Dry Creek was conducted at station 10274 at McMinn Road. The riparian zone of the property immediately upstream and downstream of the bridge crossing is improved pasture and is used for grazing cattle. Cattle were noted to be in the stream during several monitoring events and likely affect the water quality at the station.

WATER QUALITY

Based upon limited data, the *Draft 2016 Integrated Report* identified nitrate as a concern. Through additional CRP funding, sampling began at station 10274 at McMinn Road in the summer of 2015 and became a routine station on the FY 2016 monitoring schedule. Fourteen samples have been collected at station 10274 since regular sampling began with a **mean nitrate concentration of 4.03 mg/L, double the screening level**. Almost 60% of the samples exceeded the screening level. These results support the concern for nitrate.

Although not included on the IR as a concern, parameters associated with non-point source pollution were reviewed. *E. coli* results often exceeded the criterion. The geometric mean for samples collected from 2015 through 2018 was 542 MPN/100 mL. Out of fourteen ammonia samples, two exceeded the 0.33 mg/L screening level with a mean of 0.5 mg/L. None of the total phosphorus or chlorophyll *a* results surpassed their screening levels. Five of the dissolved oxygen grabs were below 5 mg/L, with a mean of the low readings at 4.15 mg/L.

During the 2018 Coordinated Monitoring Meeting, the partners agreed to drop sampling at station 10274 since there were enough data collected to assess the stream. The resources were allocated to address concerns elsewhere in the basin. No sampling is scheduled at this station in 2019.

SEGMENT 0404F – SPARKS BRANCH

Sparks Branch is a tributary of Dry Creek and is a receiving water for the City of Pittsburg wastewater treatment plant. There is little riparian vegetation along the stream as land in the Sparks Branch watershed is intensively used for improved pastures and grazing.

WATER QUALITY

Sparks Branch was not assessed in the *Draft 2016 Integrated Report* since there were no data shown in SWQMIS after 2005. Due to the lack of data, and since Sparks Branch is a receiving stream, the monitoring partners agreed to add routine sampling in 2016. With additional funding provided through CRP, quarterly monitoring at station 10276 at CR 4220 began in April 2016 and continued through FY 2018.

Although there were no current listings or concerns for this water body, a review of the data revealed that they may be forthcoming in future assessments. Parameters associated with non-point source pollution were reviewed including bacteria, ammonia, nitrate, and total phosphorus. The geometric mean of the *E. coli* results was 608 MPN/100 mL. Over half of the nitrate samples were above the screening level with a mean of 8.89 mg/L. Although over half of the chlorophyll *a* results were reported below the LOQ, two samples were reported at more than double the screening level at 31 µg/L and 35.3 µg/L. None of the ammonia samples were reported above the screening level while one total phosphorus result surpassed its screening level at 1.13 mg/L. The remaining eight phosphorus samples averaged 0.26 mg/L. One dissolved oxygen grab was below 5 mg/L at 4.4 mg/L.

During the 2018 Coordinated Monitoring Meeting, the partners agreed to drop sampling at station 10276 since there were enough data to assess the stream, and to allocate the resources to address concerns elsewhere in the basin. No sampling is scheduled at this station in 2019.

SEGMENT 0404J – PRAIRIE CREEK

Prairie Creek flows on the southern border of Camp County before its confluence with Big Cypress Creek near US 259. The Lake O' the Pines I-Plan workgroup identified 24-Hour dissolved oxygen monitoring as a priority for this watershed in order to evaluate potential impacts on loadings into the reservoir.

WATER QUALITY

The stream remained on the *Draft 2016 Integrated Report* with a concern for non-attainment of the 24-Hour dissolved oxygen average and minimum criteria. The concern was based upon inadequate data as there were no diel data available for the 2016 assessment.

Due to the concern, diel sampling at station 15386 at FM 557 began in FY 2017. One-third of the nine diels conducted through 2018 were below the criterion for 24-Hour dissolved oxygen average and 24-Hour dissolved oxygen minimum. Results for the low dissolved oxygen diels showed a 24-Hour average of less than 2.5 mg/L and 24-Hour minimum of less than 1.0 mg/L. Stream flow was reported as 0 cfs for all three of these studies.

Four diel events are scheduled to be conducted by WMS at station 15386 in 2019. Conventionals and bacteria sampling may be added to the schedule in the future.

SEGMENT 0404N – LAKE DAINGERFIELD

Lake Daingerfield is an eighty-acre reservoir which was completed in 1935 as a Civilian Conservation Corps project. Water released from Lake Daingerfield flows into Brutons Creek and then into Ellison Creek Reservoir. This segment was included on the *Draft 2016 Texas §303(d) List* for non-support and concern for the screening level of mercury in fish tissue. A fish consumption advisory is in effect for the entire reservoir.

Region 5 monitors at station 17337 (Lake Daingerfield at Headwaters in Daingerfield State Park) quarterly for conventionals, bacteria, and field parameters.

SEGMENT 0404A – ELLISON CREEK RESERVOIR

Ellison Creek Reservoir (sometimes called Lone Star) is located due west of Lone Star in southern Morris County. The drainage area of the Ellison Creek watershed is thirty-seven square miles and the reservoir has a surface area of approximately 1,516 acres. The reservoir provides process water and cooling water for U. S. Steel Company and the Southwest Gas and Electric Company Power Plant. Water discharged from Ellison Creek Reservoir flows into Big Cypress Creek immediately above US 259 near the headwaters of Lake O' the Pines.

WATER QUALITY

Ellison Creek Reservoir was included on the *Draft 2016 Texas §303(d) List* for Polychlorinated biphenyls (PCBs) and dioxin in fish tissue, and for sediment toxicity. The *Draft 2016 Integrated Report* showed concerns for screening levels for cadmium, iron, lead, manganese, nickel, and

zinc in sediment. Sediment samples were last collected in June 2005. All sediment samples were collected at station 14473 near the dam greatly exceeded the screening limits. The table below shows the sampling results and includes the screening limit for each parameter.

Parameter	Unit	Result	Screening Limit
Cadmium	mmol/kg	11	4.98
Iron	mg/kg	82,800	40,000
Lead	mg/kg	258	128
Manganese	mg/kg	2360	1,100
Nickel	mg/kg	59.3	48.6
Zinc	mg/kg	1120	459

Figure 30: Table of sediment sample results

TRENDS

Statistical analysis revealed an increasing trend for dissolved oxygen in Ellison Creek Reservoir.

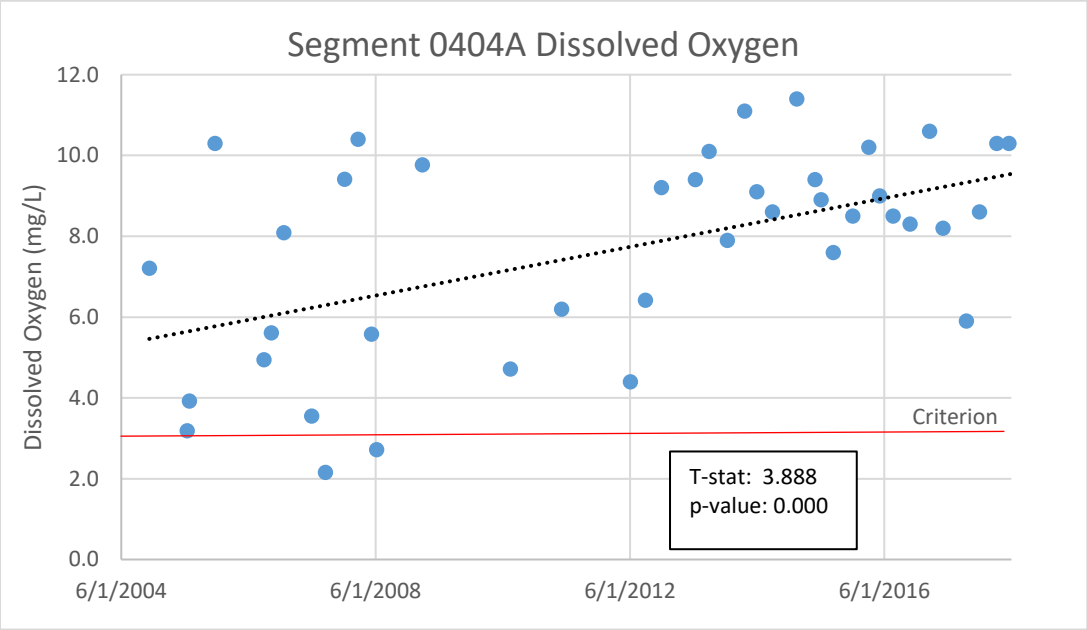

Figure 31: Graph of DO trend in Segment 0404A

The table below details the FY 2019 Coordinated Monitoring Schedule in Segment 0404. TCEQ Region 5 monitors Station 14473, located at the dam, quarterly, for metals in water and field

parameter (denoted "*"). Flow is measured at all stream stations or obtained from a USGS gage except at station 13631. This site is located at the headwaters of Lake O' the Pines. Diel sampling is scheduled to be conducted at station 15836 four times per year. Although sediment samples are needed to address the concerns, no sediment sampling is scheduled during 2019.

Segment	Station	Site Description	CE	Field	Conv	Bacteria	Flow
0404_01	13631	BIG CYPRESS CREEK AT US 259 3 MI SOUTH OF LONESTAR	R5	12	12	12	NA
0404_02	10308	BIG CYPRESS CR BRIDGE ON SH 11 EAST OF PITTSBURG	R5	12	12	12	12
0404_02	10310	BIG CYPRESS CREEK AT US 271 6.9 KM NORTH OF PITTSBURG	R5	12	12	12	12
0404A	14473	ELLISON CREEK RESERVOIR AT DAM WEST OF LONE STAR STEEL	R5	4	4*	NA	NA
0404B	10261	TANKERSLEY CREEK AT FM3417 5.7 KM SOUTH OF MOUNT PLEASANT	WMS	4	4	4	4
0404C	10266	HART CREEK AT TITUS COUNTY ROAD 4550	WMS	4	4	4	4
0404J	15836	PRAIRIE CREEK AT FM 557 7.4 MI SW OF PITTSBURG	WMS	4	NA	NA	4
0404N	17337	LAKE DAINGERFIELD AT HEADWATERS	R5	4	4	4	NA

Figure 32: Table of Segment 0404 FY 2019 CMS

SEGMENT 0403 – LAKE O' THE PINES

The Lake 'O the Pines watershed encompasses approximately 885 square miles. The lower portion of the watershed lies within the Pineywoods Ecoregion and is composed of hardwood and pine forests. The upper portion, near Lake Bob Sandlin is in the Post Oak Savanah Ecoregion which is comprised of patches of oak woodlands interspersed with grasslands. The watershed is rural. Land is predominantly used for agriculture, including silviculture, poultry, and cattle.

Lake O' the Pines, which is about 18,700 acres, was created for flood control after the historic flooding of the City of Jefferson in 1945. The reservoir was authorized by the U.S. Congress through the Flood Control Act of 1946. Construction of the Ferrell's Bridge Dam on Big Cypress Bayou was completed in 1959.

Figure 33: Photo of the 1945 flood in Jefferson

Despite historic rainfall in 2015 and in early 2016, Lake O' the Pines performed its primary function and prevented the City of Jefferson from flooding. Through controlled water releases, over one million acre-feet of water was discharged from the lake between January and August 2016 which was enough water to fill Caddo Lake almost 7 times.

Lake O' the Pines has a normal conservation pool of 230 feet. Discharges from the two gates in the control structure vary from a minimum of 5 cfs to a maximum of 3,000 cfs. The storage capacity of the reservoir is approximately 254,000 acre-feet. Lake O' the Pines provides water for eight cities and towns, numerous rural water districts, a steel manufacturer, and electricity generators. In addition to recreation and tourism, the reservoir is an important resource to the timber industry as well as to agricultural enterprises such as poultry, dairy, and cattle operations.

Figure 34: Photo of Lake O' the Pines from the dam

WATER QUALITY

Segment 0403 - Lake O' the Pines is divided into four assessment units:

- AU_01 Lower 5,000 acres near the dam
- AU_02 Middle 5,000 acres
- AU_03 Middle 5,000 acres below SH 155
- AU_04 Upper 3,700 acres

In the *Draft 2016 Integrated Report*, the TCEQ showed Lake O' the Pines as an eutrophic reservoir and ranked it in the top thirty percent for elevated chlorophyll compared with over 130 resevoirs state-wide. As discussed in the Lake Cypress Springs narrative, samples collected midday with a high pH and super-saturated dissolved oxygen was an indication of eutrophication.

In the *Draft 2016 Integrated Report*, AU 0403_02 was impaired for high pH and had a concern for non-support for high pH in AU 0403_01. Six of the 24 surface pH measurements collected during the assessment period in AU 0403_02 were above the 8.5 s.u. criterion while fifteen percent of the pH readings were above the criterion in AU 0403_01. The median of the pH exceedances were 8.81 and 8.90, respectively. The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0403.

Segment AU	Description	Parameter	Support	Data
0403_01	Lower 5000 acres	High pH	CN	AD
0403_02	Middle 5000 acres	High pH	**NS**	AD
0403_04	Upper 3700 acres	DO 24-HR Min	**NS**	ID
0403_04	Upper 3700 acres	DO Grab Min.	CS	AD

Figure 35: Table of Draft 2016 Integrated Report for Segment 0403

In AU 0403_01 of Lake O' the Pines, the median pH was 7.2 s.u. based upon 223 observations made over a 45-year data record. High pH has not historically been an issue in this portion of the reservoir. From 1973 through 2010, only one pH value was reported above the 8.5 s.u criterion. A reading of 9.1 s.u. was observed in September 1998. Since 2010, a high pH has been recorded six times. These readings were reported during the summer months, in 2012, 2013, 2014, 2016, and 2017.

All seven of the high pH readings in AU 0403_01 corresponded with super-saturated dissolved oxygen levels, while most also corresponded with chlorphyll values reported above the screening level. The highest pH (9.3 s.u.) was measured in August 2013 which was the same day that the peak chlorophyll sample (64.8 µg/L) was collected. On that day, a dissolved oxygen measurement of 127.6% saturation was made at this station. Of note is that a low dissolved oxygen reading, less than 5 mg/L, has been recorded three times since 2000. On all three occasions, the pH was near the historic median of 7.2 s.u. and chlorophyll was reported below the screening level.

In the middle 5,000 acres, the historical median pH for AU 0403_02 was 7.65 s.u. Data records from 1998 through 2010 showed three samples with a pH above 8.5 s.u. From 2011 through March 2018, a high pH was observed nine times. As with the lower AU, all of the high pH readings were obtained during in the summer months, with the exception of March 2012. The peak pH of 9.2 s.u. was recorded in August 2013. All of the high pH values corresponded with dissolved oxygen readings above saturation, and most were also associated with elevated chlorophyll concentrations. The greatest chlorophyll *a* level (67.5 µg/L) and dissolved oxygen (13.3 mg/L) concentration were obtained in April 2013. A surface pH of 8.9 s.u. was recorded that day.

Although there were no listings or concerns for the AU 0403_03 of Lake O' the Pines, a review of the data showed that pH could become a concern during the next assessment period. Similar to the lower portions of the reservoir, high pH has been measured on a greater frequency since 2010. From 1987 through 2010, only one high pH was recorded. The highest pH in AU 0403_03 was observed in August 2008 at 9.2 s.u., and dissolved oxygen was 11.5 mg/L. From 2011 to June 2018, a pH over the 8.5 s.u. criterion was reported eight times. As with the other assessment units, the high pH value was associated with a high dissolved oxygen reading and often with a chlorophyll concentation above the screening level. The elevated values were primarily collected during the summer months.

Unlike the other assessment units of the reservoir, only two high pH values were recorded since 1997 in the headwater AU (AU 0403_04) of Lake O' the Pines. The median pH was 7.1 s.u with a peak of 8.7 s.u. observed in September 2012. Chlorophyll *a* was 62.1 µg/L, almost triple the screening level, while dissolved oxygen was observed at 118.4% saturation.

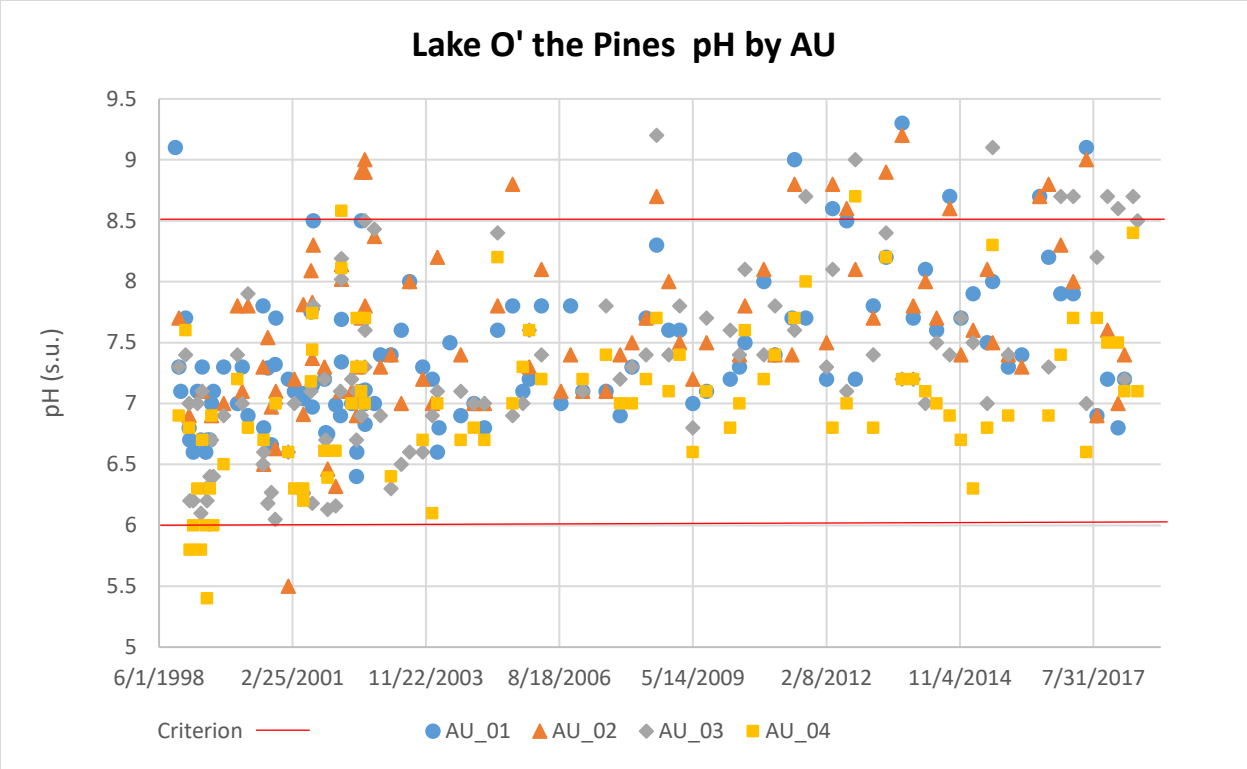

Figure 36: Graph of pH in Lake O' the Pines

Another area of interest in Lake O' the Pines was nutrient input since they are necessary to support primary productivity. As discussed earlier in this section, the TMDL study found that a 56% reduction in phosphorus entering the reservoir was necessary to increase dissolved oxygen concentrations within Lake O' the Pines.

Nutrients and/or chlorophyll concentrations regularly exceeded their respective screening levels during the assessment period. Chlorophyll *a* exceeded the 26.7 µg/L screening level in about forty percent of the samples collected in Lake O' the Pines from December 2007 through November 2014. While none of the total phosphorus or nitrate samples collected in the two lower assessment units exceeded screening levels, the excess nutrients entering Lake O' the Pines resulted in elevated chlorophyll *a* results throughout the entire reservoir. From 2008 through June 2018, the **mean chlorophyll concentration across the reservoir was almost 25 µg/L** only slightly below the 26.7 µg/L screening level. The highest chlorophyll *a* concentration was measured in June 2018 in AU 0403_04 at 97.3 µg/L, **more than 3.5 times the screening level**. Similar to pH, most elevated chlorophyll values were measured beginning in 2011 and continued into 2018.

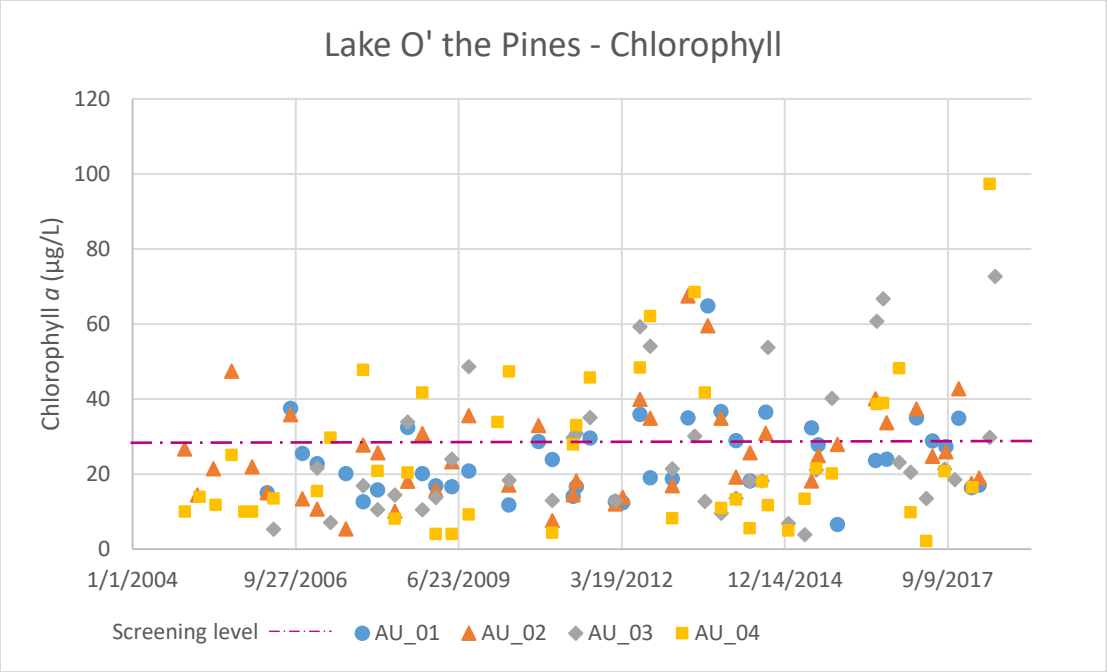

Figure 37: Graph of chlorophyll samples in Lake O' the Pines

In contrast to the lower assessment units, the mean of the **nitrate samples** collected in AU 0403_04 was 1.66 mg/L**, nearly 4.5 times the screening level of 0.37 mg/L, while the mean total phosphorus concentration was 1.5 times the 0.2 mg/L screening level**. Although highly diminished by the time the water reached AU 0403_03, **nitrate was still twice the screening level and phosphorus was well above the method detection limit**.

A review of the data that may be used in the next assessment period revealed similar results. The table below shows the percent of samples that exceeded the screening level in each assessment unit for nitrate, total phosphorus, and chlorophyll *a* for samples collected between December 2009 and November 2016. Although nutrients were mostly reported below the LOQ in the lower two assessment units, almost half of all chlorophyll samples in Lake O' the Pines were reported above the screening level.

Parameter	0403_01	0403_02	0403_03	0403_04
Chlorophyll *a*	45%	48%	43%	52%
Nitrate	0%	0%	8%	26%
Total Phosphorus	0%	0%	0%	22%

Figure 38: Table of nutrient screening level exceedances

The recent high pH, chlorophyll, and dissolved oxygen values suggest that Lake O' the Pines is becoming more eutrophic. Since all of the grab samples were primarily collected between 10 AM and 2 PM, the peak hours of primary productivity, the pH cycling phenomenon can be assumed. However, without diel data, pH cycling cannot be demonstrated nor the pH range measured.

The data further suggest that pH is generally increasing throughout the entire reservoir including the two middle assessment units where the the increasing trend was statistically significant. All of the pH measurements reported above the 8.5 s.u. criterion in Lake O' the Pines were also reported with super-saturated dissolved oxygen values. Similar to Lake Cypress Springs, a correlation between pH and DO percent saturation was approximately 0.8 in the middle assessment units. For AU 0403_03, the correlation was 0.83 while it was 0.79 for AU 0403_02. The combination of elevated chlorophyll and super-saturated DO supports the assumption that the higher pH readings were a result of primary productivity.

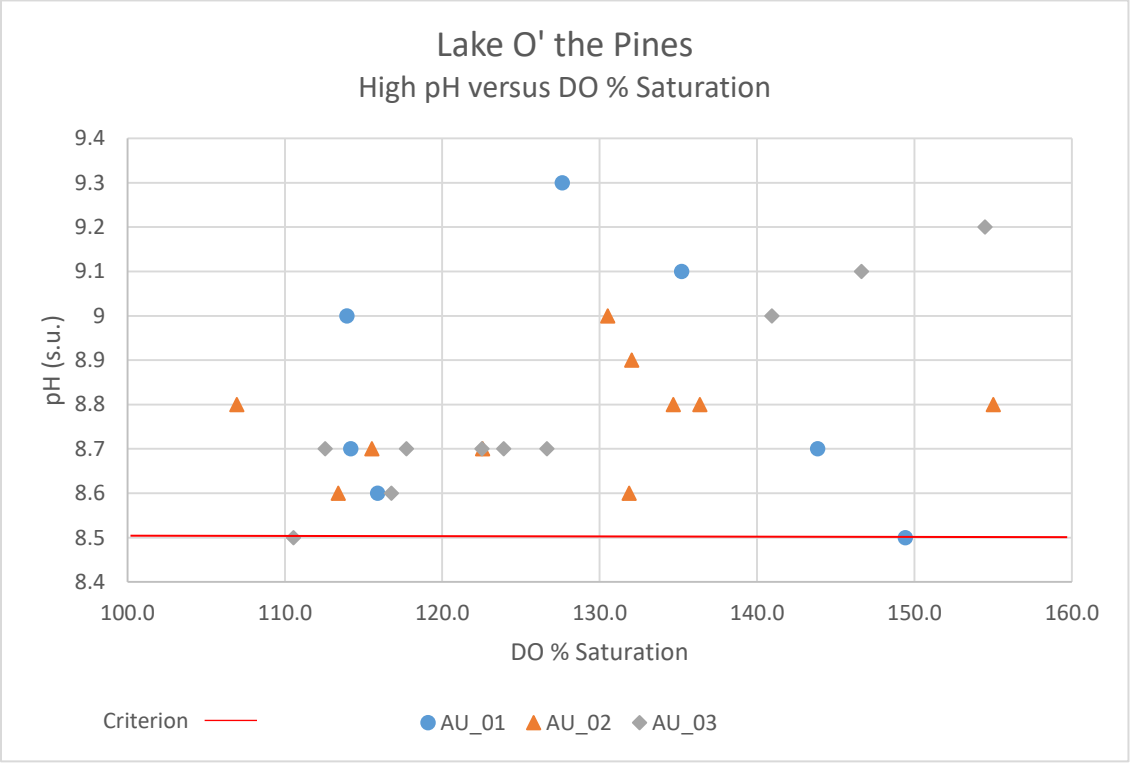

Figure 39: Graph of high pH versus DO saturation

Alkalinity and pH tend to be low in most water bodies in East Texas. Although alkalinity was not increasing at a statistically significant rate, the parameter has been generally increasing in Lake O' the Pines over the past two decades with the most pronounced increased in the lower

assessment units. The parameter appeared to be increasing a similar rate to pH, yet the source(s) for the higher alkalinity has not been identified.

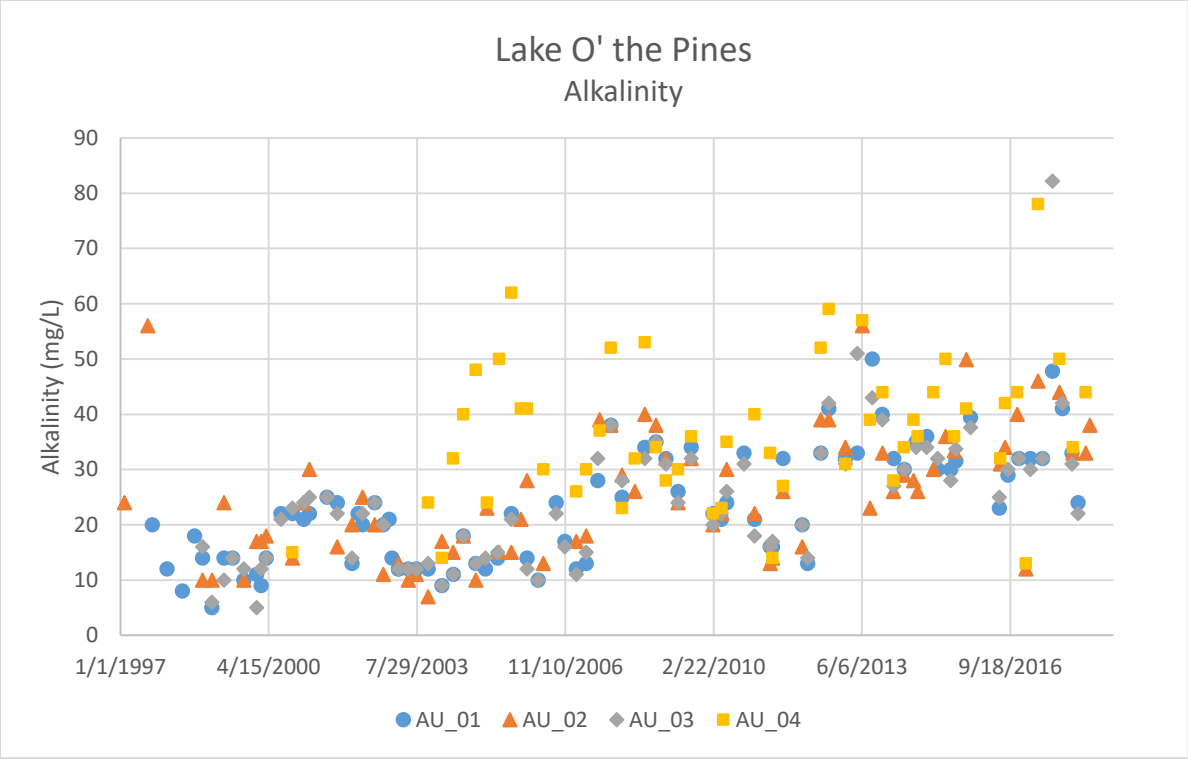

Figure 40: Graph of alkalinity in Lake O' the Pines

Unlike the other assessment units, low dissolved oxygen, less than 5 mg/L, was more frequently observed in the headwaters of the reservoir in AU 0403_04. Fifteen percent of the 35 dissolved oxygen grab samples collected since 2009 were low with a mean of 3.76 mg/L. Three of the low readings were obtained between September 2014 and September 2015. The remaining low values were observed in May 2009 and July 2012. Due to the low DO grab samples, AU 0403_04 had a concern for low dissolved oxygen. Additionally, this AU was impaired for low 24-Hour DO Minimum. There were no diel data collected during the assessment period and none are presently scheduled. Diel collections should be considered in the future to address this impairment.

Due to the high concentration of sulfate in Big Cypress Creek, a review of the sulfate results in AU 0403_04 was performed. The data showed that the peak sulfate levels were collected during the drought periods and that recent sulfate concentrations may be decreasing. As discussed in Big Cypress Creek, not enough data have been collected to discerne whether the

decreasing concentrations were a result of a change in water quality in the stream or if the lower values were a result of higher flows due to flooding and releases from Lake Bob Sandlin.

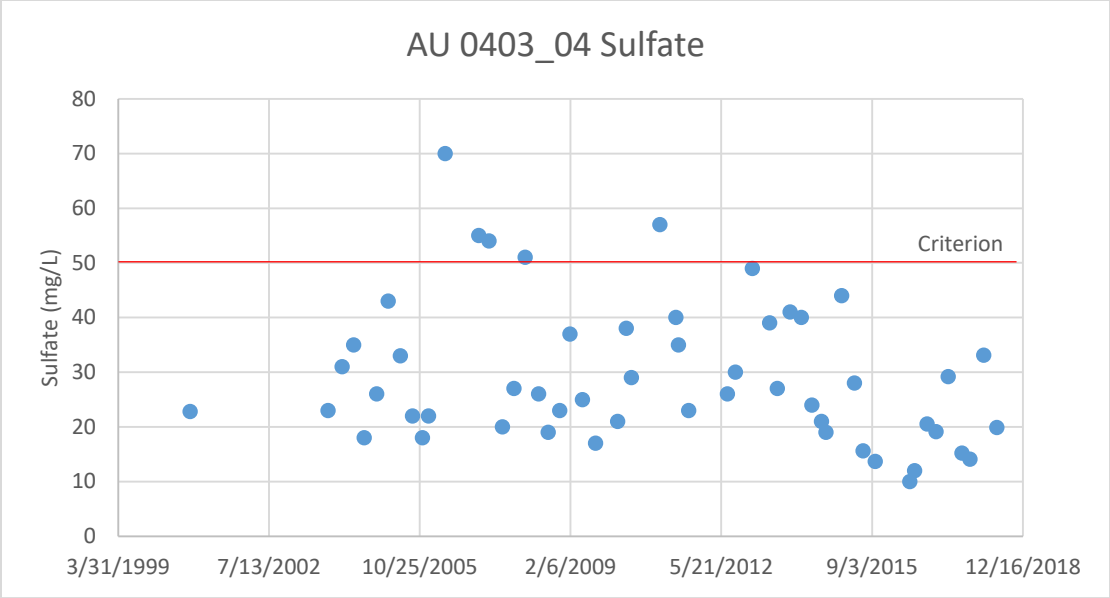

Figure 41: Graph of sulfate in AU 0403_04

TRENDS

An increasing trend for chlorophyll was identified for AU 0403_01 and AU 0403_02 in the *2009 Cypress Creek Basin Summary Report.* This increasing trend continued in AU 0403_01 in the 2014 analysis. The chlorophyll trends did not persist into the current report; however, pH was increasing at a statistically significant rate in both of the middle assessment units.

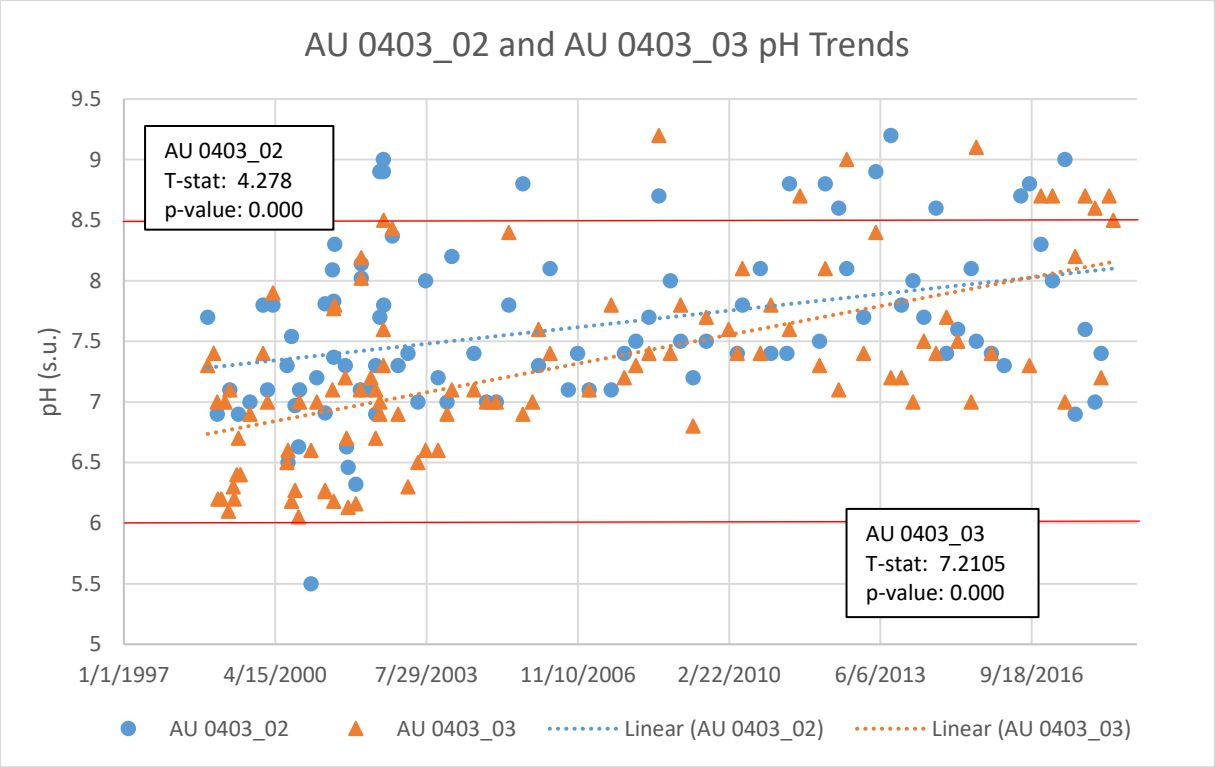

Figure 42: Graph of pH trends in Lake O' the Pines

A decreasing trend for transparency and total dissolved solids were identified in AU 0403_01. Decreasing transparency may be due to higher turbidity and/or higher chlorophyll. Since total dissolved solids were decreasing at a statistically significant rate and chlorophyll had been increasing at a statically significant rate in the past two basin summary reports, the decreasing transparency trend was most likely due to increased algal production.

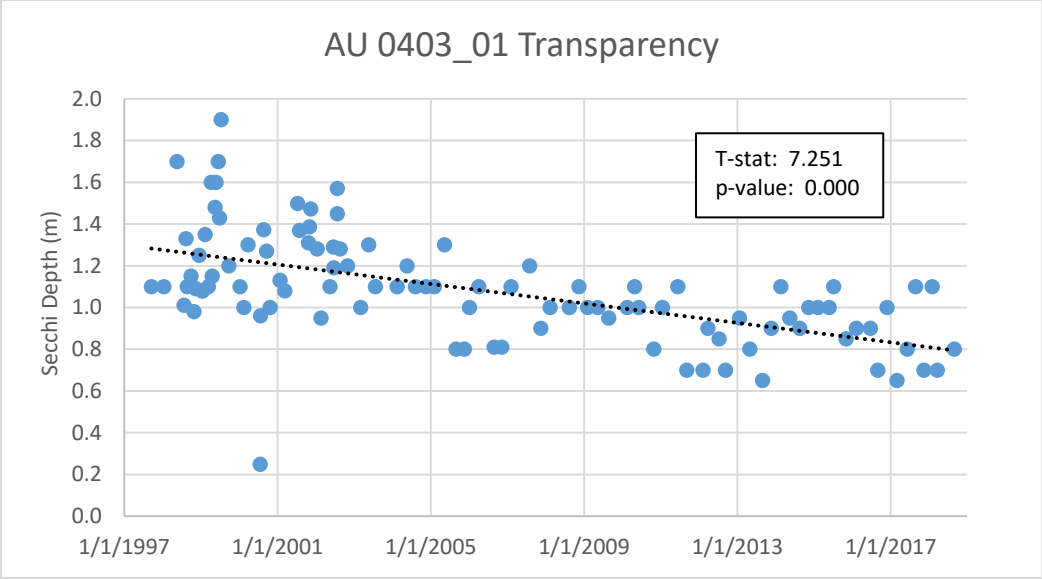

Figure 43: Graph of transparency trend in AU 0403_01

The table below details the FY 2019 Coordinated Monitoring Schedule in Segment 0403. Quarterly sampling for field parameters, conventionals, and bacteria is conducted by TCEQ Region 5 in all four assessment units.

Segment AU	Station #	Site Description	CE	Field	Conv	Bacteria
0403_01	10295	LAKE O THE PINES MID LAKE NEAR DAM	R5	4	4	4
0403_02	16156	LAKE O THE PINES MID LAKE	R5	4	4	4
0403_03	10297	LAKE O THE PINES NEAR NETMWD INTAKE	R5	4	4	4
0403_04	17087	LAKE O THE PINES 2.7 KM NE OF INTERSECTION OF SH 155 AND US 259	R5	4	4	4

Figure 44: Table of FY 2019 CMS in Segment 0403

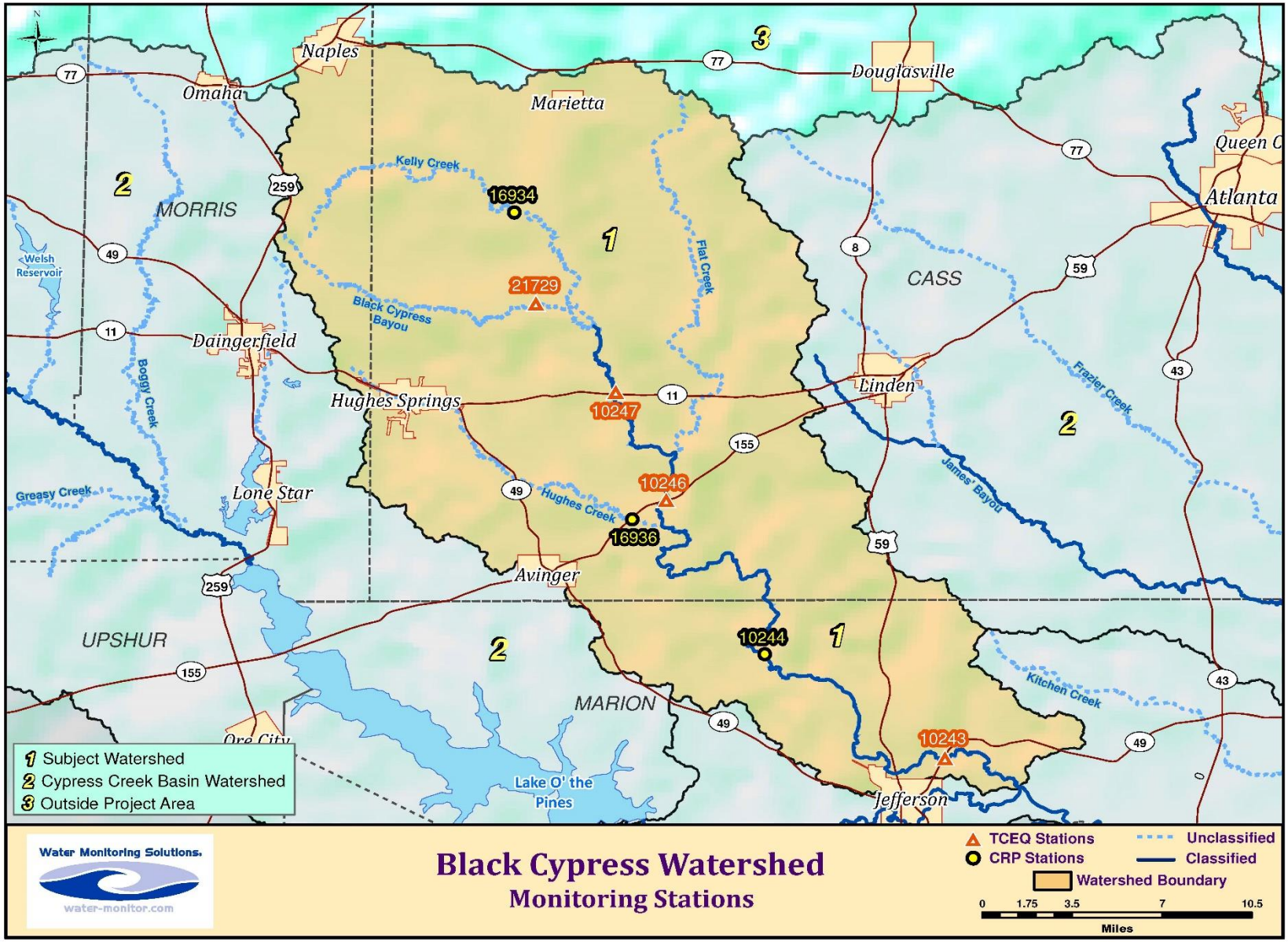

Figure 45: Map of Black Cypress Bayou watershed

SEGMENT 0410 – BLACK CYPRESS CREEK (BAYOU)

Black Cypress Bayou was formerly designated as Segment 0402A, an unclassified water body. Segment 0410 became a classified water body in the most recent TSWQS revision and is shown as Segment 0410 in the *Draft 2016 Integrated Report*. The segment boundary begins at the confluence with Big Cypress Creek and upstream to FM 250. Segment 0410 is divided into four assessment units plus Segment 0410A which is an unclassified water body that is intermittent with perennial pools.

Figure 46: Black Cypress Creek at US 59

WATER QUALITY

Segment 0410 was included on the *Draft 2016 Texas §303(d) List* for copper, dissolved oxygen, *E. coli*, and mercury in fish tissue. All but one of the listings in the segment were based upon either inadequate or limited data.

Both the lowest (AU 0410_01) and the middle assessment units (Pruitt Lake) of Black Cypress Creek were impaired for copper, although copper was not an issue elsewhere in the stream. Presently, the source of copper has not been identified. The copper listing in AU 0410_01 was based upon a single result of 8.01 µg/L, analyzed in January 2008. No dissolved copper results

were reported in SWQMIS after this sample until August and November 2017 at station 10243 (SH 49). The mean of these two samples was 0.85 µg/L. In AU 0410_03, dissolved copper samples were collected in 2007 through 2009, and from 2015 through 2018 at station 10246 (Pruitt Lake). The average concentration of all samples was 1.64 µg/L with a maximum of 5.27 µg/L collected in January 2008. The mean of the samples collected over the past three years was 0.86 µg/L. These recent results suggest that the segment was meeting the Chronic and Acute criteria of 2.29 µg/L and 2.81 µg/L, respectively.

The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0410.

Segment AU	Description	Parameter	Support	Data
0410_01	From Big Cypress Creek	Copper	**NS**	ID
0410_01	upstream to White Oak Creek	Copper	CN	ID
0410_02	From White Oak Creek	DO 24-HR Avg.	**NS**	ID
0410_02	upstream to	DO 24-HR Min.	**NS**	ID
0410_02	Pruitt Lake	*E. coli*	CN	LD
0410_03	Pruitt Lake	Copper	**NS**	LD
0410_03	Pruitt Lake	Copper	CN	LD
0410_03	Pruitt Lake	DO 24-HR Min.	**NS**	ID
0410_03	Pruitt Lake	DO Grab Scr. Level	CS	LD
0410_03	Pruitt Lake	mercury in tissue	**NS**	OE
0410_04	From Pruitt Lake	DO 24-HR Avg.	CN	ID
0410_04	upstream to	DO Grab Scr. Level	**NS**	AD
0410_04	Kelly Creek	*E. coli*	**NS**	LD
0410A	From Kelly Creek	DO 24-HR Avg.	**NS**	ID
0410A	upstream to	DO 24-HR Min.	**NS**	ID
0410A	FM 250	*E. coli*	CN	LD

Figure 47: Table of *Draft 2016 Integrated Report for Segment 0410*

As a result of changes to the TSWQS discussed on page 18, AU 0410_01 was removed from the §303(d) list for low dissolved oxygen in the *Draft 2016 Integrated Report*. Data collected during the assessment period showed that the AU was meeting the dissolved oxygen criterion.

Routine sampling in AU 0410_02 had previously been conducted at station 16705 (CR 1617) through 2010. Sampling resumed in this assessment unit in 2015 at station 10244 near Berea. The coordinated monitoring committee agreed that station 10244 was more representative of the hydraulic conditions of the reach. The assessment unit had impairments for 24-Hour dissolved oxygen average and 24-Hour dissolved oxygen minimum along with a concern for bacteria.

Both dissolved oxygen listings were carry-forwards from previous assessments as there were no diel studies performed during the assessment period for the *Draft 2016 Integrated Report*. To address the impairments, diel sampling began in 2015, and eleven studies had been completed through April 2018. Three of the 24-Hour dissolved oxygen average results fell below the 4.0 mg/L criterion with an average concentration of 3.37 mg/L. A single 24-Hour dissolved oxygen minimum fell below the 3.0 mg/L standard at 2.3 mg/L in June 2015. The flow was reported as 0.2 cfs and severity of low flow for this diel.

The AU also showed a concern for non-attainment of the bacteria standard. Results from station 16705 collected from January 2008 through July 2010 had a geometric mean of 155 MPN/100 mL which supported the concern. However, the geometric mean of the results collected at station 10244 from October 2016 through April 2018 was 68.16 MPN/100 mL, well below the 126 MPN/100 mL criterion. These results indicate that the AU was meeting its contact recreational use designation. Pruitt Lake, AU 0410_03, had an impairment for 24-Hour dissolved oxygen minimum and a concern for dissolved oxygen screening level. No diel sampling was conducted during the assessment period. A single event was conducted in July 2015. The minimum dissolved value was 2.0 mg/L, below the 3.0 mg/L criterion. Only a few dissolved oxygen grab samples were made after 2004, and most readings were in 2007 through 2009. Regular sampling at Pruitt Lake resumed in FY 2015. The average dissolved oxygen grab, based upon 21 observations, was 6.1 mg/L with the lowest value at 2.9 mg/L. These results suggest that the AU was meeting its designated use.

In the uppermost reach of Black Cypress Creek, AU 0410_04, there were impairments for dissolved oxygen screening level and bacteria, along with a concern for the 24-Hour dissolved oxygen average. There have been no diel events conducted in this reach since 2004, and none are currently scheduled.

Regular dissolved oxygen grab sampling resumed in this assessment unit at station 10247 (SH 11) in 2011. Out of 27 observations, seven failed to meet the 4 mg/L criterion, with an average concentration of 2.7 mg/L. Most of the low dissolved oxygen readings were obtained during the summers of 2011, 2012, and 2013. A single low value of 2.7 mg/L was recorded in July 2016.

There were no bacteria samples collected between 2006 and 2011, and irregular sampling was conducted from 2011 to 2014. The twenty-five *E. coli* samples analyzed from March 2014 through July 2018 had a geometric mean of 137 MPN/100 mL. These results support the bacteria impairment.

0410A Black Cypress Creek

Segment 0410A is an intermittent reach of Black Cypress Creek. It extends from Kelly Creek upstream to FM 250. The *Draft 2016 Texas §303(d) List* showed an impairment for 24-Hour dissolved oxygen average and 24-Hour dissolved oxygen minimum. The listings were a carry-forward from previous assessments as there were no diel data available to review.

This reach also had a concern for non-attainment of the bacteria criterion. Sampling conducted from February 2016 through June 2018 had a geometric mean of 99.25 MPN/100 mL based upon sixteen samples. These data indicate that this reach was meeting its contact recreation designated use.

TRENDS

There were no trends identified in Segment 0410.

In order to obtain data needed for the assessment of this segment, sampling is being conducted by TCEQ Region 5 and WMS in FY 2019. The TCEQ Region 5 is scheduled to collect field, flow, conventionals and bacteria samples on a quarterly basis at stations 10243, 10246, 10247, and 21729. In addition, Region 5 will make monthly flow measurements and collect bacteria samples at station 10247 along with collecting quarterly metals in water at stations 10243 and 10246. Region 5 is also scheduled to conduct six diel studies at station 10246 and one at 21729. WMS is scheduled to collect field, conventionals, bacteria, and flow on a quarterly basis and perform four diel studies at station 10244.

The FY 2019 Coordinated Monitoring Schedule for Segment 0410 is detailed in the Figure 48. Metals in water sampling (denoted by "*") is scheduled to be collected quarterly by TCEQ Region 5 at stations 10243 and 10246.

Segment	Station	Site Description	CE	Field	Conv	Bacteria	Flow	24 HR DO
0410_01	10243	BLACK CYPRESS CREEK AT SH 49	R5	4	4*	4	4	NA
0410_02	10244	BLACK CYPRESS BAYOU AT COUNTY ROAD NORTHWEST OF BEREA	WMS	4	4	4	4	4
0410_03	10246	BLACK CYPRESS BAYOU AT SH 155	R5	4	4*	NA	NA	6
0410_04	10247	BLACK CYPRESS BAYOU AT SH 11	R5	4	4	12	12	NA
0410A	21729	BLACK CYPRESS CREEK AT CR 2924	R5	4	4	4	4	1

Figure 48: Table of FY 2019 CMS for Segment 0410

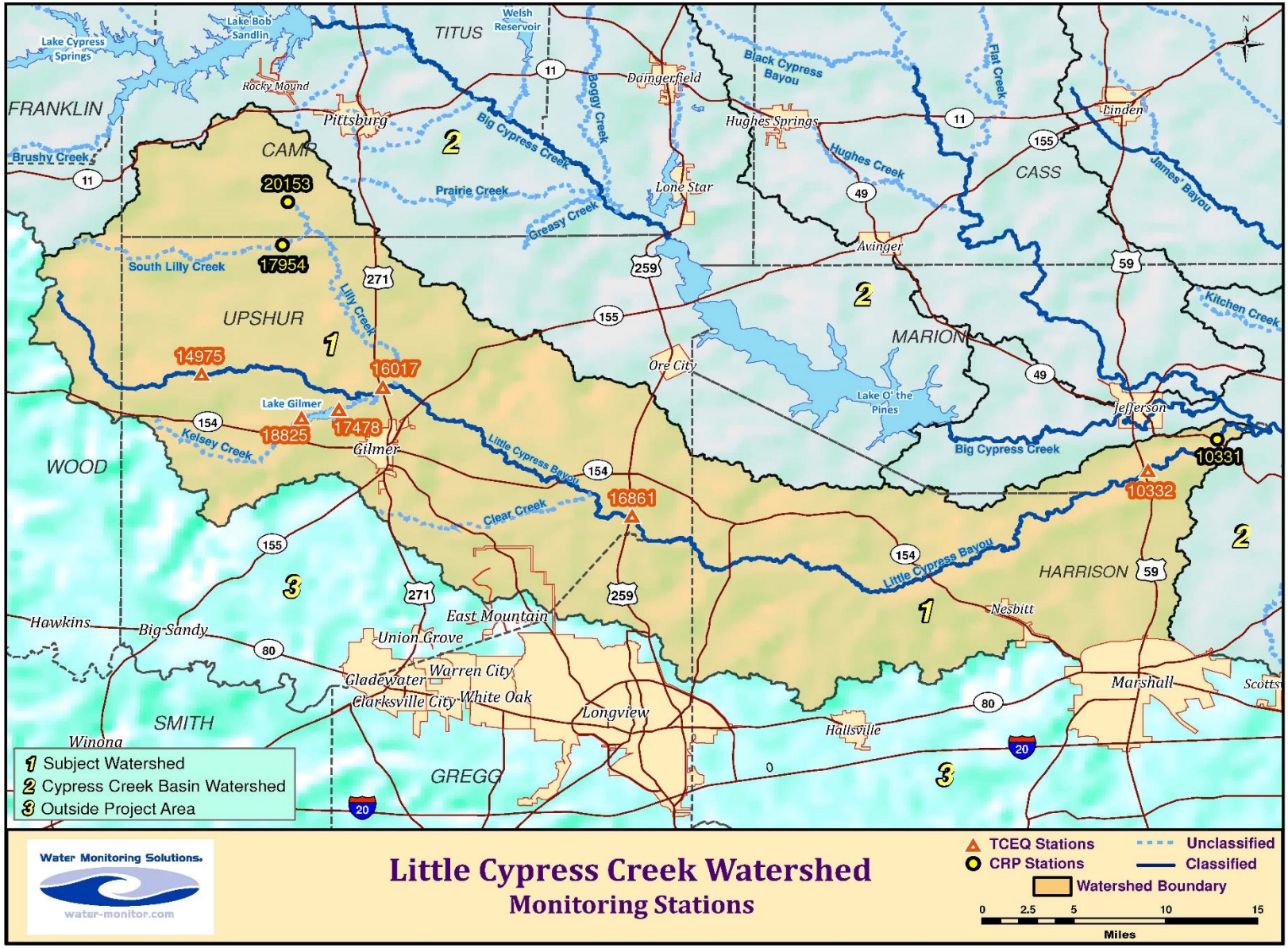

Figure 49: Map of Little Cypress Creek watershed

SEGMENT 0409 – LITTLE CYPRESS CREEK (BAYOU)

Little Cypress Bayou emerges in the Pineywoods near FM 2088 in Wood County. The approximately 163-kilometer (105 miles) bayou forms much of the southern boundary of the Cypress Creek Basin, and joins Big Cypress Creek east of Jefferson.

WATER QUALITY

The Little Cypress Creek segment was identified as impaired for low levels of dissolved oxygen in 2000 and for elevated bacteria in 2006. These impairments were included in the *Draft 2016 Texas §303(d) List*. The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0409.

Segment AU	Description	Parameter	Support	Data
0409_01	From Big Cypress to Lawrence Creek	DO 24-HR Avg.	**NS**	ID
0409_02	Upstream from	DO 24-HR Avg.	**NS**	ID
0409_02	Lawrence Creek	DO 24-HR Min.	CN	ID
0409_02	29.2 km (18.1 mi)	*E. coli*	**NS**	LD
0409_03	Upstream to Kelsey Creek	*E. coli*	CN	AD
0409_04	Upstream to FM 2088	*E. coli*	**NS**	AD
0409A	Lilly Creek	DO Grab Min.	CS	AD
0409A	Lilly Creek	*E. coli*	**NS**	AD
0409B	South Lilly Creek	DO Grab Min.	CS	AD
0409B	South Lilly Creek	*E. coli*	**NS**	AD
0409E	Clear Creek	Habitat	CS	ID
0409E	Clear Creek	Macrobenthic Community	CN	ID

Figure 50: Table of Draft 2016 Integrated Report for Segment 0409

ASSESSMENT UNIT 0409_01

The lower 41 kilometers of Little Cypress Creek, from the confluence with Big Cypress Creek on the Harrison/Marion County line to Lawrence Creek, encompasses AU 0409_01. Sampling is conducted at two stations within this AU:

- Station 10331 Little Cypress Creek at FM 134
- Station 10332 Little Cypress Creek at US 59

The reach was listed for non-support of the 24-Hour dissolved oxygen criterion of 5.0 mg/L. The listing was a carry-forward from previous assessments as it was based upon inadequate data primarily collected in 2002 and 2003. Due to the listing, diel studies resumed in October 2016 in this reach. Of the seven diels completed through April 2018, four 24-Hour dissolved oxygen averages were less than 5.0 mg/L and had a mean of 4.3 mg/L. All but one diel met the 24-Hour dissolved oxygen minimum criterion of 3.0 mg/L. These results support the impairment.

Although all of the other assessment units in Little Cypress Creek and its tributaries of Lilly Creek and South Lilly Creek had concerns or impairments for *E. coli*, this reach met its contact recreation designated use. The geometric mean for samples collected over the past five years at station 10332 was 50.8 MPN/100 mL. Of note is that there was a statistically significant decreasing *E. coli* trend at this station. The trend was based upon 63 samples collected from 2001 through April 2018.

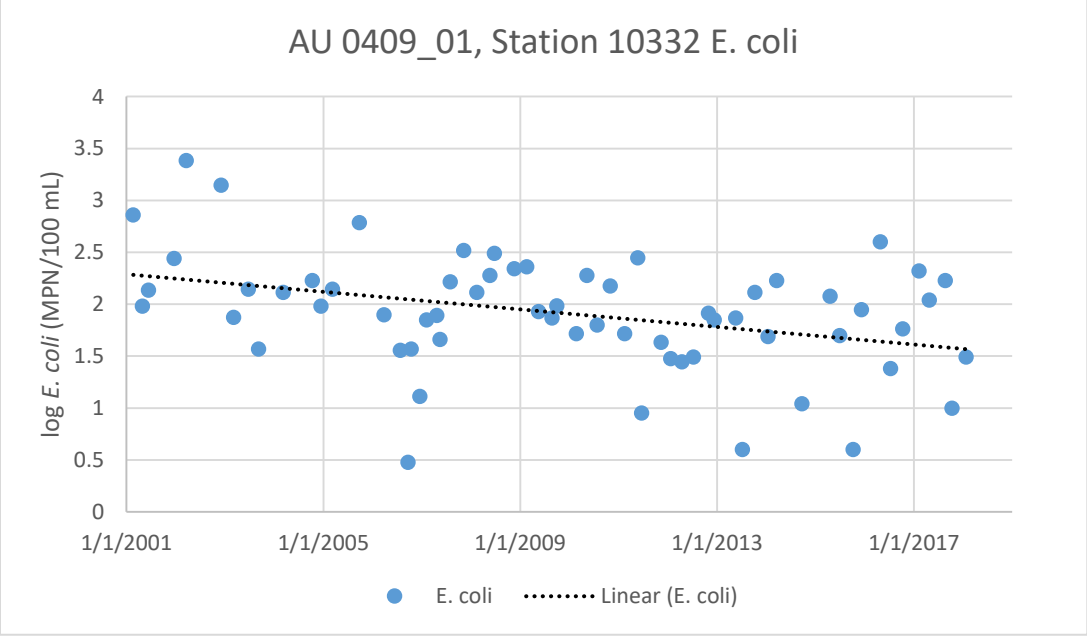

Figure 51: Graph of E. coli trend in AU 0409_01

In 2019, WMS will monitor station 10331 quarterly for field, flow, bacteria, and conventional parameters and will conduct diel studies four times per year. Region 5 is scheduled to collect field, flow, bacteria, and conventional parameters quarterly at station 10332.

Figure 52: Photo of Little Cypress Creek at station 10331

ASSESSMENT UNIT 0409_02

The 29.2-kilometer reach extending upstream of Lawrence Creek, AU 0409_02, was on the *Draft 2016 Texas §303(d) List* for not supporting the 24-Hour DO Average and *E. coli* criteria. There was also a concern for non-attainment of the 24-Hour dissolved oxygen minimum standard. These listings were a carry-forward from previous assessments and were based upon inadequate data. The last 24-Hour dissolved oxygen results in this reach were collected in July 2005.

All data for AU 0409_02 were collected at station 15773 (FM 450). Sampling at this station was discontinued in 2012. TCEQ staff determined that the location was not representative of the hydraulic conditions of the AU and another station has yet to be identified. The *E. coli* results for samples collected from 2009 to 2012 had a geometric mean of 117 MPN/100 mL, below the 126 MPN/100 mL criterion. However, until sampling is resumed within this assessment unit, these impairments will likely remain.

ASSESSMENT UNIT 0409_03

The upper-middle reach of Little Cypress Creek extends 52.2 kilometers upstream to the confluence with Kelsey Creek. This AU had a concern for non-attainment of the *E. coli* criterion. The geometric mean of samples collected over the past five years was 153 MPN/100 mL, supporting the concern.

Due to the changes to the TSWQS discussed on page 18, the assessment unit was delisted for low dissolved oxygen. Data collected during the assessment period met the DO criterion.

Region 5 is scheduled to collect field, flow, bacteria, and conventional parameters quarterly at station 16861, located at US 259, in 2019.

ASSESSMENT UNIT 0409_04

The uppermost reach of the segment extends from the headwaters near FM 2088 in Wood County downstream 41.1 kilometers. Two stations are monitored in the AU:

- Station 16017 Little Cypress Creek at US 271
- Station 14975 Little Cypress Creek at FM 852

The assessment unit was included on the *Draft 2016 Texas §303(d) List* for not supporting the *E. coli* geometric mean criterion of 126 MPN/100 mL. The geometric mean of the 22 samples collected from 2012 to 2017 at station 16017 was 244 MPN/100 mL. The geometric mean of the monthly samples collected at station 14975 from June 2017 through July 2018 was 598 MPN/100 mL. These results support the *E. coli* listing.

TCEQ Region 5 is scheduled to collect quarterly samples for field, flow, conventional, and bacteria samples at station 16017 in 2019 and is sampling monthly for bacteria and flow at station 14975.

SEGMENT 0409A – LILLY CREEK

Lilly Creek originates two miles west of Pine in Camp County and flows southeast for nine miles to its confluence with Little Cypress Creek. Lilly Creek is sampled at station 20153, located on FM 556 south of Pittsburg.

Lilly Creek was listed for bacteria in the *Draft 2016 Integrated Report*. The geometric mean of the *E. coli* samples collected over the past five years was 328 MPN/100 mL. A Recreational Use Attainability Analysis should be considered in Lilly Creek to determine whether primary contact recreation is the appropriate use designation.

Figure 53: Photo of Lilly Creek at station 20153

A concern for dissolved oxygen grab minimum was included in the *Draft 2016 Integrated Report*. From 2008 to 2014, one sample per year fell below the 3.0 mg/L criterion. The low dissolved oxygen readings were observed in July of those years. No values less than 3.0 mg/L have been reported in Lilly Creek since October 2014, suggesting that the low dissolved oxygen readings were due to low stream flow.

In 2019, quarterly sampling is scheduled to be conducted at station 20153 for bacteria, flow, conventional, and field parameters by WMS.

SEGMENT 0409B – SOUTH LILLY CREEK

South Lilly Creek is an unclassified water body that extends from its confluence with Lilly Creek to FM 1647 in Upshur County. The stream is intermittent, the watershed has no population centers, and is comprised of improved pastures and forested land. Much of riparian vegetation along the stream has been removed and cattle commonly have direct access to the stream. South Lilly Creek is sampled at station 17954, located at FM 2454 south of Pittsburg.

South Lilly Creek was first identified as impaired for bacteria in 2006. The impairment continued into the *Draft 2016 Integrated Report*. Data collected over the past five years had a geometric mean of 446 MPN/100 mL indicating that the *E. coli* levels remained above the 126 MPN/100 mL criterion. At present, this reach does not meet its primary contact use designation.

A Recreational Use Attainability Analysis was conducted in South Lilly Creek by the Texas Institute for Applied Environmental Research in 2016 (*Texas Institute for Applied Environmental Research, 2017*). No recreational use of the stream was observed during the study period, and landowner interviews indicated that the stream was not used for contact recreation. Barriers to recreational use included access to the stream limited to road crossings, barbed wire fencing, logjams, thick vegetation, and venomous snakes. As a result of the study, TCEQ may choose to apply a secondary contact recreation standard.

A concern for dissolved oxygen grab minimum was shown on the *Draft 2016 Integrated Report*. From 2008 to 2014, four dissolved oxygen observations were below 3.0 mg/L, with average of 1.48 mg/L. Stream flow was reported as 0 or less than 0.01 cfs for all four low dissolved oxygen results. No low dissolved oxygen readings were recorded since October 2014 suggesting that the low dissolved oxygen readings were due to low stream flow.

WMS is scheduled to conduct quarterly monitoring for field parameters, flow, conventional parameters, and *E. coli* at station 17954 in 2019.

SEGMENT 0409D – LAKE GILMER

Lake Gilmer is located in central Upshur County. The reservoir was constructed in 2001 and covers approximately 1,010 surface acres. There were no concerns or impairments shown in the *Draft 2016 Integrated Report* for this water body. Quarterly monitoring is conducted by Region 5 at stations 17478 (dam) and 18825 (FM 852) for conventional, bacteria, and field parameters in 2019.

SEGMENT 0409E – CLEAR CREEK

Clear Creek, located in Upshur County, is a small tributary to Little Cypress Creek. The *Draft 2016 Integrated Report* shows a concern for non-attainment for impaired benthic community along with a concern for screening level for habitat. Biological monitoring was conducted in Clear Creek at station 18590 (Bobwhite Road) in June and August 2006. The mean rapid bio-assessment score (benthic macroinvertebrates) was 19, well below the criterion of 29. The habitat quality index was below the 20 criterion with a score of 15.

For 2019, no monitoring is scheduled in Clear Creek, but may be considered for future biological studies.

TRENDS

The decreasing *E. coli* trend in AU 0409_01 was the only statistically significant trend observed in Segment 0409. No trends were identified in this segment in the 2009 or 2014 basin summary reports.

The FY 2019 Coordinated Monitoring Schedule in Segment 0409 is shown in the table below. Diel sampling is scheduled to be conducted by WMS four times per year at station 10331.

Segment	Station	Site Description	CE	Field	Conv	Bacteria	Flow
0409_01	10331	LITTLE CYPRESS CREEK AT FM 134	WMS	4	4	4	4
0409_01	10332	LITTLE CYPRESS CREEK AT US 59	R5	4	4	4	4
0409_03	16861	LITTLE CYPRESS BAYOU AT US259	R5	4	4	4	4
0409_04	14975	LITTLE CYPRESS CREEK AT FM 852	R5	NA	NA	12	12
0409_04	16017	LITTLE CYPRESS BAYOU AT US 271	R5	4	4	4	4
0409A	20153	LILLY CREEK AT FM 556	WMS	4	4	4	NA
0409B	17954	SOUTH LILLY CREEK AT FM 2454	WMS	4	4	4	4
0409D	17478	LAKE GILMER AT MID DAM	R5	4	4	4	NA
0409D	18825	LAKE GILMER AT FM 852	R5	4	4	4	NA

Figure 54: Table of FY 2019 CMS in Segment 0409

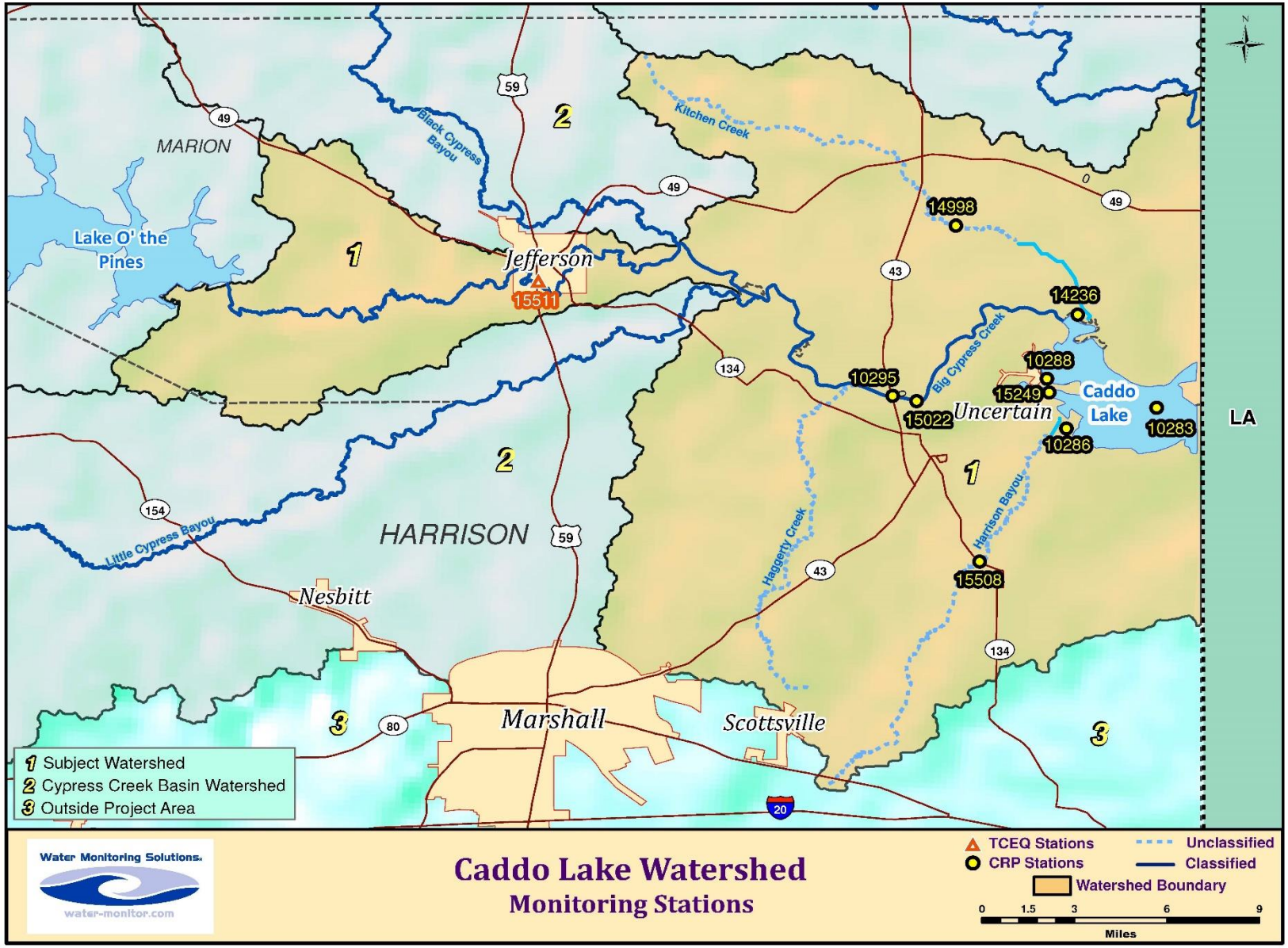

Figure 55: Map of Caddo Lake watershed

CADDO LAKE WATERSHED

The Caddo Lake and its watershed straddles the Texas and Louisiana border. It is in the rolling terrain of the Pineywoods Ecoregion. The landscape is a mix of rich bottomlands and pine and oak forests with scattered areas of cropland, planted pastures and native pastures. Caddo Lake has a surface area of approximately 26,800 acres with approximately half of the water body located within each state. Texas encompasses approximately 358 square miles of the 2,700 square-mile drainage basin. Caddo Lake and much of the surrounding watershed are swampland with shallow waters and towering bald cypress trees.

Urban development is sparse. The largest city is Jefferson, with a population of about 2,400. The land is predominantly used for agriculture, including forestry, poultry, and cattle production. Major tributaries include Black Cypress Bayou (0410), Little Cypress Bayou (0409), Kitchen Creek (0401B), Haggerty Creek (0401C), and Big Cypress Creek below Lake O' the Pines (0402). Black Cypress and Little Cypress Bayous are discussed in their respective sections.

Figure 56: Photo of monitoring team on Caddo Lake

SEGMENT 0402 – BIG CYPRESS CREEK (BAYOU) BELOW LAKE O' THE PINES

Segment 0402 is the portion of Big Cypress Creek that flows between Ferrell's Bridge Dam forming Lake O' the Pines and Caddo Lake. This segment is generally deep, wide, and supports heavy recreational use including boating and camping activities. The Big Cypress Creek watershed contains over five thousand acres of bottomland hardwood forest dominated by cypress swamps. Because of the uniqueness of the habitat, the TPWD has designated it an important recovery area for the state-threatened paddlefish.

WATER QUALITY

The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0402. The segment was identified on the Texas §303(d) List as having elevated mercury in fish tissue in 1998, and the DSHS fish consumption advisory extends across the entire segment.

Segment AU	Description	Parameter	Support	Data
0402	Big Cypress Creek Below Lake O' the Pines (entire)	Mercury in tissue	**NS**	ID
0402_02	Haggerty Creek upstream to Black Cypress Bayou	DO 24-HR Avg.	**NS**	LD
0402_03	Black Cypress Bayou to French Creek	Macrobenthic Community	CN	ID
0402B	Hughes Creek	DO Grab Min.	CS	AD

Figure 57: Table of Draft 2016 Integrated Report for Segment 0402

The 15 km reach of Big Cypress Creek between Caddo Lake and Haggerty Creek, AU 0401_01, was listed for low pH in 2000. The impairment was removed from the *2016 Draft Texas §303(d) List* due to changes to the TSWQS discussed on page 18. Data collected during the assessment period revealed that the AU was meeting its designated use with a median pH of 6.6 s.u., based upon 79 readings. Only three measurements made during the assessment period fell below the 5.5 s.u. criterion with the lowest value at 5.2 s.u. The pH had not been reported below the criterion since January 2013.

Figure 58: Photo of Big Cypress Creek at station 10295

Big Cypress Creek between Haggerty Creek and the confluence with Black Cypress Bayou (AU 0402_02) was first listed for depressed dissolved oxygen in 2010. The impairment was based upon one of the four monitoring events failing to meet the 5.0 mg/L 24-Hour DO Average criterion. The result of the low measurement was 4.9 mg/L, collected in July 2010. At present, no sampling is being conducted in this reach. All sampling was discontinued after FY 2012 due to a change in property ownership preventing access to the stream. Other potential monitoring locations within the reach either posed safety concerns or were not representative of the AU. Note that monitoring at station 16254, the City of Marshall water intake, was discontinued after FY 2009 due to the determination that the site was not representative of the assessment unit.

Big Cypress Creek between the confluences with Black Cypress Bayou and upstream to French Creek is AU 0402_03. There were no listings within this reach and one concern for impaired macroinvertebrate community. Biological sampling was last conducted in this reach in May 2007, outside of the current assessment period. The benthic organisms had an RBA score of 24, falling below the 29 criterion. Critical period monitoring was not performed that year due to high water levels in the stream. Benthic monitoring, in coordination with the TPWD and USF&W

paddlefish reintroduction project, is being considered by the coordinated monitoring committee.

With the exception of mercury in fish tissue, there were no concerns or listings in AU 0402_04, the 13 km reach between French Creek and Lake O' the Pines. There is no sampling scheduled in this reach in FY 2019.

TRENDS

In the both the 2009 and 2014 basin summary reports, an increasing trend for pH was observed at station 15511. The increasing pH trend continued into the current period and was accompanied by increasing trends for alkalinity and specific conductance.

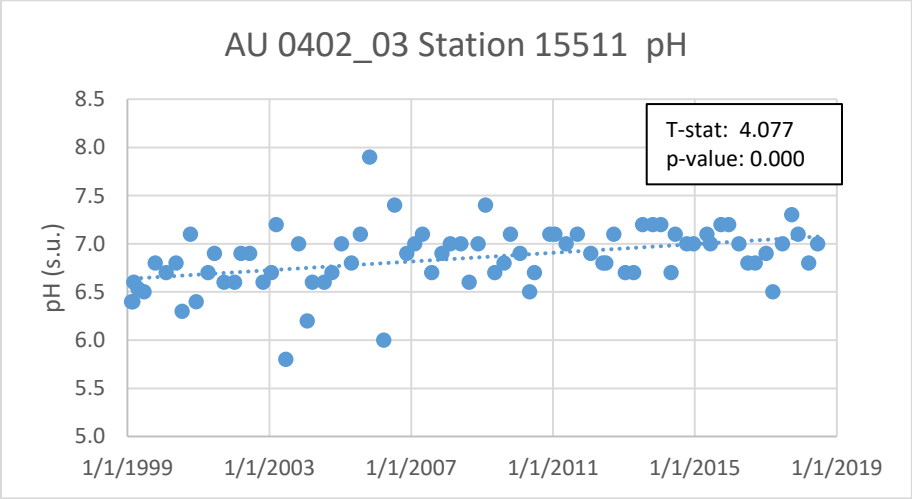

Figure 59: Graph of pH trend in AU 0402_03

Although the pH was increasing at a statically significant rate, the median pH remained close to neutral. From 1998 to 2007, the median pH was 6.7 s.u. while the median pH was 7.0 s.u. for samples collected from 2008 through 2018.

Of interest was the increasing trend for alkalinity at station 15511. The station is located downstream of Lake O' the Pines, near Jefferson. The average alkalinity concentration for the 89 samples collected from 1999 through 2018 was 22.3 mg/L. The mean of the 45 samples collected from 1999 through 2008 was 18.1 mg/L while the mean for samples collected from 2009 through 2019 was 27.4 mg/L. The source(s) of the higher alkalinity has not been identified.

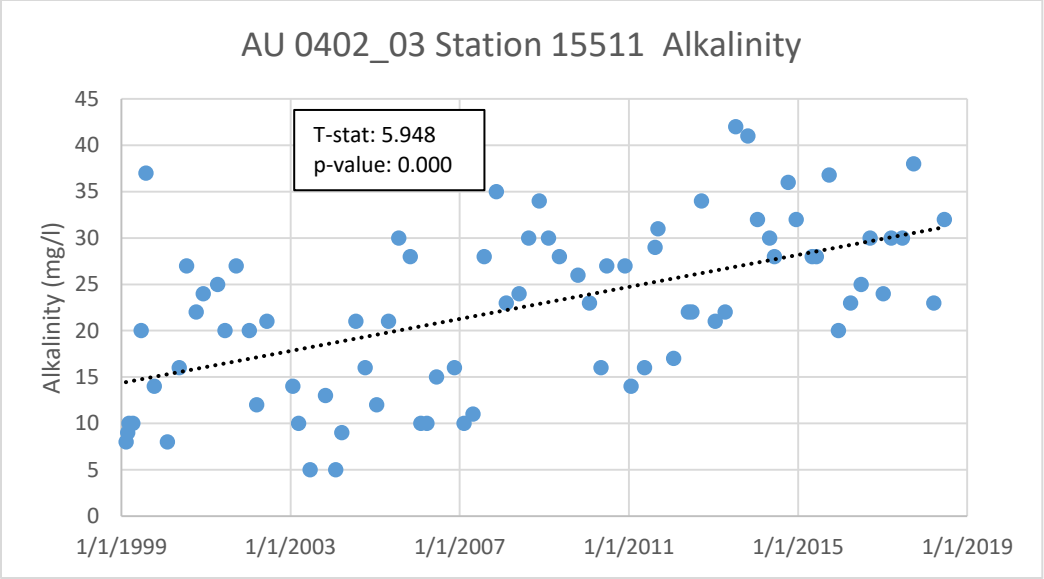

Figure 60: Graph of Alkalinity trend in AU 0402_03

The increasing trend for specific conductance at this station appeared to be a result of the pervasive drought. The specific conductance values dramatically decreased during the heavy rainfall periods of 2015 and 2016, as identified in the graph below.

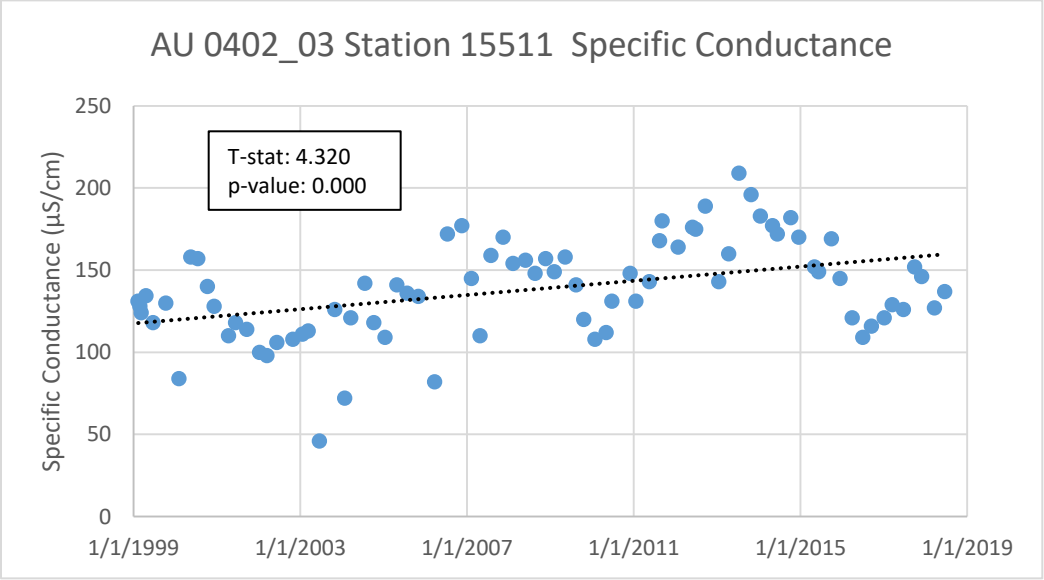

Figure 61: Graph of Specific Conductance trend in AU 0402_03

An increasing trend for specific conductance was identified at station 10295 in the 2014 report, but did not continue into the current analysis.

Monitoring in AU 0402_01 includes monthly field parameters and flow at station 15022 near the Caddo Lake State Park boat ramp by CLI; and quarterly for field parameters, conventionals,

bacteria, and flow at SH 43 (station 10295) by WMS. TCEQ Region 5 samples AU 0402_03 at station 15511 quarterly for flow, bacteria, and for field and conventional parameters.

SEGMENT 0402B HUGHES CREEK THROUGH SEGMENT 0402E KELLEY CREEK

Tributaries of Big Cypress Creek include Segments 0402B – 0402E: Hughes Creek (0402B), Haggerty Creek (0402C), Flat Creek (0402D), and Kelley Creek (0402E). With the exception of Hughes Creek, there were no concerns or impairments shown for these segments. Neither Haggerty Creek nor Flat Creek were assessed in the *Draft 2016 Integrated Report*. Sampling in Haggerty Creek was conducted for only one year in FY 2006; there are no active monitoring stations in Flat Creek. Due to their small watershed size, monitoring resources have been allocated downstream of their confluence with Big Cypress Creek.

Hughes Creek had a concern for the dissolved oxygen grab minimum of 5.0 mg/L. Three of the thirteen samples collected during the assessment period fell below the grab criterion with a mean of 2.97 mg/L. These low readings were observed in July 2013, July 2014, and in October 2014. Data collected both in July and in October 2016 and 2017 had similar results. There is a large pool at the SH 155 crossing, and the stream often has very low flow resulting in low dissolved oxygen values. Access to a more representative location further away from the road crossing is restricted due to fencing on private property.

The FY 2019 Coordinated Monitoring Schedule for Segment 0402 is shown in the table below. WMS samples quarterly for field parameters and flow quarterly at station 16936: Hughes Creek at SH 155, and at station 16934: Kelley Creek at FM 250.

Segment	Station	Site Description	CE	Field	Conv	Bacteria	Flow
0402_01	15022	BIG CYPRESS CREEK AT CADDO LAKE STATE PARK BOAT RAMP	CLI	11	NA	NA	11
0402_01	10295	BIG CYPRESS CREEK AT SH 43	WMS	4	4	4	4
0402_03	15511	BIG CYPRESS BAYOU AT US 59 IN JEFFERSON	R5	4	4	4	4
0402B	16936	HUGHES CREEK AT SH155	WMS	4	NA	NA	NA
0402E	16934	KELLEY CREEK AT FM250	WMS	4	NA	NA	4

Figure 62: Table of FY 2019 CMS for Segment 0402

SEGMENT 0401 – CADDO LAKE

Caddo Lake is impounded by Caddo Dam in Caddo Parish, Louisiana. The uppermost portion of the lake extends into Harrison and Marion Counties in East Texas. Believed to have been formed by a log jam in the Red River, Caddo Lake was one of the largest natural lakes in the South before it was dammed in 1914. The upper half of the lake is shallow and swamp-like creating an unique and diverse ecosystem that is one of the best examples in the southern United States of a mature Bald Cypress forest. In recent years, it has been invaded by nonnative plants such as Hydrilla, water hyacinth (*Eichhoria crassipes*), and giant salvinia (*Salvinia molesta*). Invasive plant species in the Cypress Creek Basin were discussed in detail in the 2016, 2017, and 2018 Cypress Creek Basin Highlights Reports.

WATER QUALITY

The table below details the impairments (NS) and concerns (CN, CS) as shown in the *Draft 2016 Integrated Report* for Segment 0401.

Segment AU	Description	Parameter	Support	Data
0401	Caddo Lake (entire)	Mercury in tissue	NS	ID
0401_01	Lower 5000 acres	Iron in sediment	CS	ID
0401_02	Harrison Bayou arm	DO 24-HR Avg. & Min.	NS	LD
0401_03	Goose Prairie arm	DO Grab Min.	NS	AD
0401_03	Goose Prairie arm	DO Grab Scr. Level	CS	AD
0401_05	Clinton Lake	DO 24-HR Avg. & Min.	NS	LD
0401_07	Mid-lake near Uncertain	DO 24-HR Avg. & Min.	NS	ID
0401A	Harrison Bayou	DO 24-HR Avg. & Min.	NS	LD
0401A	Harrison Bayou	*E. coli*	CN	LD

Figure 63: Table of Draft 2016 Integrated Report for Segment 0401

In 1998, the Texas Department of State Health Services issued a fish consumption advisory for Caddo Lake due to mercury in fish tissue. As a result, all assessment units of Caddo Lake were listed for mercury in fish tissue in the *Draft 2016 Texas §303(d) List*.

Due to its shallow, swamp-like conditions, the most common water quality impairment in Caddo Lake was for low dissolved oxygen concentrations. Invasive aquatic plants often cover the entire surface of the arms of the lake, especially in the summer months, preventing sunlight from entering the water column and exacerbating the low DO problems.

The Harrison Bayou arm, Clinton Lake, and the Mid-lake near Uncertain assessment units were listed for not meeting the 24-Hour DO Average and 24-Hour DO Minimum criteria of 5 mg/L and 3 mg/L, respectively. Although these listings in the *Draft 2016 Integrated Report* were based upon a limited number of samples, five out of seven diel studies conducted during the assessment period failed to meet the 24-Hour DO Average and 24-Hour DO Minimum criteria.

Diel studies in Caddo Lake were discontinued after FY 2009. Numerous diel events had been conducted during the previous decade which yielded similar low dissolved oxygen results and were possibly reflective of the natural oxygen cycles in the arms of Caddo Lake. As a result, stakeholders recommended that the limited CRP resources be directed elsewhere in the basin.

Figure 64: Photo of Caddo Lake near Goose Island

Similar to the other shallow assessment units of Caddo Lake, the Goose Prairie Arm (station 10288) was listed for not meeting the DO Grab Minimum criterion of 3 mg/L and had a concern for the DO Grab screening level of 5 mg/L. Approximately 36% of the 45 dissolved oxygen readings reported during the assessment period were below the criterion, with an average of the low DO concentrations of 1.49 mg/L. These data support the impairment.

Low DO in grab samples were not uncommon in the other arms of Caddo Lake. A review of the data collected since 2010 revealed that about 28% of the surface DO grabs collected in the

arms of Caddo Lake were below the criteria while almost 45% were below the screening level. However, all of the samples collected at the mid-lake station met the DO grab criterion. Figure 65 shows the dissolved oxygen grab sampling results by Caddo Lake station for data collected from January 2010 through June 2018. The number and percent of samples reported below the criterion (3 mg/L) and the screening level (5 mg/L) are identified for each station.

Station Name	Station #	n	< 3 mg/L	%	< 5 mg/L	%
Clinton Lake	14236	94	33	35.1%	47	50.0%
Uncertain	15249	123	33	26.8%	56	45.5%
Harrison Bayou Arm	10286	91	21	23.1%	36	39.6%
Goose Prairie Arm	10288	83	23	27.7%	34	41.0%
Mid-lake	10283	130	0	0.0%	6	4.6%

Figure 65: Table of DO Grab results in Caddo Lake

With few exceptions, the low DO grab samples occurred primarily within the warm weather months, and the highest values were recorded in the winter months. As illustrated in the chart below, dissolved oxygen varied widely across the reservoir with the maximum values recorded at over 12 mg/L.

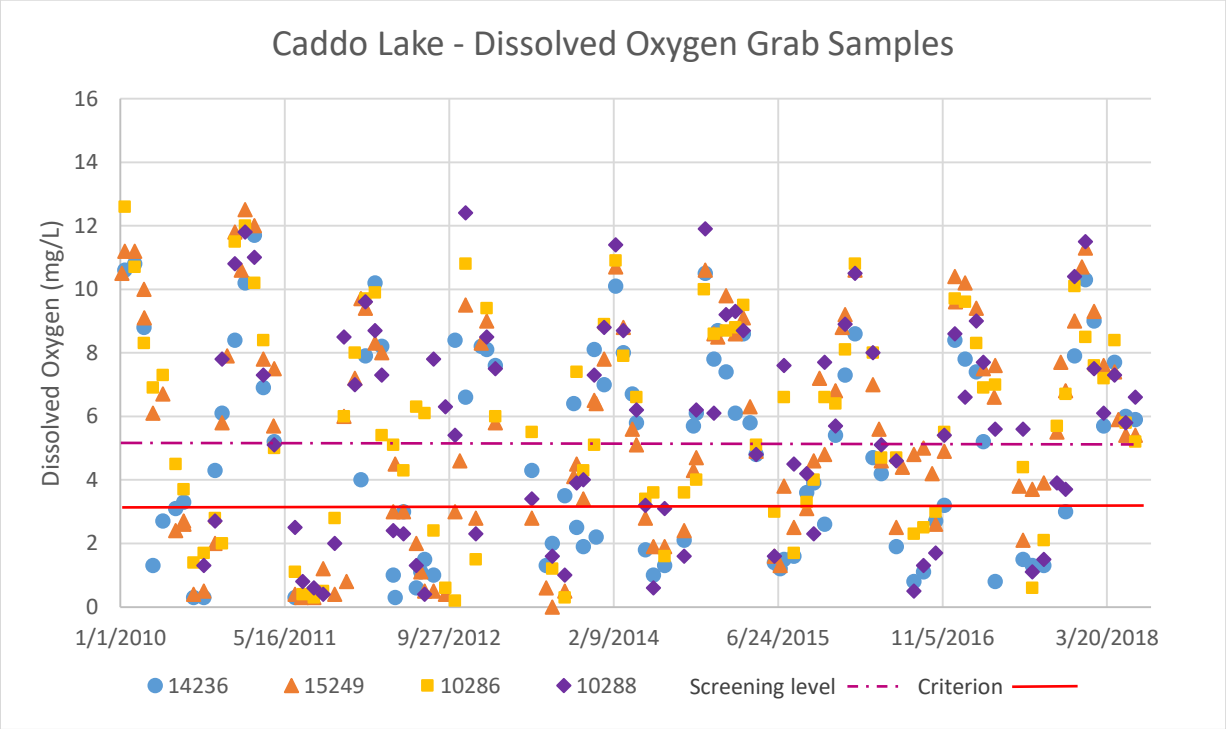

Figure 66: Graph of DO Grab results in Caddo Lake

The *Draft 2016 Integrated Report* included a concern for screening level for iron in sediment in AU 0401_01. This concern was a carry-forward from previous assessments as no data were collected during the assessment period. No iron in sediment sampling is currently scheduled.

Beginning with the 1996 assessment, AU 0401_03 Goose Prairie Arm was listed for low pH. The CLI began monthly sampling at this station for field parameters in September 2010. Data collected during the most recent assessment period showed that the AU was meeting its designated use and was delisted in the *Draft 2016 Integrated Report*. The AU should remain delisted in the next assessment period as all results were within the pH criteria.

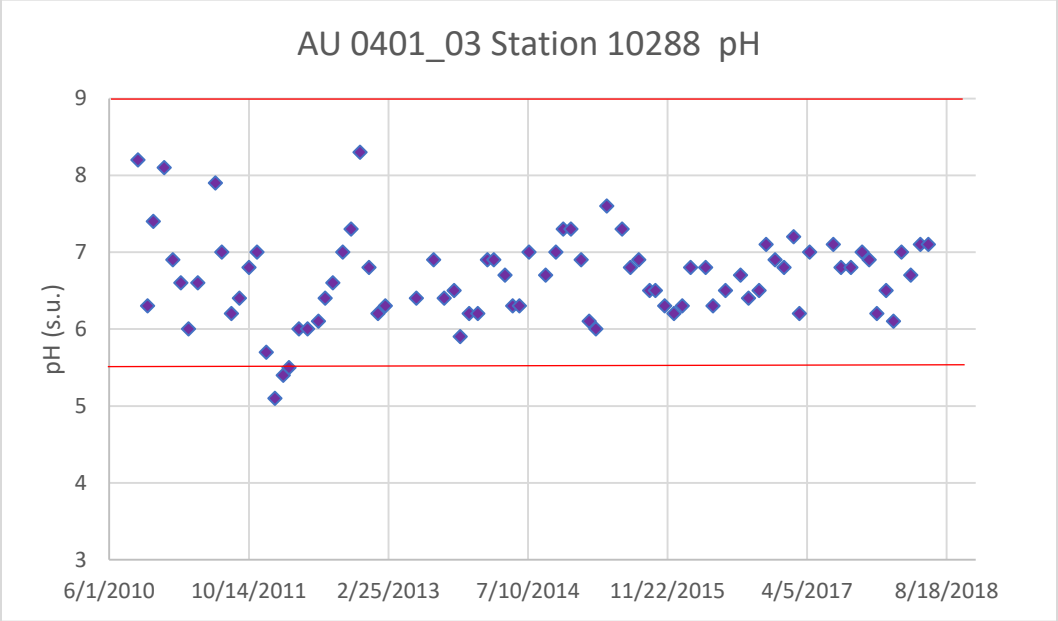

Figure 67: Graph of pH in AU 0401_03

Similarly, all recent surface pH samples were within the pH criteria across Caddo Lake.

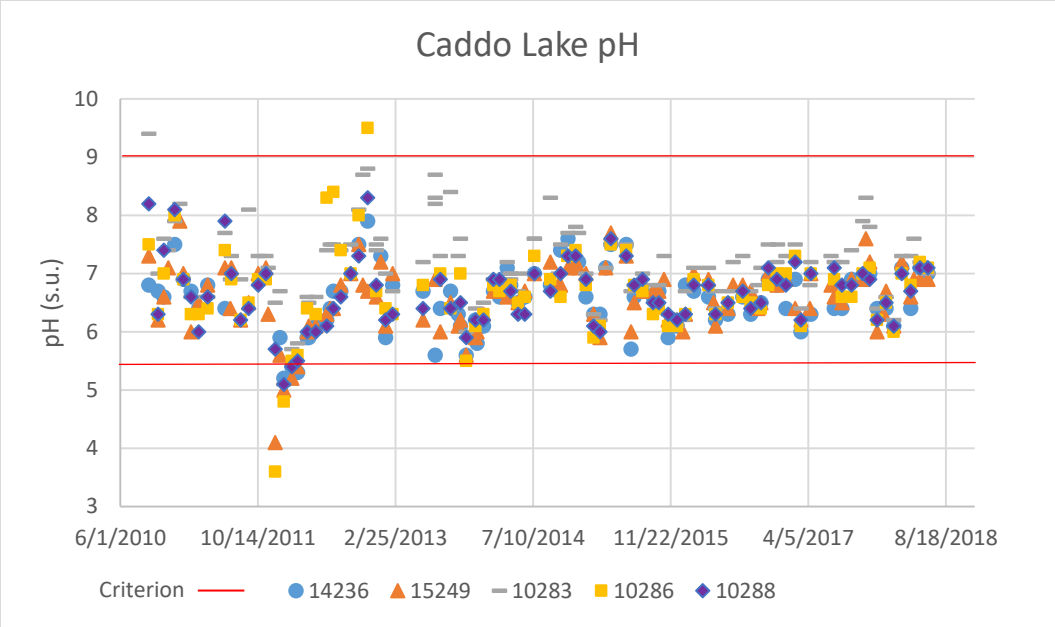

Figure 68: Graph of pH in Caddo Lake

SEGMENT 0401A – HARRISON BAYOU

Harrison Bayou (0401A) is a tributary of Caddo Lake. The stream is approximately 14 miles long and extends from its confluence with Caddo Lake toward the southwest to a point just upstream of FM 1998, east of Marshall, Texas.

Harrison Bayou was listed for low dissolved oxygen in 2000 and was included in the *Draft 2016 Texas §303(d) List* for not meeting the 24-Hour DO Average and 24-Hour DO Minimum criteria. The listing was based upon one out of six diel events not meeting the criteria. The last diel study was conducted in July 2012. Similar to many areas of Caddo Lake, these impairments were possibly due to natural conditions.

Sampling for bacteria was added to the Coordinated Monitoring Schedule in FY 2016 in response to the concern and continues into FY 2019. Quarterly monitoring is conducted at station 15508 for flow, bacteria, and for field and conventional parameters by WMS.

SEGMENT 0401B – KITCHEN CREEK

Kitchen Creek is an unclassified water body and a tributary of Caddo Lake. The stream crosses SH 49 near Smithland and drains into Clinton Lake east of Goat Island. Kitchen Creek is monitored quarterly by WMS for field parameters at station 14998 in 2019. There were no impairments or concerns for this tributary.

TRENDS

Increasing trends for specific conductance were identified at station 15249 during both the 2009 and 2014 Basin Summary Reports. These trends did not persist into the current analysis, and no trends were observed in Segment 0401.

The FY 2019 Coordinated Monitoring Schedule for Segment 0401 is shown in the table below. Five Caddo Lake stations are being monitored by the Caddo Lake Institute (CLI) and WMS in FY 2019. WMS is also collecting conventionals and bacteria samples in Harrison Bayou and collecting field parameters in Kitchen Creek on a quarterly basis.

Segment	Station	Site Description	CE	Field	Conv	Bacteria	Flow
0401_01	10283	CADDO LAKE MID LAKE	WMS/CLI	11	4	4	NA
0401_02	10286	CADDO LAKE HARRISON BAYOU ARM	CLI	11	NA	NA	NA
0401_03	10288	CADDO LAKE IN GOOSE PRAIRIE	CLI	11	NA	NA	NA
0401_05	14236	CADDO LAKE CLINTON LAKE	CLI	11	NA	NA	NA
0401_07	15249	CADDO LAKE NEAR SHORE AT END OF FM 2198 SE OF UNCERTAIN	WMS/CLI	11	4	4	NA
0401A	15508	HARRISON BAYOU AT FM 134	WMS	4	4	4	4
0401B	14998	KITCHEN CREEK AT MARION CR3416	WMS	4	NA	NA	NA

Figure 69: Table of FY 2019 CMS for Segment 0401

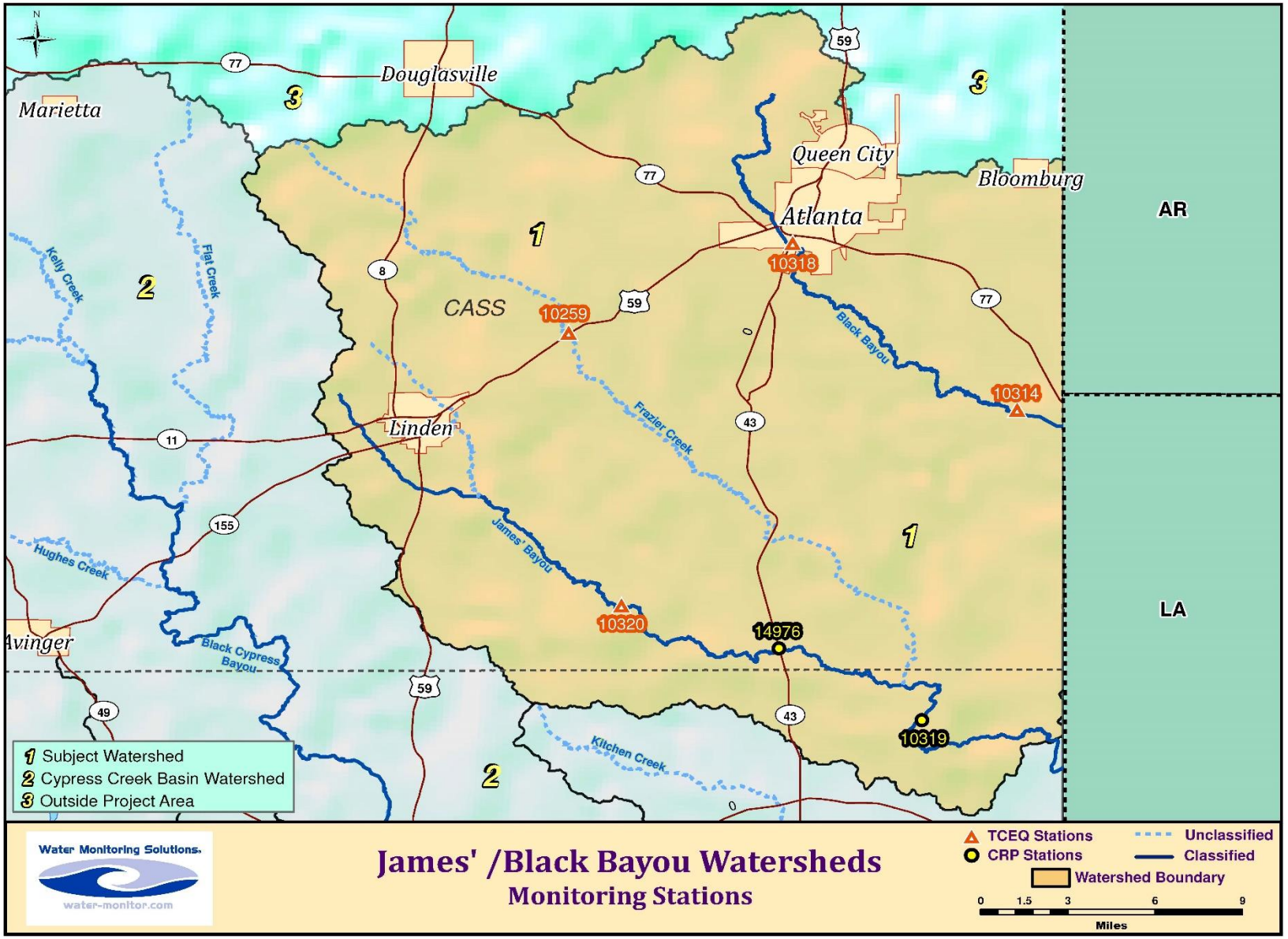

Figure 70: Map of James' Bayou and Black Bayou watersheds

SEGMENT 0406 – BLACK BAYOU

Figure 71: Photo of station 10308 in Black Bayou

Black Bayou, a relatively small watershed, emerges near Wright Patman Reservoir in northeastern Cass County, flows through Atlanta, Texas and on to the Louisiana border. The stream is intermittent in its upper reaches and traverses flat to gently rolling terrain that supports grasses, mixed hardwoods, and pines. Black Bayou is generally a slow, meandering water body with sand and clay loam bottom. During periods of low flow, the stream has a tendency to become stagnant and dissolved oxygen levels decrease under these conditions.

Black Bayou is divided into two assessment units (AU). Monitoring in the upper unit, AU 0406_02, is conducted at station 10318 which is located at the State Highway (SH) 43 crossing in Atlanta, Texas. The lower portion of the segment (AU 0406_01) extends from the Louisiana state line upstream 19.1 kilometers to the confluence with Hurricane Creek. Samples are collected at station 10314 located on Cass County Road (CR) 4659 near the Louisiana state line.

WATER QUALITY

Both assessment units of Black Bayou are listed for depressed dissolved oxygen in the *Draft 2016 Texas §303(d) List*. A review of data collected during the assessment period (December 1, 2007 – November 30, 2014) showed that three of the 24 dissolved oxygen measurements at station 10314 (AU 0406_01) fell below the criterion of 1.0 mg/L. Data collected since 2014 indicate that Black Bayou will continue to not meet the Texas State Water Quality Standards (TSWQS) for this parameter. However, it should be noted that flow was reported as zero for these low dissolved oxygen samples.

Similarly, low dissolved oxygen measurements in AU 0406_02 were also associated with no flow. Only one of the six low dissolved oxygen samples had flow reported above zero. The low dissolved oxygen listings can likely be attributed to natural conditions such as drought resulting in low stream flow.

This AU is impaired for *E. coli* bacteria. First listed in 2006, the AU continues to exceed the TSWQS of 126 MPN/100 mL with a geometric mean of 354.11 MPN/100 mL. There are no permitted dischargers in this reach of the stream. Elevated bacteria is probably due to non-point sources such as livestock and wildlife. A Recreation Use Attainability Analysis may be considered to address this listing.

There is also a concern for high chlorophyll *a* in this assessment unit. Thirty percent of the 26 samples exceeded the screening level of 14.1 µg/L. The mean of these exceedances was 46.39 µg/L.

In FY 2019, quarterly sampling for flow, bacteria, conventional, and field are scheduled to be collected by TCEQ Region 5 at stations 10314 (Black Bayou at Cass CR 4659) and 10318 (Black Bayou at SH 43).

TRENDS

Declining trends for specific conductance, dissolved oxygen, and pH were identified in Segment 0406 in the *2014 Cypress Creek Basin Summary Report*. However, none of these trends persisted into the current analysis. No trends continued into the current analysis.

BIOLOGICAL MONITORING

One way to determine if a stream is healthy is by measuring the diversity of aquatic life in the water. Biologists sample streams and collect data about aquatic life such as fish and benthic macroinvertebrate organisms (insects, mussels, worms, and other bottom-dwelling aquatic animals) to make a broad assessment of aquatic ecosystem health. Data from biological monitoring and habitat assessments are analyzed through a series of scoring metrics called an Index of Biotic Integrity or IBI. The IBI uses criteria such as a species' sensitivity to pollutants and population diversity to rank water bodies into five categories: exceptional, high, intermediate, limited and minimal. As a rule, perennial streams are presumed to support a high aquatic life use, but periodic intensive surveys such as those done by TCEQ and Water Monitoring Solutions, Inc. (WMS) offer confirmation of the presumption and a holistic view of the health of streams in the Cypress Creek basin.

The *Draft 2016 Integrated Report* showed concerns for not meeting the Aquatic Life Use designations in Black Bayou. Concerns for non-attainment in AU 0406_01 included both fish and benthic macroinvertebrates while only benthics were shown in AU 0406_02. A concern for the habitat screening level was also included in the lower assessment unit.

In the *2009 Cypress Creek Basin Summary Report*, a Use Attainability Analysis conducted by TCEQ was discussed. The study was conducted by the TCEQ in 2003 and 2004. Of note was the absence of darter taxa which had been present during previous biological sampling events, and at least one darter species had been collected at every station in the Cypress Creek Basin since 2002.

As a result of these findings, biological monitoring was conducted at stations 10314 and 10318 in 2012 and in 2014. Figure 72 details the sampling results by date and category. Although, according to local residents, station 10318 had gone completely dry during the 2011 drought, the IBI for fish scored in the high range. The darter species, *Etheostoma gracile* (Slough Darter) and *Etheostoma chlorosomum* (Bluntnose Darter) were collected during all of the field efforts. The metrics calculated the habitat at borderline intermediate - high while the benthics were intermediate.

Category	9/6/2012	10/11/2012	5/21/2014	7/31/2014
Fish	49 (High)	41 (Int.)	43 (High)	45 (High)
Benthos	22 (Int.)	25 (Int.)	23 (Int.)	22 (Int.)
Habitat	19 (Int.)	20 (High)	19 (Int.)	20 (High)

Figure 72: Table of Biological Sampling Results in Black Bayou

Despite being the most downstream site, station 10314 has been regularly reported as intermittent or having low flow conditions. The absence of darter species at this station during UAA sampling was possibly due to low flow conditions rather than due to contaminants or perturbed water quality. Sampling was scheduled at station 10314; unfortunately, the station was either completely dry or had only small pools during every sampling event except May 2014.

The results of the May 2014 monitoring showed the IBI for fish to be in the high category; however, no darter species were collected. Both the habitat and benthic macroinvertebrates scored intermediate.

Figure 73: Photos of station 10314 in May 2014 (left) and July 2014 (right)

It should be noted that habitat and benthic macroinvertebrates are scored using state-wide metrics while the fish IBI is regionalized. Rapid Bioassessments for benthic organisms in the Cypress Creek Basin often fall into the Intermediate category (Crowe and Bayer, 2005, Rogers and Harrison, 2007). One might infer that impaired water quality is negatively affecting benthic diversity; however, the benthic population is very diverse with over 285 species collected in the watershed.

Impaired water quality that negatively affects the benthic community should also negatively impact the fish community. Biological monitoring results indicate this is not the case in the Cypress Creek Basin. Rather, state-wide scoring metrics may not accurately reflect results in the ecoregions in the basin. The current metrics include an abundance of EPT taxa (Ephemeroptera, Plecoptera, Trichoptera) and percent Elmidae. Regionalization of benthic scoring metrics will possibly show more correlation between fish and benthic community scoring.Although species within the EPT families are found in the basin, due to the lack of riffles, emergent plants, clear water, and rock/gravel substrate, these species are not abundant. Many species of mayflies (Ephemeroptera) and stone flies (Plecoptera) in particular have fine gills that cannot function efficiently in the turbid waters commonly found in the Cypress Creek Basin, thus are seldom present in abundant numbers.

These organisms, along with the caddisflies (Trichoptera) and riffle beetles (Elmidae) require stable substrates, such as gravel or rock bed streams. Only a few species within these four families are adapted to the turbid water and silty bottomed streams commonly found in East Texas. While the lack of diverse habitat plays a major role in limiting the number of intolerant benthic species, ecoregion-specific metrics would more adequately evaluate the benthic community. TCEQ recognizes this disparity and is currently developing ecoregion-specific metrics to address this issue.

The average HQI score in the basin is on the borderline of Intermediate and High. Some components of the habitat assessment metrics include the number of riffles, types of substrate, and emergent vegetation. Many streams in the basin will have an artificially reduced HQI score due in part to these metrics (Crowe and Hambleton, 1998).

Most perennial streams in East Texas function as glide/pool rather than as riffle/run. Streams typically have low velocity and due to the murkiness of the water, it is often difficult to determine where a pool begins and ends without making stream width and depth measurements. Riffles are not common in the basin and are mostly found in the western

portion of the basin. When riffles are present, they are usually found in small, intermittent streams that often become completely dry without pools during extended periods of drought.

While it is common to find aquatic plants along stream margins, due to the high turbidity, erosional sediments and heavy tree canopy, emergent macrophytes are seldom encountered within the stream channel.

Even though the riparian zone may be natural and show few, if any, signs of human impact, the habitat may still score at the low end of the High range or at the upper end of the Intermediate range. For example, Frazier Creek is considered an ecoregion reference stream and has been classified as a "Least Disturbed Stream" (Bayer *et al.*, 1992; Linam *et al*., 1999). Due to these designations, one would expect HQI scores for Frazier Creek to be in the High or Exceptional categories. However, the assessors scored the habitat at 18.5 (Intermediate) during both monitoring events in 2003. While habitats such as riffles and emergent vegetation are important to supporting diverse biota, an ecoregion-specific habitat assessment would better describe streams within the Cypress Creek Basin especially when considering that the least impacted reference sites should represent realistic, attainable conditions for aquatic ecosystems (Omemik, 1995).

SEGMENT 0407 – JAMES' BAYOU

Figure 74: Photo of seining in Jims Bayou at station 14976

The headwaters for James' Bayou are located west of Linden. The stream flows toward the southeast through pine and hardwood forests before crossing the Louisiana border to ultimately flow into Caddo Lake. In 2018, James' Bayou was monitored at four sites for conventional and field parameters and bacteria.

WATER QUALITY

As a result of the change to the TSWQS, AU 0407_01 was delisted for low dissolved oxygen and pH. Data collected during the assessment period met the DO and pH criteria.

In 2014, this AU became listed for benthic macroinvertebrate and fish communities. These listings were a carry-forward from previous assessments due to inadequate data to assess the reach. The *Draft 2016 Integrated Report* also included a concern for habitat.

Through coordinated monitoring meetings and stakeholder input, biological monitoring was recommended to address the impairments and concern. Monitoring was conducted at station

14976, located at SH 43, in 2016 and 2017. The field effort was not conducted during this assessment period (December 1, 2007 – November 30, 2014), but indicate that AU 0407_01 meets its aquatic life use designations. For FY 2019, WMS is scheduled to collect bacteria, conventional, field parameters, and flow quarterly at stations 14976 and 10319.

Since 2000, the upper assessment unit 0407_02 of James' Bayou has been listed for not meeting the 24-Hour dissolved oxygen average and minimum criteria. The listing in the *Draft 2016 Integrated Report* is a carry-forward due to inadequate data.

In 2006, the upper reach became impaired for elevated *E. coli* bacteria. The *Draft 2016 Integrated Report* also showed a concern for not meeting the benthic macroinvertebrate community criterion.

From FY 2015 through FY 2018, WMS conducted 24-Hour DO monitoring at station 10321 four times per year to address the low dissolved oxygen impairments. Through March 2018, data from thirteen diel events had been accepted into the Surface Water Quality Monitoring Information System (SWQMIS). Three of the 24-Hour DO average and 24-Hour DO minimum results failed to meet the 4.0 mg/L and 3.0 mg/L criteria, respectively. The flow was reported as zero for all three events. The other ten events had stream flow and the mean 24-Hour DO average was 8.25 mg/L while the mean 24-Hour DO minimum was 8.01 mg/L.

Only seven bacteria samples, with a geometric mean of 25.99 MPN/100 mL, were evaluated for the *Draft 2016 Integrated Report*. As a result of the limited data set, the AU remained on the *Draft 2016 Texas §303(d) List*. Due to stakeholder input, WMS began sampling in FY 2013 at station 10321 quarterly for *E. coli*. Results for samples collected from January 2013 through May 2018 had a geometric mean of 88.5 MPN/100 mL, well below the 126 MPN/100mL criterion. During FY 2019, TCEQ Region 5 is scheduled to collect bacteria and flow data on a monthly basis in this assessment unit.

TRENDS

An increasing trend for pH was observed at station 10321 in the *2009 Cypress Creek Basin Summary Report* but did not continue into current analysis.

BIOLOGICAL MONITORING

James' Bayou was impaired for fish and benthic macroinvertebrate communities along with a concern for impaired habitat screening level. Biological monitoring was conducted at station

14976 (Jim's Bayou at SH 43) in 2016 and 2017. Figure 75 details the sampling results by date and category. Preliminary review of the data indicated that the stream met its high aquatic life use criterion for the fish community but not for the benthic community and habitat. As discussed in the Biological Monitoring section for Black Bayou, the reasons for not meeting the benthic macroinvertebrate and habitat standards is likely a result of the use of state-wide rather than regionalized scoring metrics.

Category	6/16/2016	8/2/2016	5/10/2017	7/6/2017
Fish	37 (Int.)	42 (High)	51 (High)	46 (High)
Benthos	22 (Int.)	28 (Int.)	23 (Int.)	26 (Int.)
Habitat	15 (Int.)	15 (Int.)	16.5 (Int.)	17.5 (Int.)

Figure 75: Table of Biological Sampling Results in James Bayou

SEGMENT 0407A –BEACH CREEK

Beach Creek, an unclassified water body, originates half a kilometer upstream of US 59 in central Cass County and flows southeast for 8.4 kilometers to its confluence with James' Bayou. The stream is intermittent in its upper and middle reaches. The lone station on Beach Creek (10256) is located at FM 125. There are no concerns or listings in the *Draft 2016 Integrated Report*. No samples have been collected in Beach Creek since August 2004, and no sampling is scheduled in this reach in FY 2019.

SEGMENT 0407B –FRAZIER CREEK

Frazier Creek is an unclassified water body that originates near US 59 in Cass County and flows southeast for 38.6 kilometers to its confluence with James' Bayou in Marion County.

There is a concern for low dissolved oxygen grab screening level in the *Draft 2016 Integrated Report* for this reach. Seven data points were available during the assessment period with no dissolved oxygen values reported below the 3.0 mg/L screening level. Further, none of the nineteen dissolved oxygen measurements made from October 2013 through March 2018 fell below the screening level. TCEQ Region 5 is scheduled to collect field parameters and flow at station 10259 (Frazier Creek at US 59) quarterly in FY 2019.

CONCLUSIONS & RECOMMENDATIONS

Dissolved oxygen, *E. coli*, and mercury in fish tissue remain the most common impairments in the Cypress Creek Basin. A review of the data supported most impairments and concerns shown in the *Draft 2016 Integrated Report*.

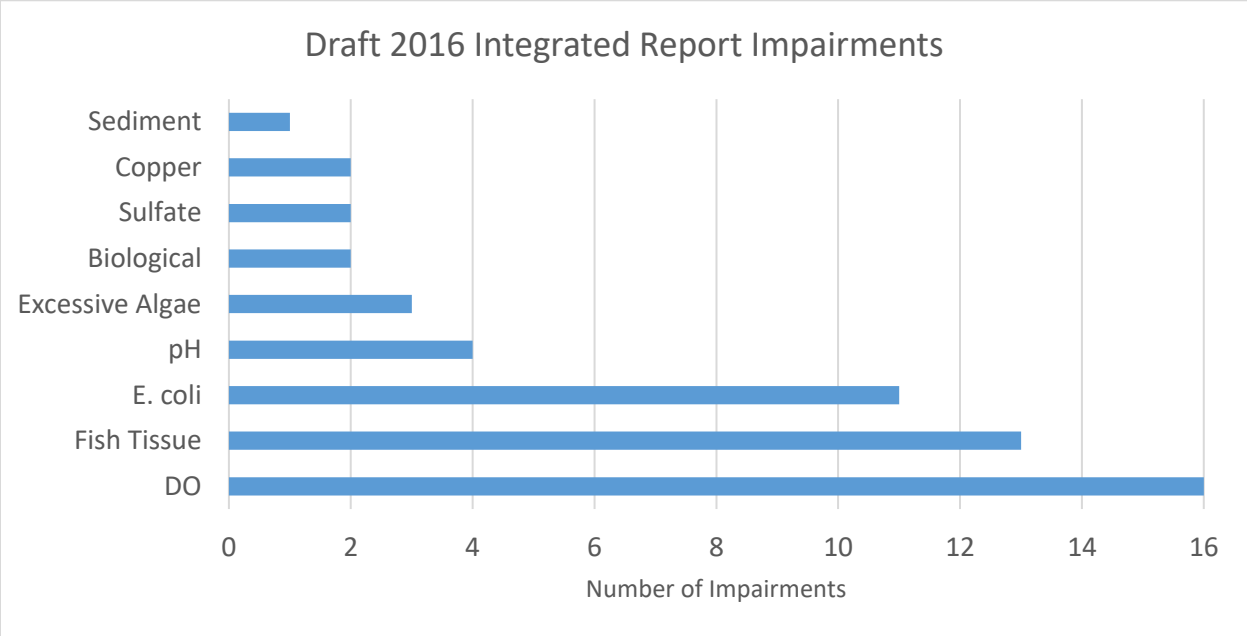

Figure 76: Impairments shown in the Draft 2016 Integrated Report

Due to data meeting the pH criterion, the Goose Prairie Arm of Caddo Lake was removed from the *Draft 2016 Texas §303(d) List* for pH. As a result of changes to the TSWQS, some assessment units of Big Cypress Creek below Lake O' the Pines and James Bayou were delisted for pH while some assessment units in Black Cypress Creek, Little Cypress Creek, and James Bayou were delisted for DO. New impairments on the §303(d) List were high pH in Lake O' the Pines and Nutrient Reservoir Criteria and high pH in Lake Cypress Springs. Segment 0408 – Lake Bob Sandlin was the only segment in the Cypress Creek Basin with no impairments or concerns.

Low dissolved oxygen impairments were found in most segments except for Lake Bob Sandlin and Big Cypress Creek below Lake Bob Sandlin. In the stream segments, low DO readings were often associated with low flow, especially in the intermittent streams of Black Bayou, James Bayou, and Segment 0410A of Black Cypress Creek. The pervasive drought most likely exacerbated the low DO conditions leading to these impairments.

The arms of Caddo Lake are shallow, swamp-like, and from May to October, the water surface is often completely covered by non-native vegetation preventing sunlight from entering the water column. Low dissolved oxygen was common in these areas, especially from samples collected during the summer months. Despite regularly recording low DO at the four stations in the upper portion of Caddo Lake, low DO readings were rare at the mid-lake station, 10283.

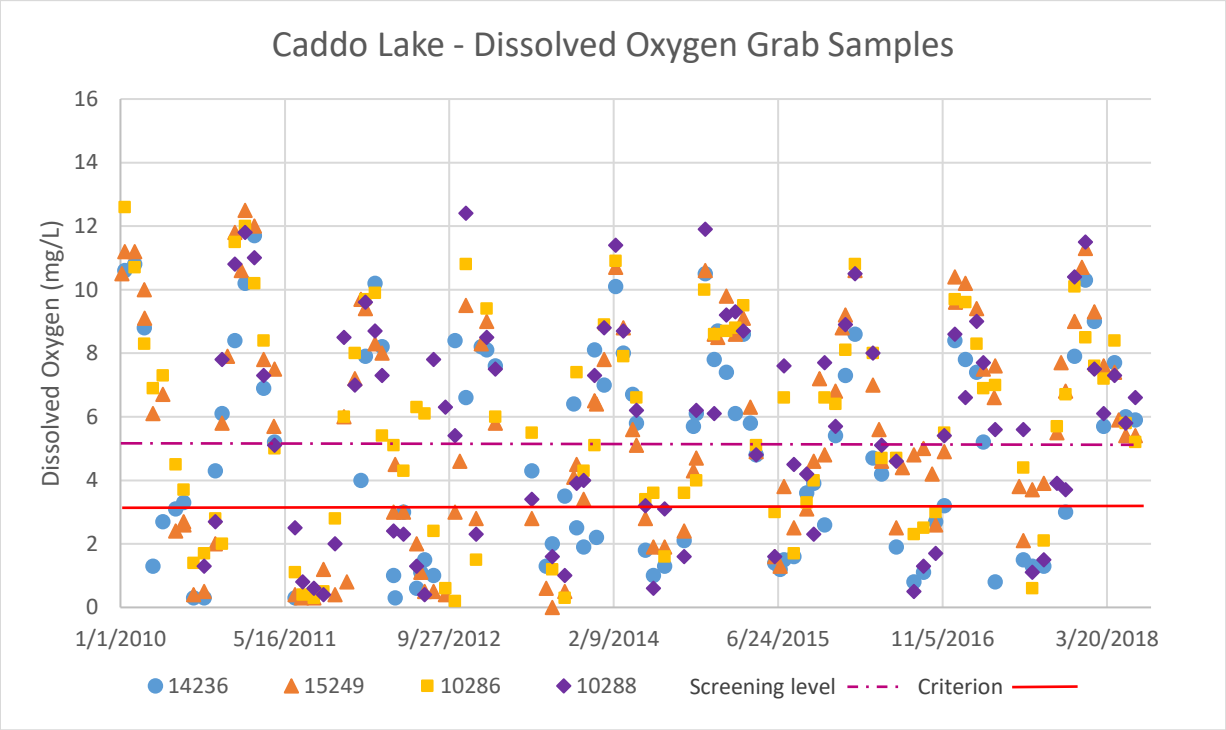

Figure 77: Graph of dissolved oxygen sampling results in Caddo Lake

Elevated bacteria levels appears to be a significant threat to the water quality of the Cypress Creek Basin. Impairments for *E. coli* were shown in many stream segments in the watershed. *E. coli* listings included Big Cypress Creek and its tributaries, Tankersley Creek and Hart Creek; Little Cypress Creek and its tributaries, Lilly Creek and South Lilly Creek; Black Cypress Creek; Black Bayou; and James Bayou. Sources of bacteria include livestock, pets, wildlife, and improperly treated human waste, such malfunctioning on-site septic systems.

A Comprehensive Recreational Use Attainability Analysis (RUAA) was conducted in Big Cypress Creek, Tankersley Creek, and Hart Creek in 2009 through 2011 to address the impairment. The project was conducted to discover whether these streams were being used for primary contact recreation of if secondary contact recreation was a more appropriate use standard. The comprehensive RUAA found no evidence of primary contact recreation occurring within the study area, and the TCEQ is considering the appropriate designation. Similarly, an RUAA was

conducted South Lilly Creek in 2016. The results from this study also indicated that the stream was not being used for primary contact recreation. Due to the mostly rural population and abundance of public reservoirs, comprehensive RUAA studies should be conducted in stream segments to address all *E. coli* impairments within the basin.

Nutrient and sulfate concentrations in Tankersley Creek, Hart Creek, and Big Cypress Creek were inversely correlated with stream flow suggesting that the primary contributor of these constituents was point-sources. A multi-million dollar upgrade to the Pilgrim's Pride WWTP, completed in 2015, measurably reduced the amount of phosphorus entering Tankersley Creek and Big Cypress Creek. Although nitrate and sulfate were lower in these streams after the plant upgrades were completed, these reductions may have been the result of higher stream flows and releases from Lake Bob Sandlin.

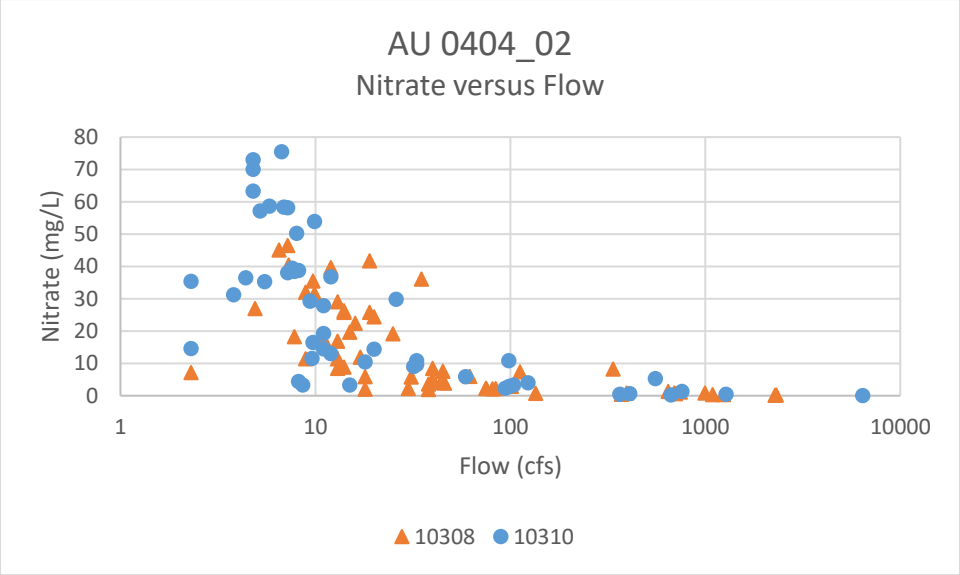

Figure 78: Graph of nitrate versus flow in AU 0404_02

The 2014 Cypress Creek Basin Summary Report found statistically significant increasing nutrient trends in Big Cypress Creek below Lake Bob Sandlin and subsequently increasing chlorophyll *a* trends in Lake O' the Pines. As a result of the lack of freshwater inflow into Big Cypress Creek, due to the pervasive drought and reduced releases from Lake Bob Sandlin, the stream became dominated by effluent. The statistically significant increasing Specific Conductance/Total Dissolved Solids trends in Big Cypress Creek below Lake Bob Sandlin identified in the 2014 report further supported this reasoning.

Despite the past four years of near historic rainfall and releases from Lake Bob Sandlin, recent data suggest that the process of eutrophication is occurring throughout the upper portion of

the Cypress Creek Basin. This conclusion is evidenced by statistically significant increasing pH trends in Lake Bob Sandlin, Lake O' the Pines, and Big Cypress Creek below Lake O' the Pines. Increasing chlorophyll levels and strong correlations between pH and dissolved oxygen percent saturation readings in Lake Cypress Springs and in Lake O' the Pines along with the decreasing transparency trend in Lake O' the Pines lend further credence to this assertion.

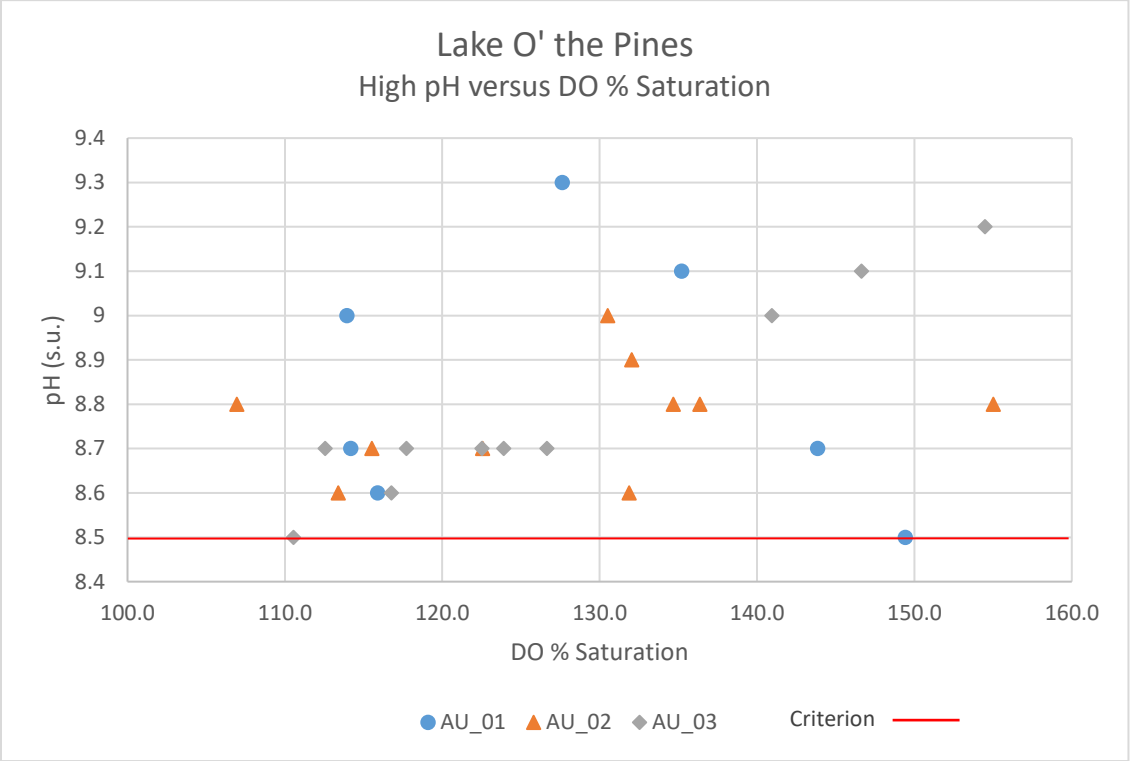

Figure 79: Graph of high pH versus DO saturation in Lake O' the Pines

Although elevated chlorophyll *a* and high pH were poorly correlated, excessive algal production should not be discounted as the basis for increasing pH in these water bodies. Grab samples are collected at 0.3-meter below the water surface, and the diurnal movement of phytoplankton vertically within the water column is well-documented. As a result, algal populations may have been above or below the 0.3-meter depth at the time of sampling. Since most samples were collected during the time of peak productivity, the percent saturation of dissolved oxygen provided a reasonable surrogate parameter for chlorophyll *a*. In nearly all cases where a high pH was measured, dissolved oxygen was also reported above 100% saturation.

Eutrophication is the most significant threat to water quality in the Cypress Creek Basin. The *Draft 2016 Integrated Report* classified Lake Cypress Springs as being an eutrophic reservoir. A review of the current data suggest that Lake Bob Sandlin and Lake O' the Pines are becoming

eutrophic, as well. The effects of eutrophication may reduce the aesthetics of the reservoir, reduce its biological diversity, and increase the cost of drinking water treatment.

Efforts to reduce nutrient loadings through the implementation of best management practices, such as those used in the Lake O' the Pines TMDL, should be considered across the entire Cypress Creek Basin.

FUTURE STUDY

Areas of future study that should be considered are:

- Diel monitoring in Lake O' the Pines for dissolved oxygen and pH could be used to evaluate the diel ranges of these parameters. Continuous monitoring data would be beneficial as a comparison with grab sampling conducted by TCEQ Region 5.
- A targeted study in Tankersley Creek and the upper reach of Big Cypress Creek could identify the source(s) of excess sulfate within the watershed. Once the source(s) is identified, a process to reduce its introduction into the water body could be implemented.
- Recreational Use Attainability Analysis should be performed in all watersheds with bacteria impairments.
- Continue biological monitoring studies to evaluate the biotic integrity of stream segments.

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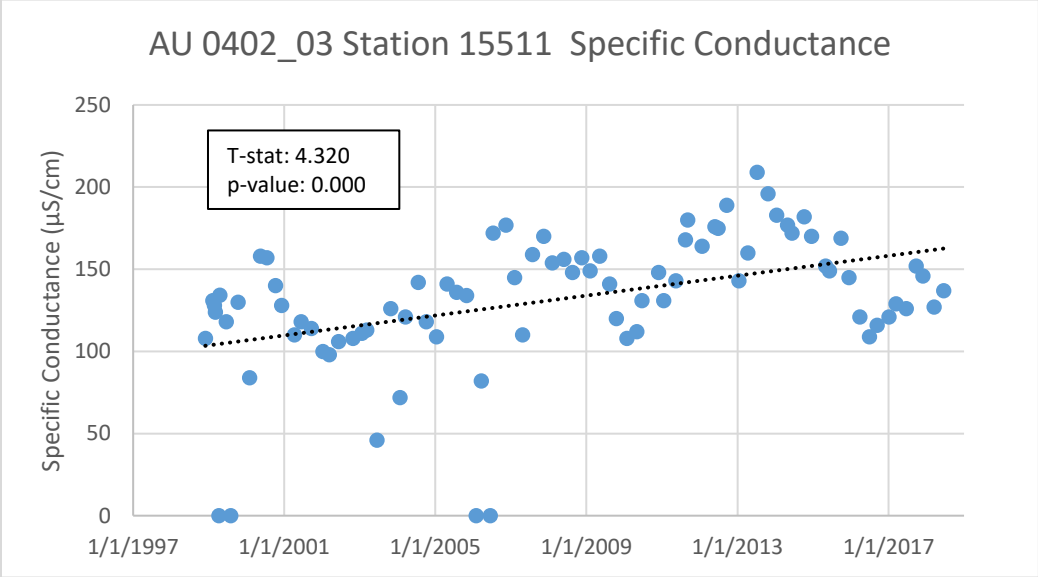
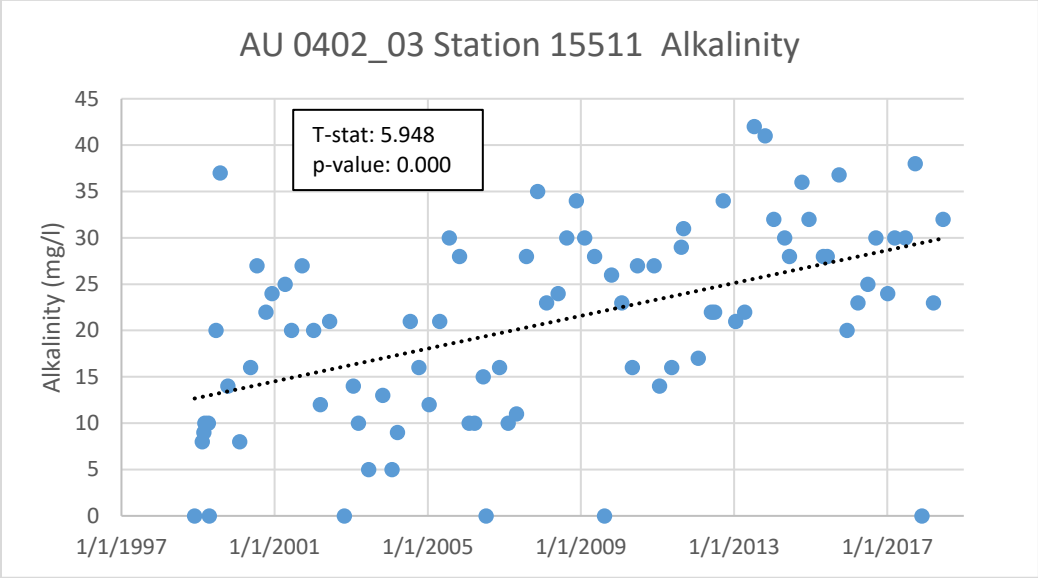
APPENDIX

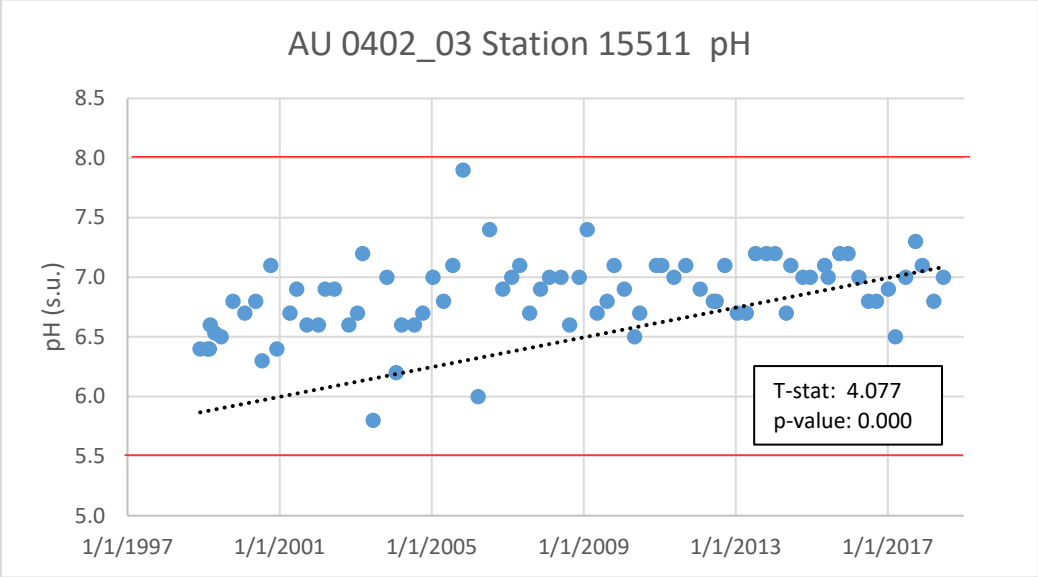
STATISTICALLY SIGNIFICANT TRENDS

Segment 0402 Big Cypress Creek below Lake O' the Pines

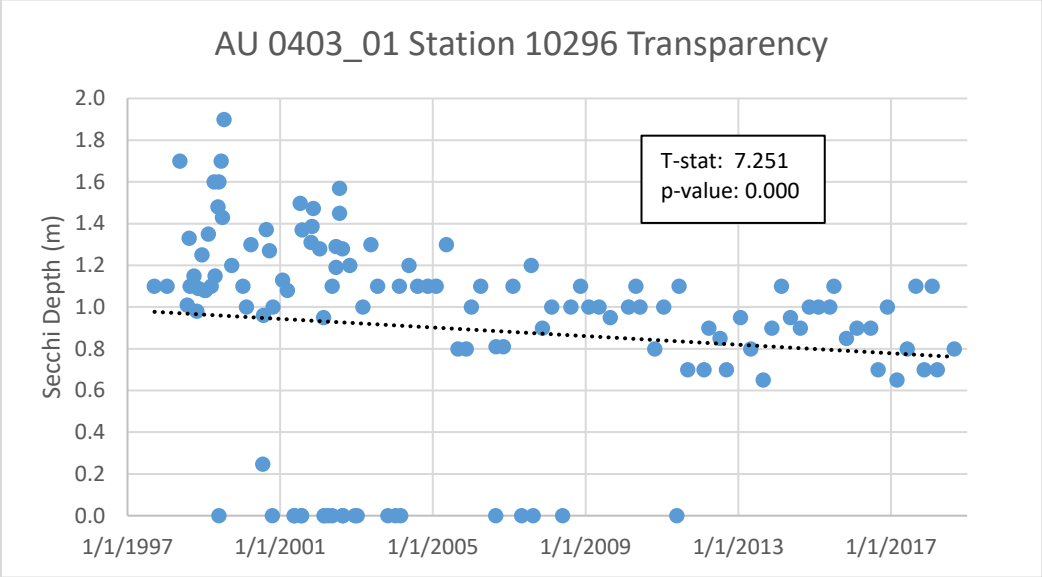


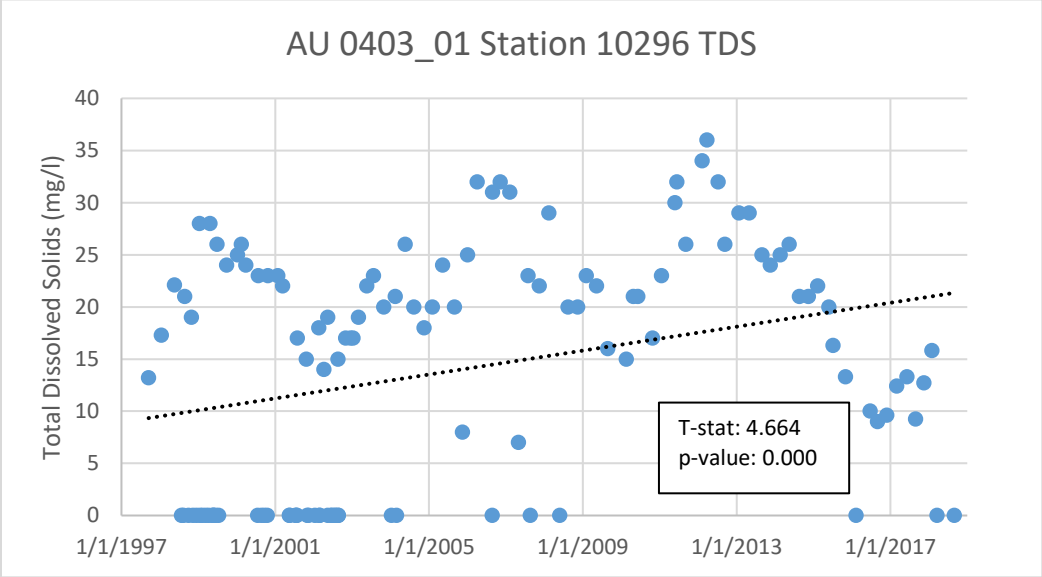


Segment 0402 Big Cypress Creek below Lake O' the Pines

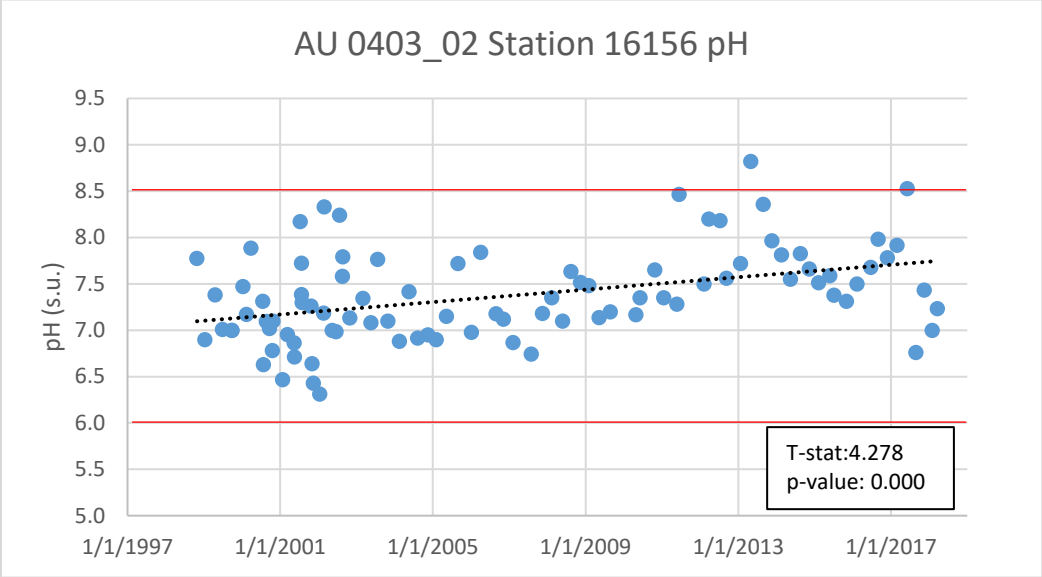


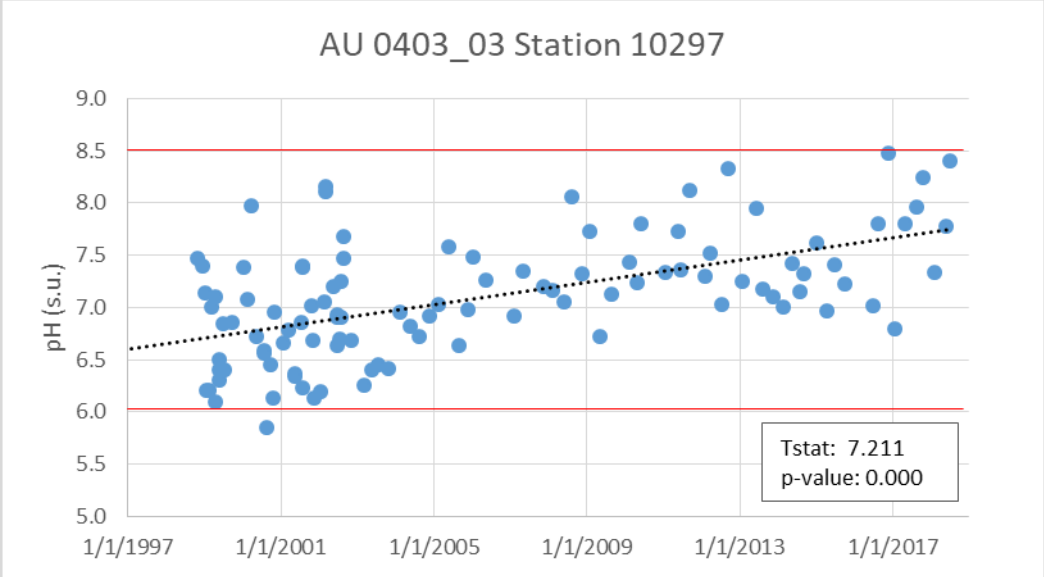
Segment 0403 Lake O' the Pines



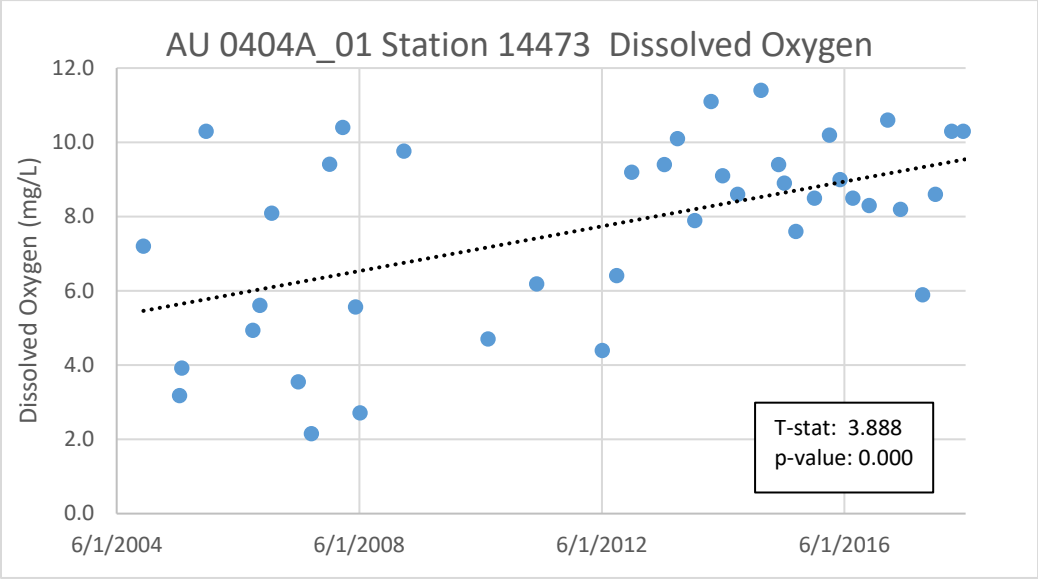


Segment 0403 Lake O' the Pines

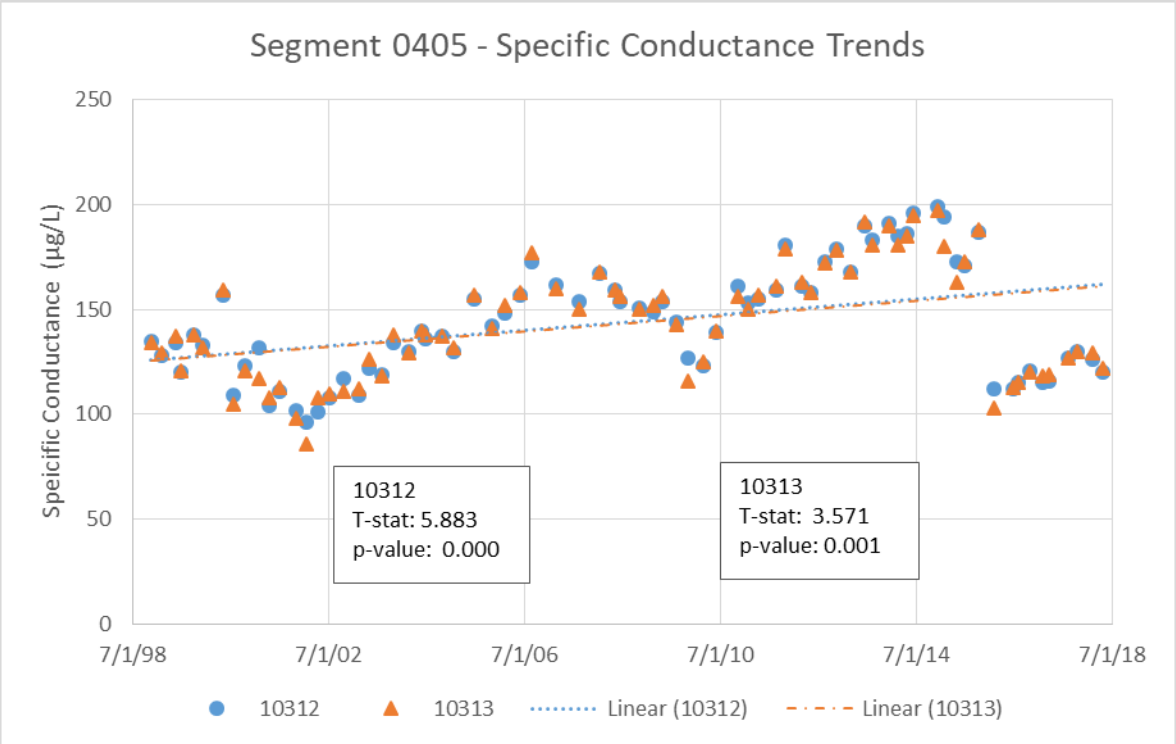




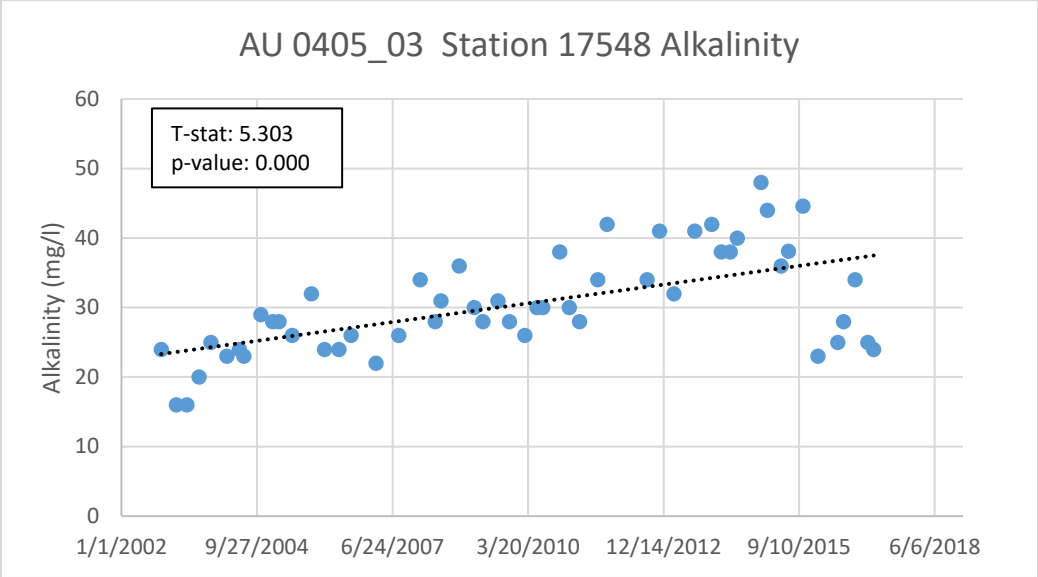
Segment 0404A Ellison Creek Reservoir

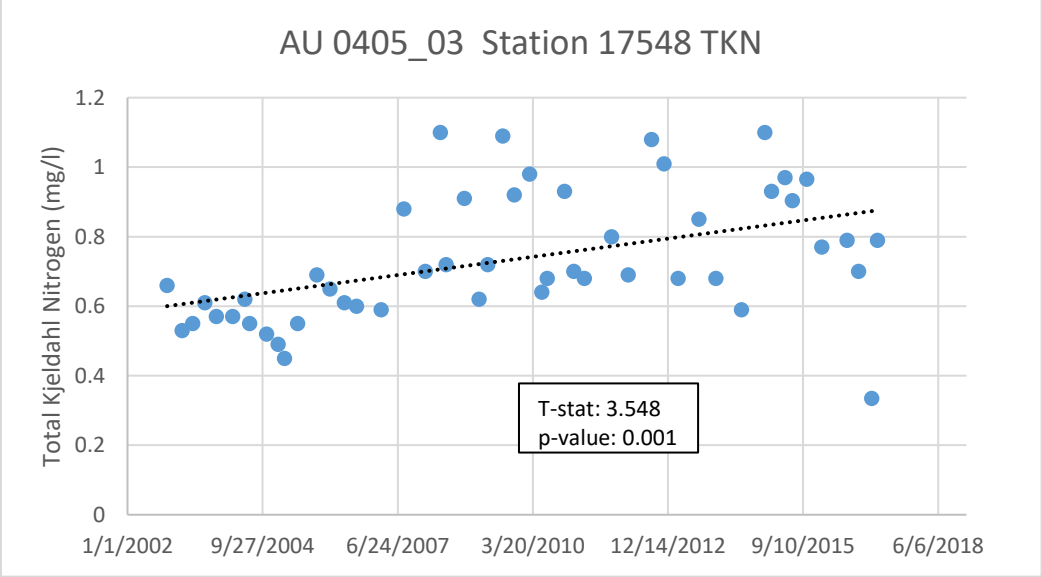


Segment 0405 Lake Cypress Springs

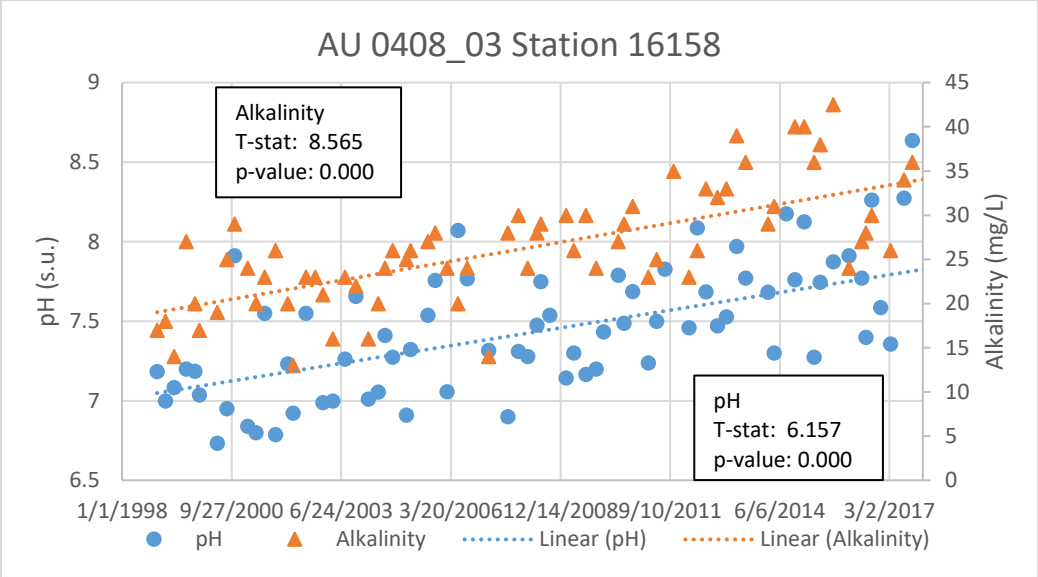


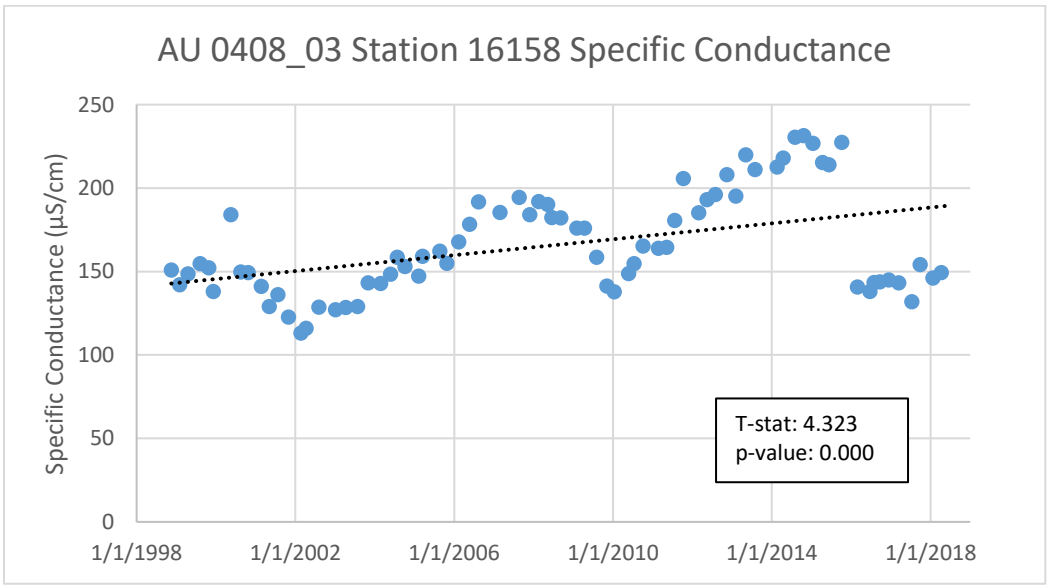
Segment 0405 Lake Cypress Springs



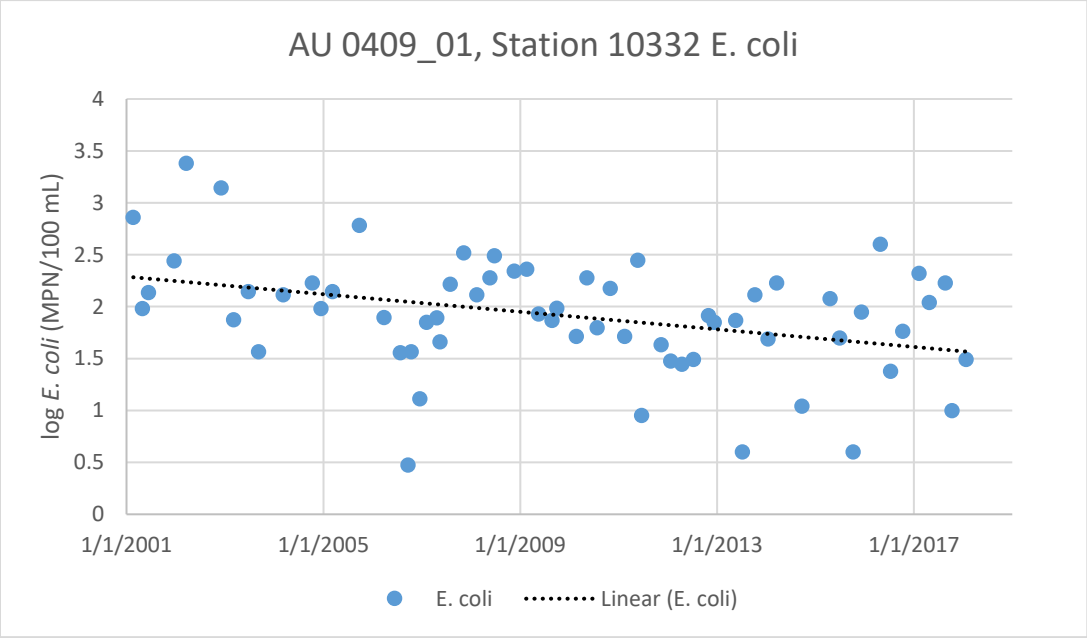


Segment 0408 Lake Bob Sandlin

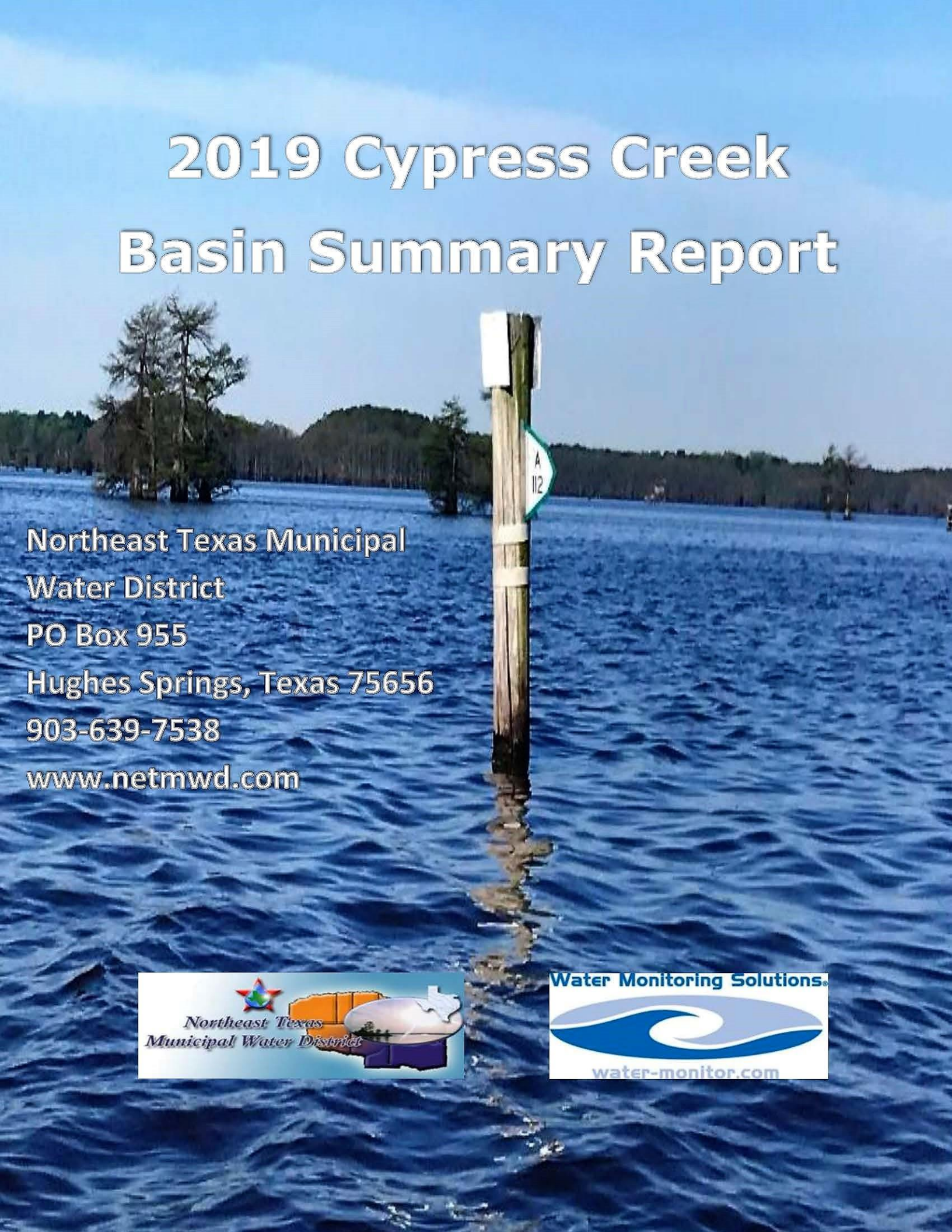




Segment 0409 Little Cypress Creek (Bayou)



2019 Cypress Creek Basin Summary Report



Northeast Texas Municipal
Water District
PO Box 955
Hughes Springs, Texas 75656
903-639-7538
www.netmwd.com

Northeast Texas Municipal Water District

Water Monitoring Solutions.
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