2024 CYPRESS CREEK BASIN HIGHLIGHTS REPORT

Texas Commission on Environmental Quality

Northeast Texas Municipal Water District

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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 Highlights 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 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: Lake Cypress Springs between the Dam and Midlake stations

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 joint NETMWD and Sulphur River Basin CRP Steering Committee meeting was held in March 2024 at North Texas Community College and virtually via Zoom. Topics included information on the construction activities of Lake Ralph Hall, Aquatic Invasive Species, updates on the Total Phosphorus Load Agreement and NETMWD On-Site Septic Facility program, and discussions of the Sulphur River Basin Summary Report and Cypress Creek Basin Highlights Report.

NETMWD plans and coordinates monitoring efforts with other basin entities, the TCEQ monitoring staff, Caddo Lake Institute, 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 Quality Assurance Project Plan.

Visit NETMWD to join the Clean Rivers Program Steering Committee or contact Robert Speight at 903-639-7538 or rspeight@netmwd.org.

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LIST OF ACRONYMS AND ABBREVIATIONS

ALM	Aquatic Life Monitoring
ALU	Aquatic Life Use
ANOVA	Analysis of Variance
AU	Assessment Unit
CCSUD	Cypress Springs Special Utility District
cfs	Cubic feet per second (measurement of stream flow)
CN	Concern for Non-attainment of water quality criterion
CS	Concern for Screening level
CRP	Clean Rivers Program
DO	Dissolved Oxygen
FCWD	Franklin County Water District
FM	Farm-to-Market Road
FY	Fiscal Year
IR	Integrated Report
LOQ	Limit of Quantitation
MGD	Million Gallons per Day
mg/L	milligrams per liter
MPN/100 mL	Most Probable Number per 100 milliliters (bacteria measurement units)
NETMWD	Northeast Texas Municipal Water District
NS	Non-support of water quality criterion
R5	TCEQ Region 5 (Tyler)
SH	State Highway
s.u.	standard units (measurement of pH)
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPLA	Total Phosphorus Load Agreement
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
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
µg/L	micrograms per liter

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, Texas Parks and Wildlife Department (TPWD), U. S. Geological Survey, Texas State Soil and Water Conservation Board, and Texas A&M University – Agrilife/ Texas Water Resources Institute.

Most years, 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 issues that may affect water quality within the basin.

Figure 1: Clean Rivers Program Steering Committee Meeting, March 21, 2024

THE CYPRESS CREEK BASIN

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 from the 1950's. This drought was followed by near-historic flooding in 2015 and 2016 which ended the drought.

Rainfall records at the Fort Sherman Dam (Lake Bob Sandlin), located in the upper portion of the basin, have been maintained since its completion in 1978. Over the past forty-five years, annual precipitation has averaged around 51.5 inches. However, from 1979 to 1999, the average was 53.7 inches per year, as compared to 49.6 inches from 2000 through 2023. During the 1999 - 2014 drought, an annual average of 48 inches of rain was recorded. At slightly over 25 inches of precipitation, 2005 was the driest year on record and was also the first year that no water had been released from Lake Bob Sandlin since its completion. In 2023, the area received below average rainfall of 45.7 inches with June being the wettest month at 8.41 inches of precipitation.

Much of the basin experienced some level of drought in 2022, especially from January through March and throughout the summer. Figure 2 presents the U.S. Drought Monitor data for the basin in Fiscal Years (FY) 2022 and 2023. The drought monitor is updated weekly and reports the percent of the area in the five stages of drought: D0 – abnormally dry; D1 – moderate drought; D2 – severe drought; D3 – extreme drought; and D4 – exceptional drought.

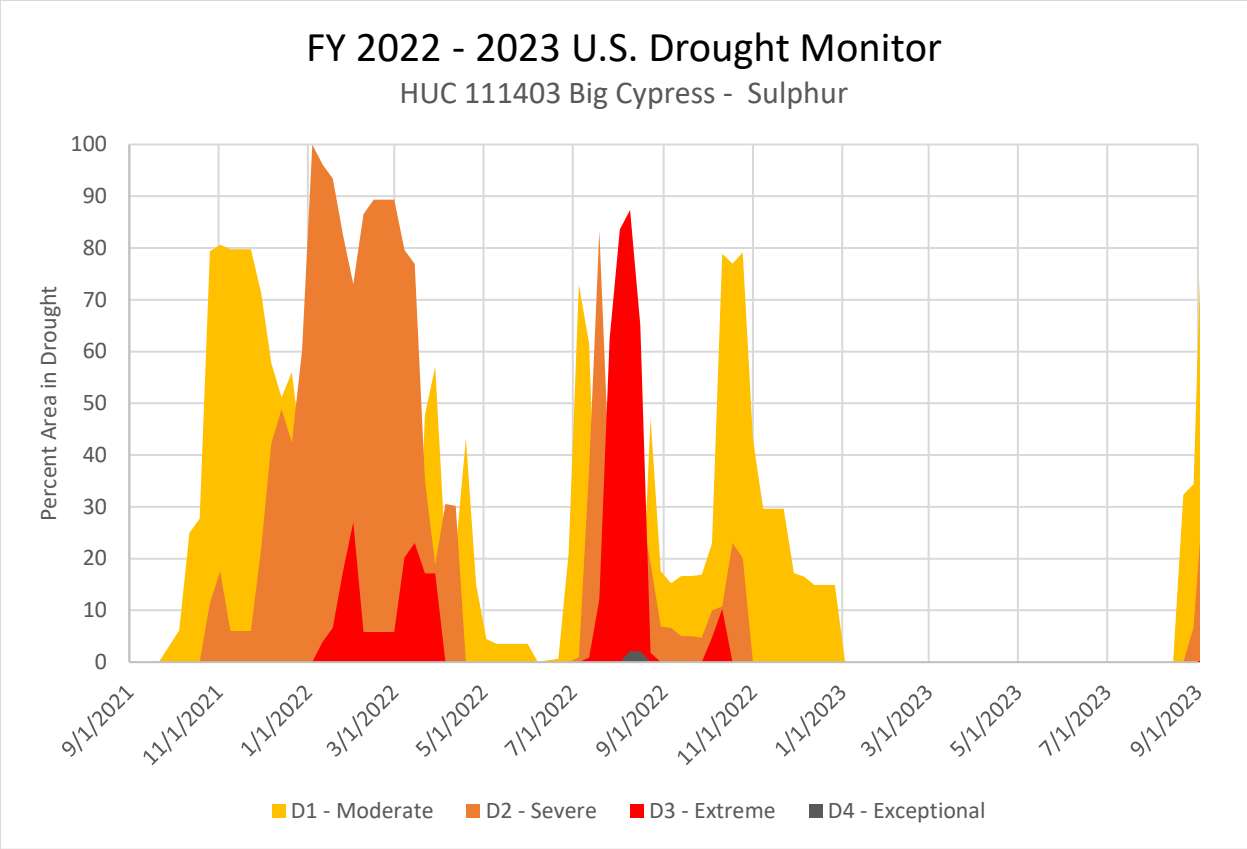

Figure 2: U.S. Drought Monitor, FY 2022 - 2023

Releases from Lake Bob Sandlin play an important role in the water quality of Big Cypress Creek and Lake O' the Pines. In addition to providing stream flow in Big Cypress Creek, the high-quality water from Lake Bob Sandlin helps to offset the nutrient-laden discharges from wastewater treatments plants in the Lake O' the Pines watershed. 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 the freeboard of the Fort Sherman Dam. On average, a little over 97,000 acre-feet of water are released each year. For the first time since 2014, no water was released from the reservoir in 2022. Between February and July 2023, over 84,000 acre-feet were released and almost forty percent of those releases were in the months of June and July. In fact, this was the most water released during those months in at least fifteen years. These large volumes of water impacted the timing of bioassessments in Big Cypress Creek and the Lake O' the Pines special study discussed later in this report.

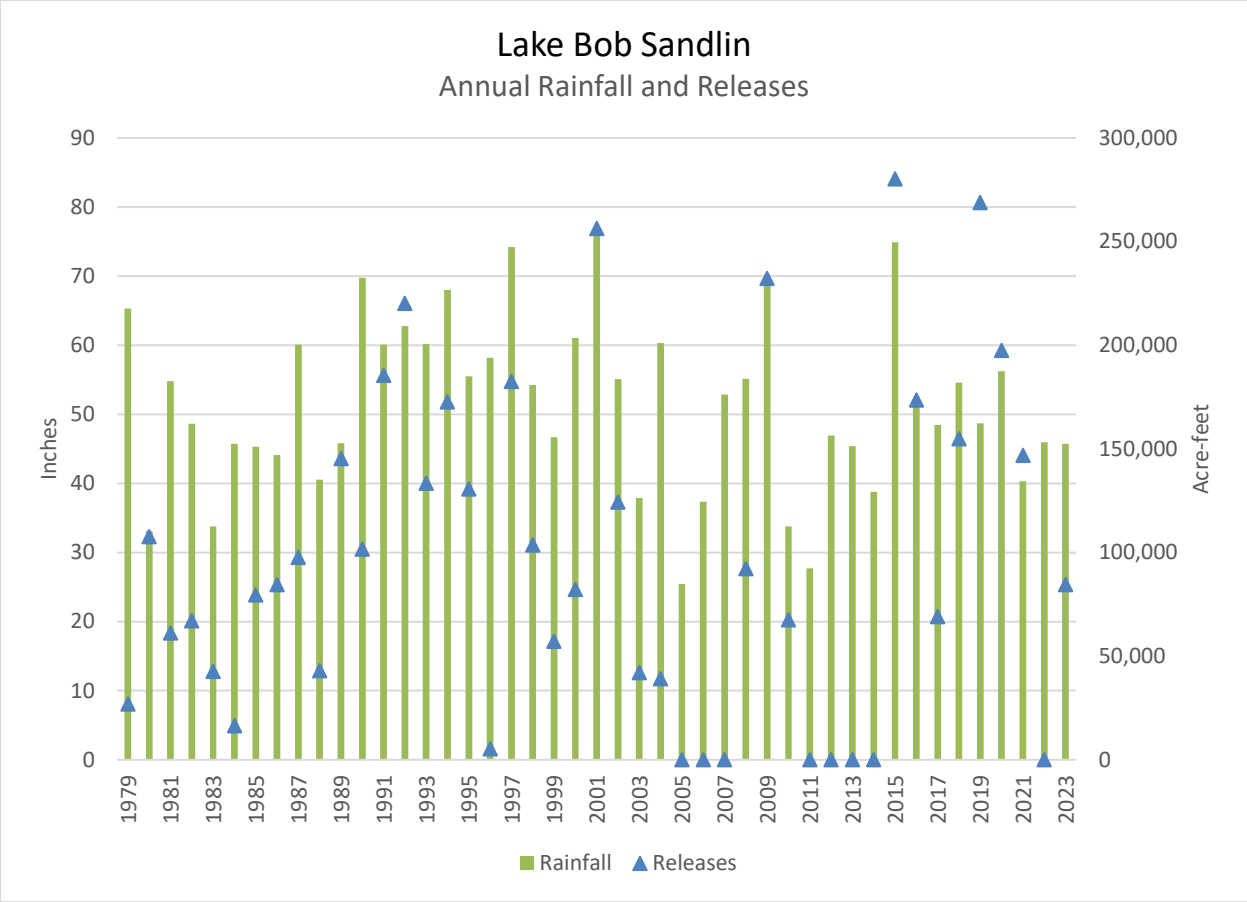

Figure 3: Graph of annual rainfall and releases form Lake Bob Sandlin

The 2024 Cypress Creek Basin Highlights Report is focused on water quality and recent studies in the Lake O' the Pines watershed. The report includes four discussion topics:

- Water Quality Monitoring
- Lake Cypress Springs 5n Study
- Lake O' the Pines Special Study
- Species of Concern and Aquatic Life Monitoring Studies

The Water Quality Monitoring section of this report details the *2022 Texas Integrated Report* (IR) and Draft 2024 TCEQ assessment of water quality for all watersheds in the Cypress Creek Basin. The Lake Cypress Springs 5n Study is the first of its kind in Texas. The study was designed to identify possible sources of nutrients that are contributing to the new 5n impairment. The Lake O' the Pines Special Study had a similar design to the Lake Cypress Springs study, focusing on the high pH impairments across the reservoir. The Species of Concern section discusses potentially threatened or endangered species in the basin. A discussion of the Aquatic Life Monitoring studies section details bioassessment studies performed by NETMWD and WMS. The lake studies and bioassessments were funded by the TCEQ Clean Rivers Program.

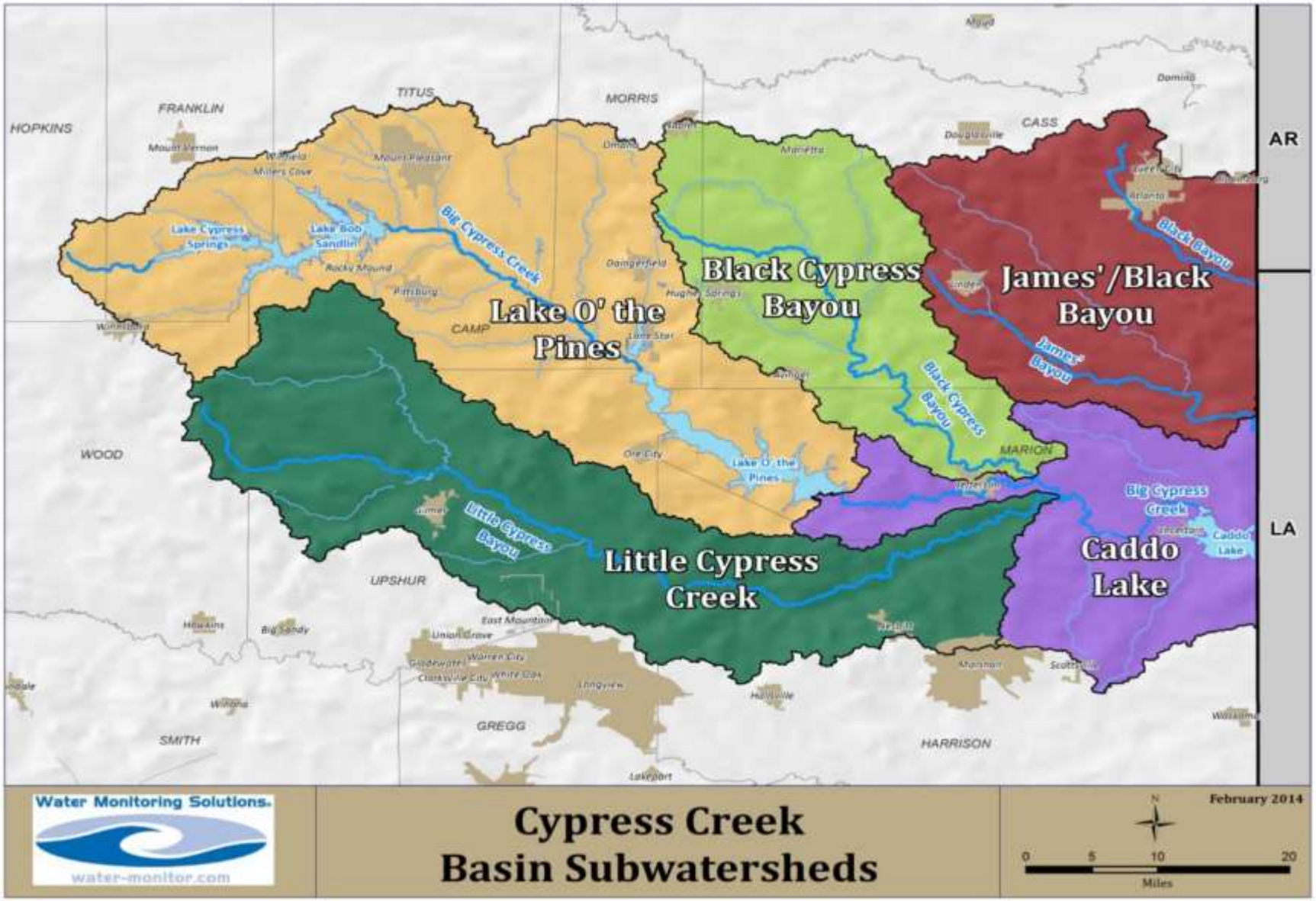

Figure 4: Map of the Cypress Creek Basin watersheds

WATER QUALITY MONITORING

Water quality monitoring and reporting is the heart of the CRP. NETMWD / WMS and TCEQ Region 5 – Tyler routinely collect water quality data. Monitoring is conducted at 41 sites located in all ten designated segments and in twelve unclassified segments within the Cypress Creek basin. The Coordinated Monitoring Schedule is a list of all monitoring in the Basin.

Clean Rivers Program partners collect monitoring data following a TCEQ-approved Quality Assurance Project Plan. The project plan references procedures and methods for sample collection and handling. The TCEQ Surface Water Quality Monitoring 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.

The resulting data are submitted to the TCEQ for inclusion in the state water quality database - Surface Water Quality Monitoring Information Systems. After a thorough review and approval by TCEQ, these data are made available for public access via the NETMWD and TCEQ websites. These data are used by the TCEQ to assess the basin.

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, or Aquatic Life Monitoring (ALM), include the collection of fish, aquatic insects, and habitat assessments to assess the overall health of streams. Water quality monitoring is often described in general terms of field parameters, conventional laboratory parameters, diel studies (data collected over a 24-hour period), stream flow, and biological assessments.

For the 2022 assessment, the TCEQ evaluated 49 classified and unclassified water bodies in the basin. The results reported in the *2022 Texas Integrated Report* (2022 IR) indicated that over half of the water bodies evaluated did not meet surface water quality standards for one or more parameters. Figure 5 details the segments and parameters shown on the *2022 Texas §303(d) List*. The §303(d) List identified nine classified and twelve unclassified water bodies that were non-supporting (NS) of water quality criteria. Low concentrations of dissolved oxygen (DO), high levels of bacteria, and mercury in fish tissue were the most common impairments.

The *2022 Texas §303(d) List* for the Cypress Creek Basin includes the impairments shown in the table below:

Segment ID	Description	Parameter
0401	Caddo Lake	Mercury in fish tissue
		DO
0401A	Harrison Bayou	DO, *E. coli*
0402	Big Cypress Creek below Lake O' the Pines	Mercury in fish tissue
		DO
0403	Lake O' the Pines	High pH, DO
0404	Big Cypress Creek below Lake Bob Sandlin	*E. coli*
0404A	Ellison Creek Reservoir	Sediment Toxicity (LOE)
		Dioxin in fish tissue
		PCBs in fish tissue
0404B	Tankersley Creek	*E. coli*
0404C	Hart Creek	*E. coli*
0404E	Dry Creek	*E. coli*
0404F	Sparks Branch	*E. coli*
0404J	Prairie Creek	DO
0404N	Lake Daingerfield	Mercury in fish tissue
0405	Lake Cypress Springs	High pH
		Nutrient Reservoir Criteria
0405A	Big Cypress Creek	DO, *E. coli*
0406	Black Bayou	DO, *E. coli*
0407	James' Bayou	DO, *E. coli*
0409	Little Cypress Bayou	DO, *E. coli*
0409A	Lilly Creek	*E. coli*
0409B	South Lilly Creek	DO, *E. coli*
0410	Black Cypress Bayou	Mercury in fish tissue
		Copper, Lead in water
		DO
0410A	Black Cypress Creek	*E. coli*

Figure 5: Table of Impairments in the Cypress Creek Basin

The Draft 2024 IR assessed data collected from December 1, 2015 through November 30, 2022. No new impairments were added to the *Draft 2024 Texas §303(d) List* while four were removed.

Assessment Unit	Description	Parameter	Reason
0405_02	Lake Cypress Springs	High pH	New Data
0409_01	Little Cypress Bayou	DO	Listing Incorrect
0409B_01	South Lilly Creek	*E. coli*	Standards Change
0410_02	Black Cypress Bayou	DO	Listing Incorrect

Figure 6: Water bodies removed from the Draft Texas §303(d) List in 2024

The high pH impairment in Assessment Unit (AU) 0405_02 of Lake Cypress Springs was removed due to data collected during the assessment period meeting the pH criteria. Three out of 31 measurements reported during the assessment period were higher than the 8.5 s.u. criterion. Note that the other two assessment units in the reservoir remain impaired for high pH.

Both low DO impairments in Little Cypress Bayou (AU 0409_01) and Black Cypress Bayou (AU 0410_02) were removed after determining that the original basis for the listing was incorrect, and that the streams met their DO criteria. Three of 63 readings assessed in Little Cypress Bayou were reported below the 4 mg/L DO grab criterion whereas two out of 45 measurements in Black Cypress Bayou were less than the 1.84 mg/L criterion.

The *E. coli* impairment in South Lilly Creek was removed due to the results of a Recreational Use Attainability Analysis that was performed in 2016. The study demonstrated that the stream was not being used for primary contact recreation. As a result, the *E. coli* criterion was raised to a geometric mean of 630 MPN/100 mL, and the stream met this criterion with a geometric mean of samples collected during the assessment period of 420.3 MPN/100mL.

The following discussion provides definitions of the common field and conventional laboratory parameters.

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 the 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 – 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.

Figure 7: Sample bottles and instruments used to measure field parameters

Transparency – Transparency is measured using a Secchi disk. It is a measure of the depth to which light is transmitted through the water column and thus the depth at which algae and aquatic plants can grow. Transparency is an important secondary parameter for assessing eutrophication, a natural aging process in lakes and reservoirs, and for identifying long-term 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.

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 and Total Dissolved Solids – 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 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, wastewater discharges, landfill run off, 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 most natural waters. 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.

Nutrients (Ammonia, Nitrate, Phosphorus) – Nutrients are essential for life. However, elevated 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 runoff. 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 nitrite can produce nitrite toxicity, or “brown blood disease.” Excess nitrate 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.

Organics - Toxic substances from pesticides and industrial chemicals pose the same concerns as metals. Polychlorinated biphenyls (PCBs), for example, are industrial chemicals that are

toxic and probably carcinogenic. Despite being banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed.

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 and organs, posing a long-term significant health threat. Bioaccumulation of mercury in the edible tissue of many fish species to the point of becoming a human health concern has prompted the Texas Department of State Health Services to issue fish consumption advisories around the basin. Mercury in edible tissue has been identified in fish tissue in water bodies throughout East Texas.

Fiscal Year 2024

The Clean Rivers Program funds quarterly sampling at seventeen stations in 2024. Laboratory and field parameters are collected at eleven stations located across the basin. Monitoring for field parameters and stream flow only is conducted at three stations, and diel sampling is performed at another three stream stations each quarter. In addition, Aquatic Life Monitoring in the upper assessment unit of Big Cypress Creek is scheduled in 2024. Aquatic Life Monitoring is comprised of biological, physical habitat, stream flow, and diel sampling methods to assess the overall health of the stream. Monitoring activities are conducted during the non-critical and critical periods. The non-critical period is from March 15 to June 30 and from October 1 to October 15. The critical period extends from July 1 to September 30.

The following pages include a map of the Fiscal Year (FY) 2024 Cypress Creek CRP monitoring stations along with a table of the stations monitored by both the TCEQ Region 5 (R5) and the NETMWD/WMS (WMS). This information can also be viewed by visiting the Coordinated Monitoring Schedule page.

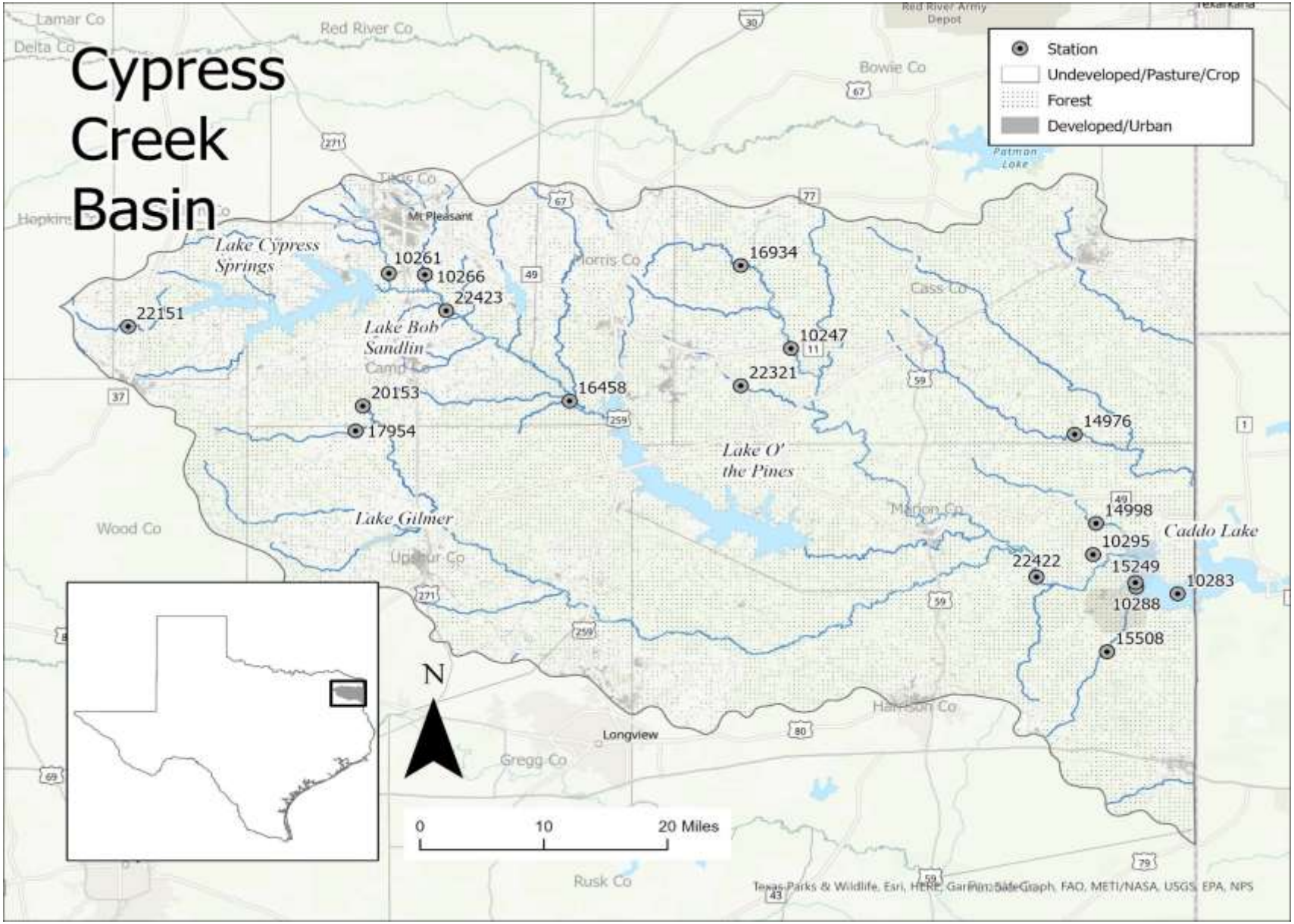

Figure 8: Map of the NETMWD/WMS Cypress Creek Basin monitoring stations

Site Description	Station #	Segment	Collector	Type	Field	Conv	Bacteria	Flow	24 HR DO	ALM
CADDO LAKE IN GOOSE PRAIRIE	10288	0401	WMS	RT	4	4	4			
CADDO LAKE MID LAKE	10283	0401	WMS	RT	4	4	4			
CADDO LAKE AT DWIGHT SHELLMANS	15249	0401	WMS	RT	4	4	4			
HARRISON BAYOU AT FM 134	15508	0401A	WMS	RT	4	4	4	4		
KITCHEN CREEK AT CR 3416	14998	0401B	WMS	RT	4			4		
BIG CYPRESS BAYOU AT US 59	15511	0402	R5	RT	4	4	4	4		
BIG CYPRESS CREEK AT SH 43	10295	0402	WMS	RT	4	4	4	4		
BIG CYPRESS BAYOU ABOVE BACKWATER JACKS	22422	0402	WMS	BS	4				4	
HUGHES CREEK AT CR 2985	22321	0402B	WMS	RT	4			4		
KELLEY CREEK AT FM 250	16934	0402E	WMS	RT	4			4		
LAKE O THE PINES N OF SH 155	17087	0403	R5	RT	4	4	4			
LAKE O THE PINES NETMWD INTAKE	10297	0403	R5	RT	4	4	4			
LAKE O THE PINES NEAR DAM	10296	0403	R5	RT	4	4	4			
LAKE O THE PINES MID LAKE	16156	0403	R5	RT	4	4	4			
BIG CYPRESS CR BRIDGE ON SH 11	10308	0404	R5	RT	4	4	4	4		
BIG CYPRESS CREEK AT US 271	10310	0404	R5	RT	4	4	4			
BIG CYPRESS CREEK AT US 259	13631	0404	R5	RT	4	4	4			
BIG CYPRESS CREEK BELOW OF WALKERS CREEK	22423	0404	WMS	BS	2			2	2	2
BIG CYPRESS CREEK NEAR GREASY CREEK	16458	0404	WMS	RT	4	4	4	4		
TANKERSLEY CREEK AT FM 3417	10261	0404B	WMS	RT	4	4	4	4		
HART CREEK AT CR 4550	10266	0404C	WMS	RT	4	4	4	4		
LAKE DAINGERFIELD AT HEADWATERS	17337	0404N	R5	RT	4	4	4			
LAKE CYPRESS SPRINGS AT FM 115	10313	0405	R5	RT	4	4	4			
LAKE CYPRESS SPRINGS NEAR DAM	10312	0405	R5	RT	4	4	4			
BIG CYPRESS CREEK AT CR SW 3170	22151	0405A	WMS	BS	4			4	4	
BLACK BAYOU AT CR 4659	10314	0406	R5	RT	4	4	4	4	5	
BLACK BAYOU AT SH 43	10318	0406	R5	RT	4	4	4	4	5	
JIMS BAYOU AT SH 43	14976	0407	WMS	RT	4	4	4	4		

Site Description	Station #	Segment	Collector	Type	Field	Conv	Bacteria	Flow	24 HR DO	ALM
LAKE BOB SANDLIN AT FM 21	16158	0408	R5	RT	4	4	4			
LAKE BOB SANDLIN AT MID DAM	10329	0408	R5	RT	4	4	4			
LITTLE CYPRESS BAYOU AT US 271	16017	0409	R5	RT	4	4	4	4		
LITTLE CYPRESS BAYOU AT US 259	16861	0409	R5	RT	4	4	4	4		
LITTLE CYPRESS CREEK AT US 59	10332	0409	R5	RT	4	4	4	4		
LITTLE CYPRESS BAYOU AT SH 154	22455	0409	R5	RT	4	4	4			
LILLY CREEK AT FM 556	20153	0409A	WMS	RT	4	4	4	4		
SOUTH LILLY CREEK AT FM 2454	17954	0409B	WMS	RT	4	4	4	4		
LAKE GILMER AT MID DAM	17478	0409D	R5	RT	4	4	4			
LAKE GILMER AT FM 852	18825	0409D	R5	RT	4	4	4			
BLACK CYPRESS BAYOU AT SH 11	10247	0410	WMS	BS	4			4	4	
BLACK CYPRESS BAYOU AT SH 11	10247	0410	R5	RT	4	4	4	4		
BLACK CYPRESS CREEK AT SH 49	10243	0410	R5	RT	4	4	4	4		
BLACK CYPRESS CREEK AT CR 2924	21729	0410A	R5	RT	4	4	4	4		

Figure 9: FY 2024 monitoring schedule in the Cypress Creek Basin

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 Cypress Springs (0405), Lake Monticello (0408A), and Lake Bob Sandlin (0408).

Figure 10: Stream flow measurement at station 15260 in Segment 0405A

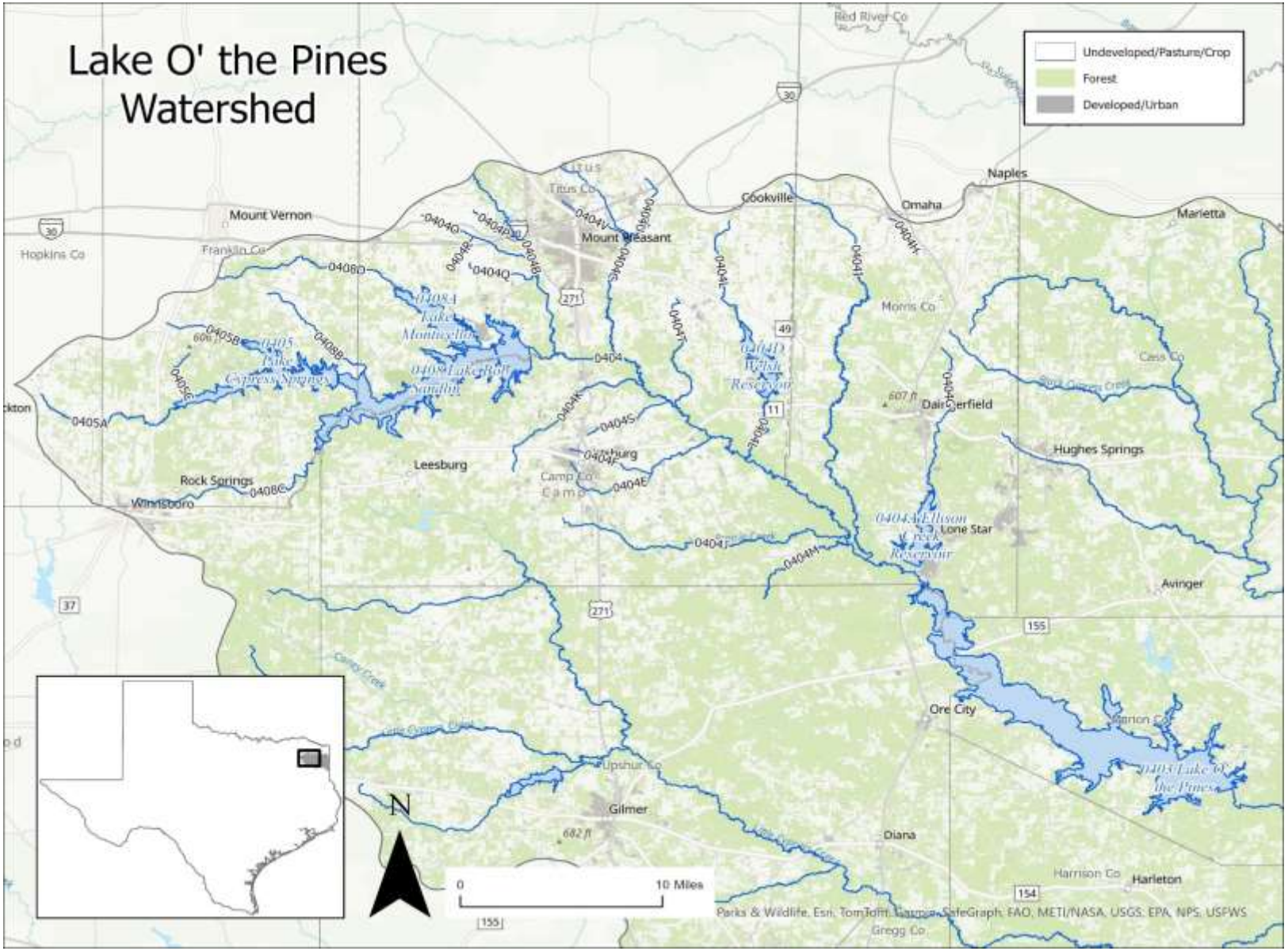

Figure 11: Map of the Lake O' the Pines watershed

UNCLASSIFIED SEGMENT 0405A – BIG CYPRESS CREEK

Big Cypress Creek originates in Hopkins County near the Franklin County line and flows southeast into Lake Cypress Springs. The current is assesment is based upon data collected at station 15260, located on State Highway (SH) 37 between Mount Vernon and Winnsboro, and from station 22151, located upstream on County Road SW 3170. Regular sampling at station 15260 began in FY 2009. Segment 0405A was listed as impaired in the *2022 Texas §303(d) List* for bacteria and dissolved oxygen. The geometric mean of the bacteria samples collected during the assessment period was 583 MPN/100 mL, well over the 126 MPN/100 mL geometric mean criterion. About 10 percent of the dissolved grab samples fell below the 2 mg/L criterion with an average of 1.0 mg/L.

The 2022 IR also included a concern for screening level for dissolved oxygen and chlorophyll *a*. Eighteen percent of the dissolved oxygen grab samples were below the 3.0 mg/L screening level. All but three of the seventeen chlorophyll *a* results exceeded the screening level of 14.1 µg/L with an average of 30.78 µg/L.

Due to the typically low flow conditions at the SH 37 location, low dissolved oxygen values were often obtained during periods of low flow. Stream flow under 1 cubic feet per second (cfs) was reported for over one-third of the site visits, and less than 2 cfs were measured at nearly half. Discussions about the representativeness of station 15260 were held at coordinated monitoring meetings. After reviewing historical data, the Coordinated Monitoring Committee agreed to move the station upstream to a site that had more representative conditions to address the DO impairment. Diel monitoring at station 22151 at CR 3170 commenced in FY 2019. Out of seven diels conducted during the assessment period, only one event from October 2019 did not meet the 24-Hour DO Average and Minimum criteria. A flow measurement of 0 cfs was reported for this diel. Of interest, dissolved oxygen met its criteria even when the stream was flowing at only 0.1 cfs. Similar results have been found for diels conducted in 2021 through 2023.

UNCLASSIFIED 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 2022 IR showed a concern for impaired habitat. No sampling has been conducted in this stream since 2002, and none is presently scheduled.

These two streams are the primary tributaries to Lake Cypress Springs.

LAKE CYPRESS SPRINGS 5N IMPAIRMENT STUDY

Lake Cypress Springs is located approximately eight miles south of Mount Vernon in Franklin County, Texas. The reservoir impounds the upper reach of Big Cypress Creek and has been voted by D Magazine as "the most beautiful lake in Texas" and as one of "our favorite lakes just a short drive from Dallas". The watershed is primarily rural though many new luxury homes have been constructed in the area over the past decade.

The reservoir is owned and operated by the Franklin County Water District (FCWD) for the purposes of municipal water supply and public recreation. The FCWD maintains several boat ramps as well as six parks, which includes campgrounds and RV parks. Walleye Park is the largest park and has a number of tent camping spots, RV pads with water and electrical hookups, a pavilion, restrooms, showers, dump station, and boat ramp.

Authorization for constructing the dam and impounding up to 72,800 acre-feet of water was granted on November 10, 1966. Construction commenced in July 1968 and was completed in February 1971. The Texas Parks and Wildlife Department (TPWD) reports that the watershed area is approximately 75 square miles and has a shoreline length of 43 miles. The shoreline is highly developed with over 800 docks and boat houses.

Figure 12: Drop inlet water release structure at Lake Cypress Springs dam

The Franklin County Dam, an earth-fill embankment dam, is 5,230 feet long with a top crest elevation of 395 feet. The uncontrolled emergency spillway is excavated on natural ground to the north side of the dam and has a crest elevation of 385 feet. The service spillway is located near the south end of the main embankment, and water is discharged through an uncontrolled rectangular drop inlet measuring 23 by 23 feet. Water is only released when the lake level exceeds the normal conservation pool elevation of 378.0 feet. The fixed 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 released from the reservoir flows directly into the headwaters of Lake Bob Sandlin.

Based on the 2007 volumetric survey by the Texas Water Development Board (TWDB), the lake has a total storage capacity of 66,756 acre-feet, encompassing 3,252 surface acres, at the conservation pool elevation of 378.0 feet. This survey estimated that sediment was filling the reservoir at a rate of approximately 100 acre-feet per year.

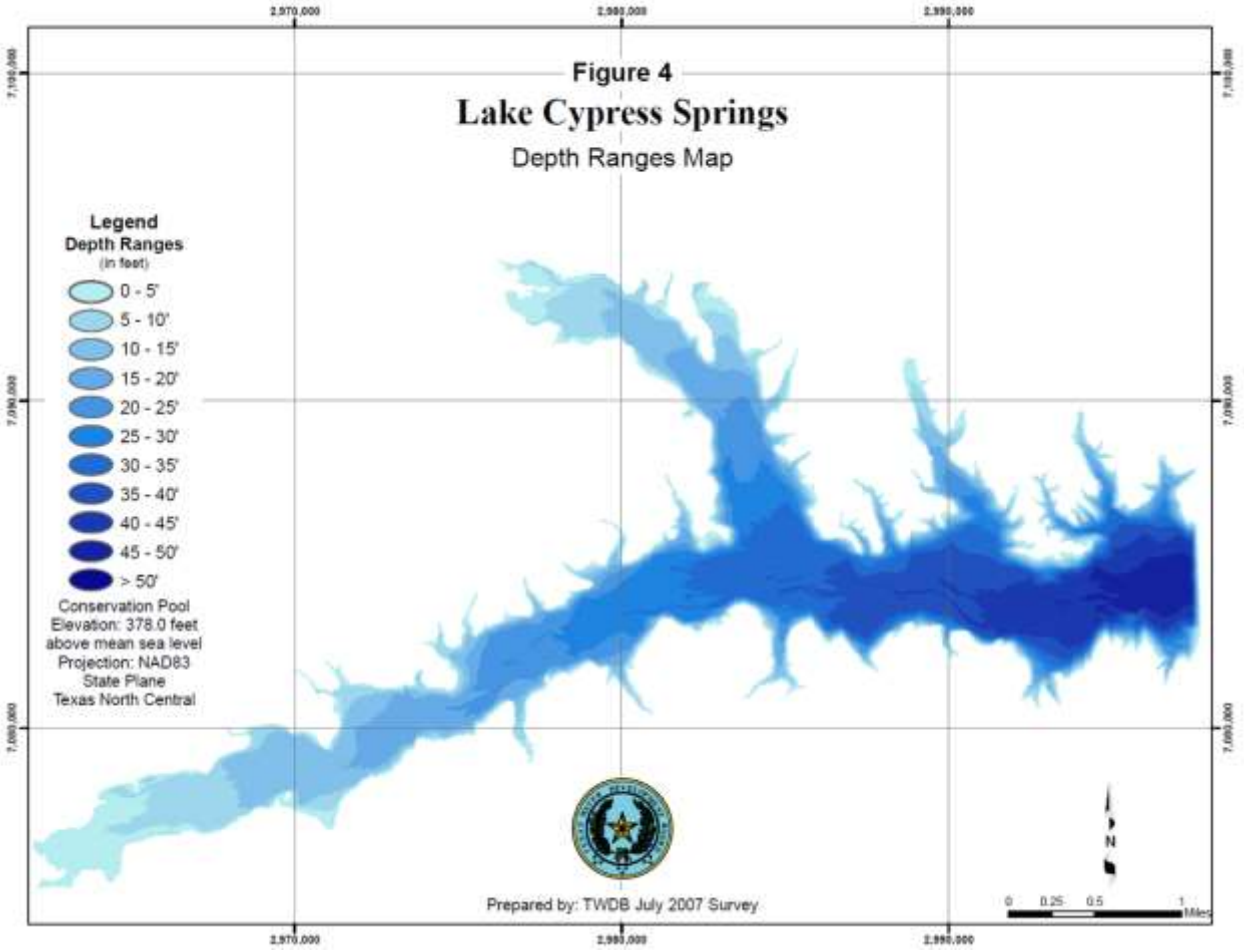

Figure 13: Bathymetric profile data from the TWDB Survey in July 2007

The TPWD reports that Lake Cypress Springs has an average annual water level variation of 2 to 2.5 feet. Lake level data compiled by the TWDB shows that the lake historically fills in the winter and spring months and reaches its lowest levels in the late summer and fall. From 1998 through 2022, the TWDB reported that the median percent full has ranged from a low of around 95% to 100% full. A relatively dry fall and winter in 2021 caused the levels to decline below 90% full at the beginning of 2022. The lake somewhat recovered in the spring but declined through the summer due to drought. Lake levels recovered in the winter of 2022 when normal amounts of rainfall returned to the region. The lake reached conservation pool in February 2023 and remained at or near 100% full through most of July 2023 before declining due to the lack of significant rainfall in late July and August

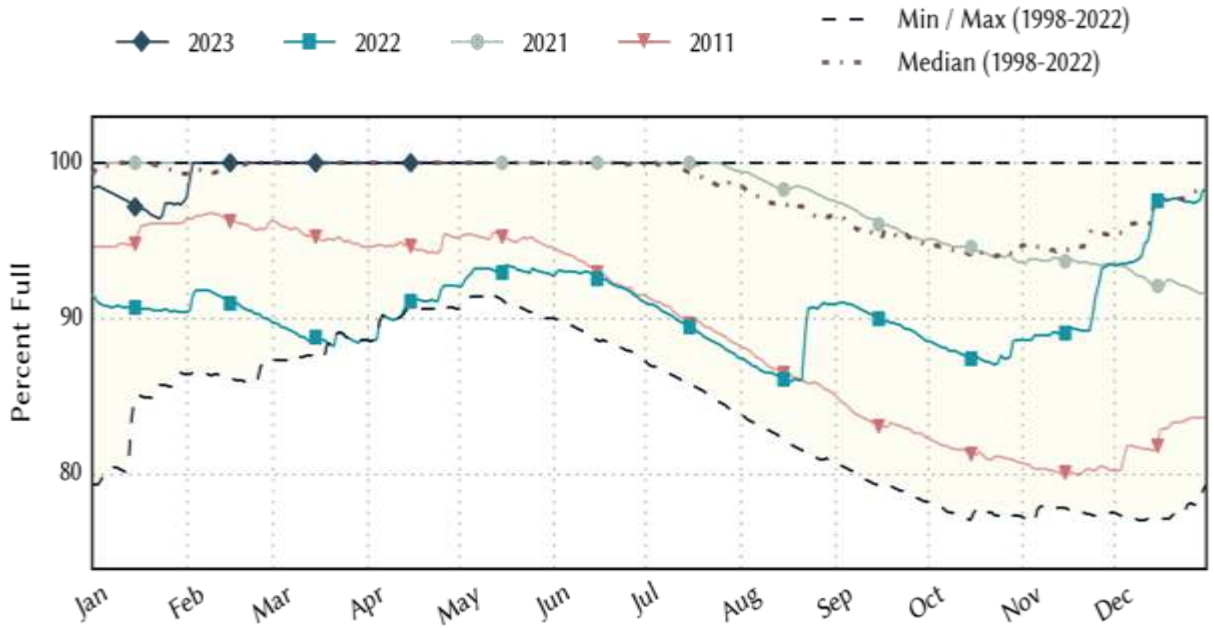

Figure 14: TWDB Lake Cypress Springs historical lake elevation

Watershed

The mostly rural watershed of Lake Cypress Springs is approximately 75 square miles and is located in the Pineywoods ecoregion while its western tributaries extend into the Post Oak Savannah ecoregion. Much of the watershed immediately surrounding the lake is forested, although the western portion includes unimproved and improved pastures used for poultry, cattle, and hay production. All residential waste is treated using on-site septic systems.

Permitted Discharges

There are no permitted municipal or industrial wastewater treatment outfalls in the Lake Cypress Springs watershed. Two permitted Concentrated Animal Feeding Operations are located in the northwestern portion of the watershed. Runoff from these operations flows into tributary streams of Big Cypress Creek before entering the western portion of the reservoir.

Drinking Water Supply

Lake Cypress Springs serves as a drinking water supply for approximately 21,000 residents located in the cities of Mount Vernon and Winnsboro, and for residents in the unincorporated areas of Franklin County, and portions of Hopkins, Wood, and Titus counties. The Cypress Springs Special Utilities District (CCSUD) supplies water to most of this population, serving almost 15,000 people across 344 square miles.

Water Monitoring Solutions, Inc. met with Kevin Spence, CCSUD General Manager, to discuss changes in Lake Cypress Springs water quality and treatment processes during his tenure with the district which extends to the late 1980's. According to Mr. Spence, the amount of chemicals used to treat Lake Cypress Springs water to meet drinking water standards has not significantly changed over the years. With the exception of switching from the use of chlorine to chloramines to reduce the potential production of trihalomethanes, no major changes to the treatment process have been necessary during his four-decade tenure with the organization.

According to the most recent TWDB Water Use Survey, slightly more than 2,500 acre-feet of water was withdrawn from the reservoir for drinking water production in 2021. The amount of water withdrawn in 2021 represents less than four percent of its total storage capacity.

Figure 15: Spring at roadside park on SH 37 near Lake Cypress Springs (Well #1762602)

Groundwater

Lake Cypress Springs lies over the Carrizo-Wilcox Aquifer, a major aquifer, which generally follows along the path of Interstate 30 from Texarkana to Sulphur Springs before turning south/southwest towards San Antonio and eventually to the Rio Grande near Carrizo Springs.

Although no quantifiable data have been discovered, conversations with local residents suggest that as many as 1,000 springs, primarily located near/in the West End to the Midlake region of the reservoir, were inundated by the construction of the reservoir, and contributions from the springs were once believed to be the reason that the water was colder than other reservoirs in the region. In fact, Lake Cypress Springs was stocked with walleye (the namesake for FCWD's Walleye Park). Unfortunately, the water was not cold enough to support a sustainable walleye fishery.

Since the land in that area is primarily sandy loam and has historically been used for agriculture and silviculture – a question has been raised about the possibility of the shallow groundwater being contaminated with nitrate since it will migrate through sandy soils into the shallow groundwater or alluvium.

The TWDB maintains a groundwater database that includes all records of wells drilled across the state. According to the TWDB site, 21 wells have been drilled in the watershed near the reservoir since the early 1940's, but water quality data has only been reported for ten. Most of these wells were 350 to 450 feet deep and the majority of the results were from samples collected prior to or within a few years of the construction of the reservoir. At present, the only active well being used for water supply is Well #1763501 which is owned and operated by CCSUD. According to the CCSUD, the other wells in the area are no longer in use, have been capped, or have been removed.

The CCSUD water well in current use was drilled in 1985 to a depth of 440 feet. Water quality samples are collected every four years as required by TCEQ. Laboratory results are available on the TWDB website for samples collected in 2006, 2010, 2014, 2018, and 2022. Dissolved nitrate values were reported below the detection limit in all years except 2018. The 2018 dissolved nitrate result was 0.053 mg/L. Dissolved phosphorus had a mean of 0.24 mg/L while the average pH for the five samples was 7.99 s.u.

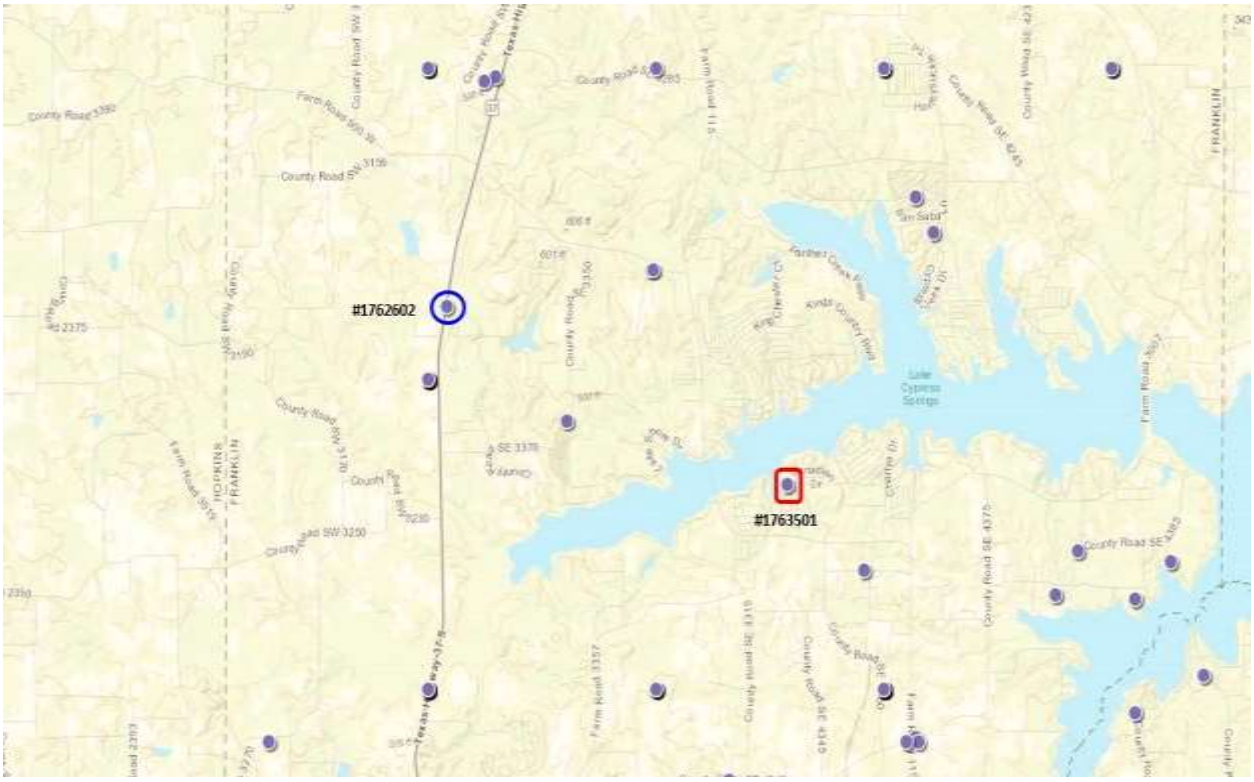

Figure 16: Groundwater wells around Lake Cypress Springs

Well #1762602 is a spring located on SH 37. In the past, this spring served as a source of drinking water for nearby residents as well as for those traveling on the highway. A basin to contain the spring water was constructed by the Civilian Conservation Corps in the 1930's and the Texas Department of Transportation currently operates a rest area at this location. The

results of two water tests were available in the TWDB database. Samples were collected in June 1942 and in March 1993. Dissolved nitrate from the 1993 test was 17.68 mg/L and had a pH of 5.41 s.u. while dissolved nitrate was 11 mg/L in 1942.

Since there were no water quality data available from shallow wells, the question of nitrate transport into the shallow or alluvial aquifer could not be answered.

Invasive Aquatic Species

The most recent vegetation survey was performed by TPWD in August 2022. Tim Bister, Marshall District Supervisor, reported that the reservoir has remained relatively free of invasive aquatic vegetation and that hydrilla has not been detected in several years. More information about their work is available in the *2023 Cypress Creek Basin Highlights Report*.

Potential Future Impacts to Water Quality

Development of large-scale industrial solar farms has been on-going in the region over the past few years. At present, there are several solar farms being proposed in Franklin County including some within the watershed of Lake Cypress Springs. Some estimate that as much of one-third of the agricultural land in Franklin County may be converted into solar farms. Construction of these farms can result in increased runoff of sediments and are potential sources of contaminants causing negative impacts to water quality.

Recently, extensive lithium deposits have been discovered in the Smackover Formation that extends from Mount Vernon east to the state lines with Arkansas and Louisiana. Standard Lithium estimates that this formation could have the highest-grade brine resource of lithium in the United States. At the time of this writing, plans for the development of lithium mining are underway.

Background Information

Located on the west side of Lake Cypress Springs, Big Cypress Creek is a significant contributor of water to the reservoir. Segment 0405A of Big Cypress Creek originates in western Hopkins County and flows through rural areas with limited residential development. Land use is largely agricultural and primarily used for dairy, cattle, and poultry production. Much of the pastureland is improved for grazing and hay production. The use of poultry litter and commercial fertilizers is common throughout this watershed to improve coastal Bermuda hay yields. Due to the rural nature of the watershed, all residential waste is treated by on-site septic systems.

Figure 17: Satellite image of the Big Cypress Creek watershed

Segment 0405B Panther Creek is another source of inflow and is in the north-central portion of the lake. Although no concerns for nitrate, ammonia, or total phosphorus were shown in the *2022 Texas Integrated Report*, Big Cypress Creek had a concern for chlorophyll *a*. This concern was the result of fourteen out of seventeen samples collected during the assessment period exceeding the 14.1 µg/L screening level with an average of 30.78 µg/L. Regular sampling for laboratory parameters had been collected in Big Cypress Creek at station 15260, located at SH

37, from 2008 through June 2020. Field parameters and diels are currently conducted at station 22151, located at County Road SW 3170. No sampling has been conducted in Panther Creek since August 2002.

The TCEQ Region 5 (Tyler) office samples Lake Cypress Springs on a quarterly basis. The reservoir was first listed as impaired for high pH in the *2012 Texas §303(d) List* and for excessive algal growth in 2016. The 2022 IR included the new 5n impairment for excessive algal growth along with the high pH impairments in all assessment units. The Draft 2024 IR removed the high pH impairment for assessment unit (AU) 0405_02 because sampling data met the high pH criterion during the assessment period.

Statistically significant increasing dissolved oxygen and pH trends were identified at station 10313 in the *2009 Cypress Creek Basin Summary Report*. Trend analyses were performed on data collected between January 1972 and August 2007. It should be noted that the pH trend did not continue into the 2014 or 2019 analysis.

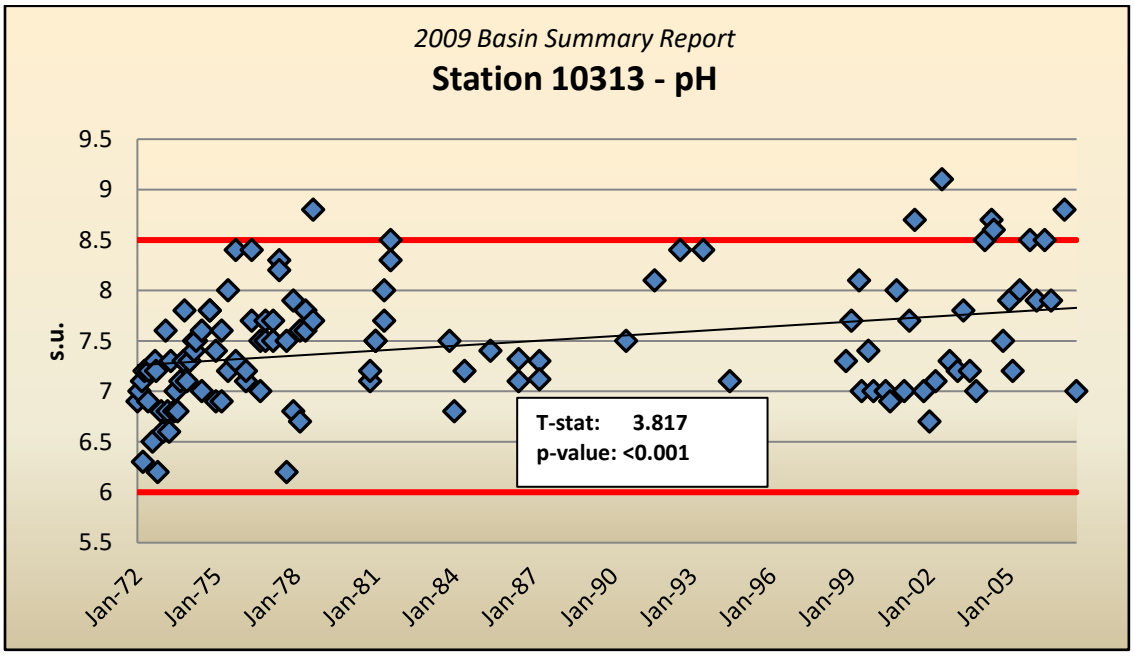

Figure 18: pH trend in 2009 Cypress Creek Basin Summary Report

Approximately twenty percent of the average mixed surface layer pH measurements in the 2022 IR exceeded the 8.5 s.u. criterion at all stations in Lake Cypress Springs. The highest pH reported was 9.2 s.u. A review of all historical data in the TCEQ database revealed that the highest pH value of 9.5 s.u. was reported in August 2013 at station 10312 near the Dam and at station 17548 in the Panther Arm. For station 10313 (Midlake), the maximum value of 9.4 s.u. was collected in May 2010.

Using the results from station 10312, the *2022 Texas Integrated Report* classified Lake Cypress Springs as eutrophic and ranked the reservoir in the top twenty-five percent of reservoirs statewide for chlorophyll *a* despite having relatively low phosphorus concentrations. The mean chlorophyll *a* concentration during the assessment period was 24.02 µg/L while the mean transparency was 1.14 meters.

Contributors of oxygen into the water column, such as phytoplankton and aquatic plants, can raise the amount of oxygen above saturation during photosynthesis. If the primary contributor of oxygen is from phytoplankton, then these organisms along with bacteria, can cause oxygen to rapidly decline during nighttime respiration.

Although DO concentration (mg/L) is used for assessment purposes, DO percent saturation is a useful indication of primary productivity. DO concentration is a calculated parameter based upon the percent saturation of oxygen, temperature, and salinity. Super-saturated DO conditions are alarming since large diel changes in DO can stress the organisms living in the water body. During peak hours of photosynthesis, DO may become super-saturated to levels high enough to cause fish kills. Oxygen is consumed by aerobic organisms through respiration which can cause DO to fall to levels low enough to cause fish kills.

In eutrophic reservoirs, algae and other primary producers can 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 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 used in the assessment 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 those found in Lake Cypress Springs.

Dissolved oxygen percent saturation is a useful parameter to evaluate relationships between DO and pH and between DO and chlorophyll *a*. The TCEQ R5 does not regularly report DO percent saturation to the Surface Water Quality Monitoring Information System database. WMS reversed the algorithm to calculate DO saturation from concentration to write the *2019 Cypress Creek Basin Summary Report*. DO percent saturation results were compared with the high pH readings (> 8.5 s.u.) in Lake Cypress Springs for data reported from 2001 through 2017. All but one of the high pH measurements coincided with DO saturation values above one hundred percent. That lone reading was 99.9 percent DO saturation. For all sites in the

reservoir, the correlation coefficient between pH and DO percent saturation ranged from 0.81 at station 17548 in the Panther Arm to 0.83 at the Midlake station 10313.

A review of the surface data collected by TCEQ Region 5 between 2017 and 2023 showed that pH has continued to exceed the high pH criterion at station 10312 (Dam). One high pH reading was reported in each year from 2019 to 2023. Each high reading was recorded during the warm weather months of June through September. No high pH values have been reported at station 10313 (Midlake) since October 2018. No sampling has been conducted at station 17548 (Panther Arm) since March 2017. All high pH surface values reported in Lake Cypress Springs are compared with the DO percent saturation in the following graph.

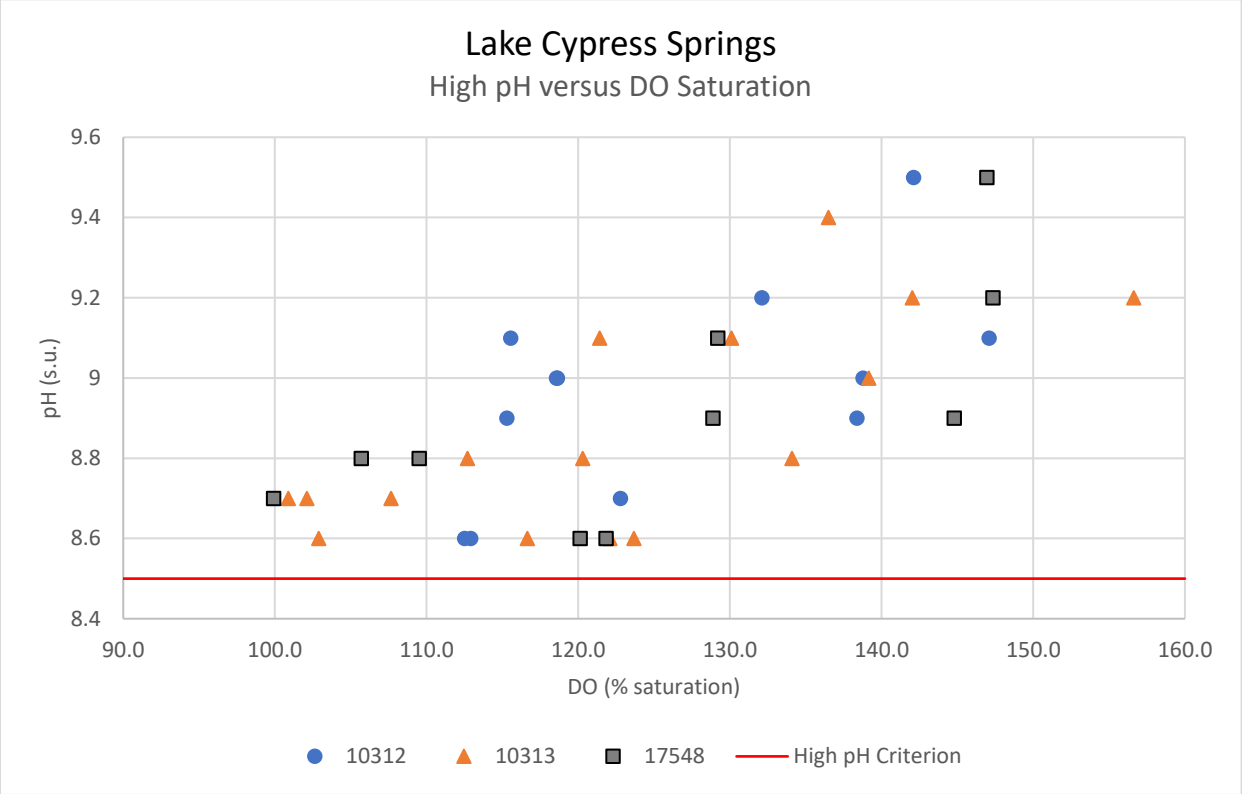

Figure 19: Comparison of pH and DO percent saturation from 2000 through 2023

The correlation coefficient between pH and chlorophyll *a* data reported from 2000 to 2018 was not robust and only ranged from 0.07 to 0.33. The correlation coefficient between DO percent saturation and chlorophyll *a* was slightly lower. Although the correlation coefficients were low, these results did not necessarily negate that the cause of high pH was eutrophication. By following the TCEQ *Surface Water Quality Monitoring Procedures, Volume 1*, all surface water grab samples in reservoirs are collected at 0.3-meter below the surface. Although most other laboratory parameters are subject to diffusion, moving from high concentration to low concentration, phytoplankton are motile organisms. The movement of phytoplankton vertically

through the water column to a depth that is most suitable for photosynthesis and reproduction is well documented in the literature. That depth may possibly be well above or below 0.3-meter at the time of sampling which may explain the lack of strong correlations between chlorophyll *a* and DO or pH.

A review of data collected since 2000 showed that chlorophyll *a* is generally trending higher across the reservoir, although not at a statistically significant rate. The historical average concentration at the Dam station 10312 was 21.1 µg/L and 29.4 µg/L at the Midlake station 10313. Of note is that the mean chlorophyll *a* values for samples collected from 2004 to 2013 and from 2014 to 2023 were quite different. For the Dam station, the mean chlorophyll *a* result was 18.6 µg/L for samples collected from 2004 to 2013 and 27.0 µg/L for those obtained from 2014 to 2023. For the Midlake station, the average chlorophyll *a* value was 28.3 µg/L in the previous decade and 36.5 µg/L in the current decade. Chlorophyll *a* at both stations were slightly correlated to TKN with coefficients of 0.35 and 0.34, and inversely correlated to Secchi transparency at -0.50 and -0.40.

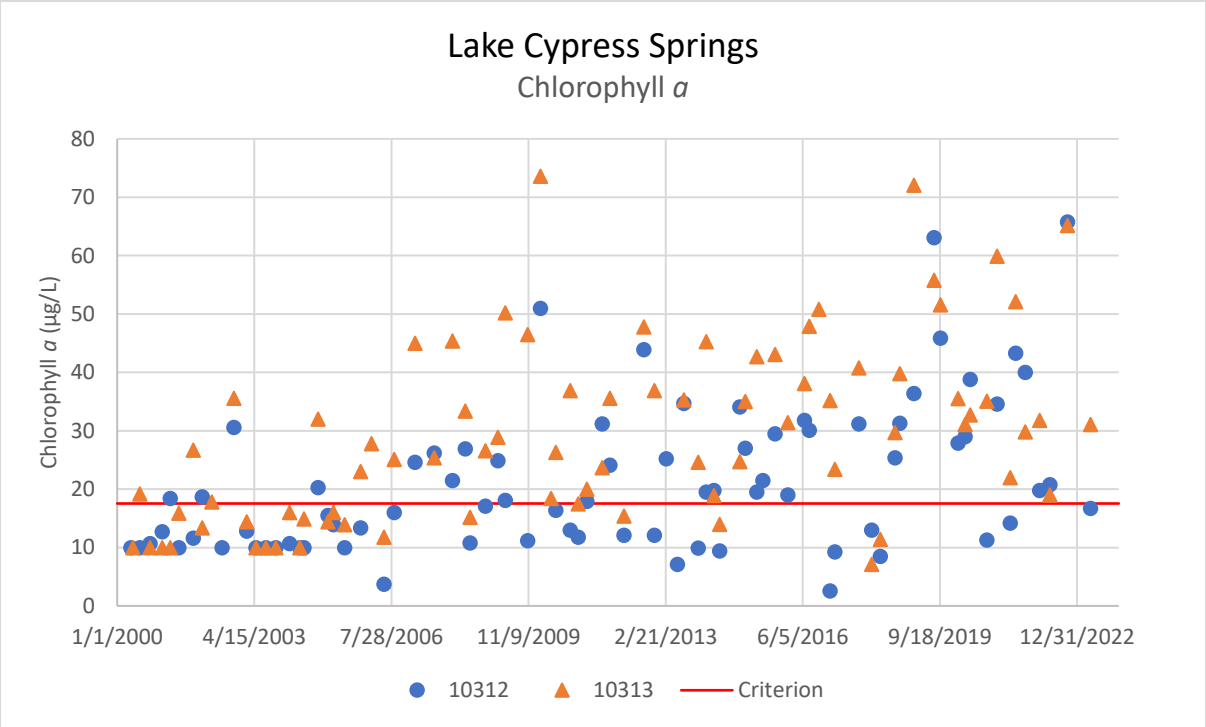

Figure 20: Chlorophyll a sample results from 2000 through 2023

Texas controls nutrient loadings to water bodies through its Surface Water Quality Standards, watershed rules, and antidegradation considerations in permitting actions using both narrative and numerical nutrient criteria. Until the *2016 Texas Integrated Report of Surface Water Quality*, TCEQ assessed nutrients in surface waters based solely on narrative criteria. The TCEQ began developing numerical nutrient criteria to include in the Surface Water Quality

Standards in the early 2000's, establishing its first nutrient criteria development plan in 2001. TCEQ has updated that plan several times, most recently in 2014, in coordination with EPA, an advisory workgroup, and through other public meetings and forums.

In 2010, TCEQ adopted reservoir-specific numerical nutrient criteria for 75 reservoirs into Section 307.10 (Appendix F) of the 2010 Texas Surface Water Quality Standards. These criteria were intended to maintain existing water quality and to protect the long-term existing conditions in these reservoirs. The objectives of the numeric and narrative criteria are to preclude excessive growth of aquatic vegetation and are also intended to protect multiple uses such as primary, secondary, and noncontact recreation, aquatic life, and public water supplies. In July 2013, EPA approved the adopted criteria for 39 of the 75 reservoirs, whose criteria were first used for assessment purposes in 2016. The 36 EPA disapproved reservoirs were subsequently removed from consideration in the 2018 Standards revision and are currently under review by TCEQ.

Lake Cypress Springs is the only reservoir in the Cypress Creek Basin with EPA-approved numerical nutrient criteria. Unlike other reservoirs in the basin, Lake Cypress Springs has reservoir-specific numerical criteria assigned for chlorophyll *a*, and narrative thresholds for total nitrogen, total phosphorus, and Secchi transparency. The chlorophyll-*a* criterion was based upon ambient data collected between July 1990 and October 2008. Using several factors to evaluate the water quality in Lake Cypress Springs, the EPA agreed that these criteria were protective of the water quality conditions in the reservoir. It should be noted that the assessment of the reservoir is based only upon the results collected at station 10312, located near the dam, and is assessed using the following values:

- Chlorophyll *a* 17.54 µg/L
- Total Nitrogen 0.8 mg/L
- Total Phosphorus 0.03 mg/L
- Secchi 1.19 m

As part of the *2022 Texas Integrated Report of Surface Water Quality*, the TCEQ revised their assessment methodology for the 39 reservoirs with EPA approved chlorophyll *a* criteria. The new methodology stated, "all reservoirs exceeding their numeric chlorophyll *a* criterion would be impaired and identified as not supporting." Additionally, a new sub-category "5n" was created for reservoirs that do not meet their applicable chlorophyll *a* criterion, but an additional study is needed to verify that the exceedance is associated with causal nutrient parameters or impacts to response variables. Due to exceedances in its chlorophyll *a*, total nitrogen, total phosphorus and Secchi transparency values as part of the *2022 Texas Integrated*

Report for Surface Water Quality, Lake Cypress Spring was one of the first reservoirs to fall into category 5n within the state and became a candidate for this special study.

SPECIAL STUDY DESIGN

This is the very first 5n impairment study in the state of Texas. The special study of the 5n impairment for excessive algal growth in Lake Cypress Springs was designed to identify potential sources of the impairment. Lake Cypress Springs is comprised of three assessment units:

- AU 0405_01 From the confluence with an unnamed tributary NHD RC 11140305002717 upstream 37.2 km (23 mi) to Lake Bob Sandlin
- AU 0405_02 Upper 2,600 acres
- AU 0405_03 Panther Arm

The project included monthly sampling for one year (September 2022 through August 2023) in each of the three assessment units plus a station located in the western end of the reservoir in AU 0405_02. Although the West End station (20346) is in a transition zone and is not representative of the assessment unit, this area was widely believed to receive much of the nutrient loading to the reservoir due to contributions from Big Cypress Creek. Sampling was conducted at the following stations:

Assessment Unit	Location	Station Number(s)
AU 0405_01	Dam	10312
AU 0405_02	Midlake; West End	10313; 20346
AU 0405_03	Panther Arm	17548

Figure 21: Table of assessment units and station numbers and locations

Sampling included the collection of field and laboratory parameters at each of the four stations. Field parameters consisted of depth profiles for DO, pH, conductivity, and temperature along with observations of transparency, lake and weather conditions, and water color. Laboratory samples were analyzed for the nitrogen suite (ammonia, nitrite, nitrate, total Kjeldahl nitrogen), total phosphorus, total alkalinity, sulfate, chloride, pheophytin *a*, and chlorophyll *a*. Total nitrogen was calculated by adding the results of nitrite, nitrate, and total Kjeldahl nitrogen. Depth profiles and field observations were recorded at the time of laboratory sample collection.

Monthly diel monitoring was conducted in each assessment unit. Dissolved oxygen, pH, conductivity, and temperature were recorded every fifteen minutes for a period of twenty-four hours. Water quality sondes were deployed on buoys to maintain the instrument within the mixed surface layer. Both the sondes and buoys were retrieved from the reservoir after each deployment. Diels were not conducted at the West End station since it is in the same

assessment unit as the Midlake station and because it is not representative of the assessment unit due to being in a transition zone.

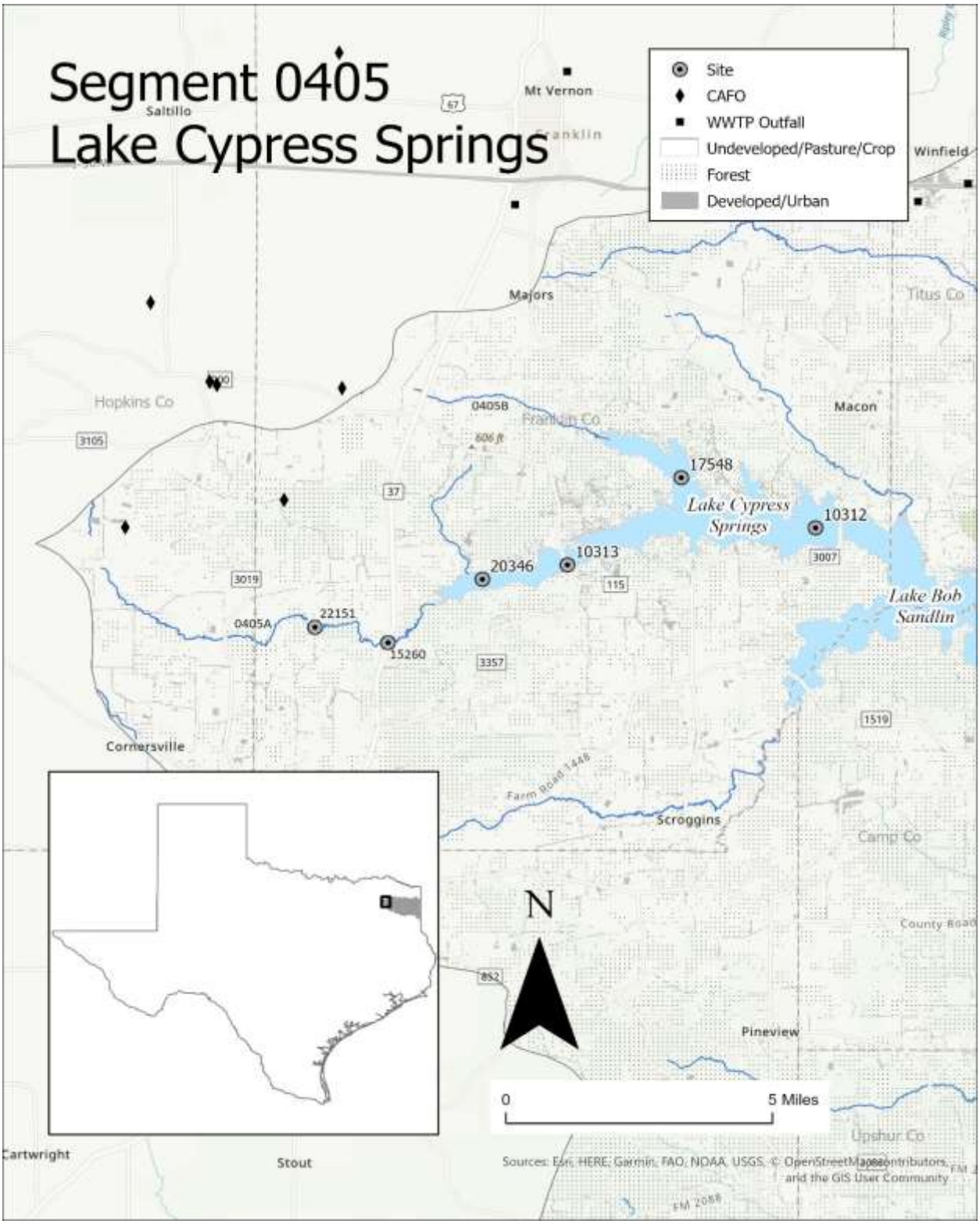

Figure 22: Map of Lake Cypress Springs watershed and monitoring stations

Mean daily lake elevation and rainfall is recorded by the U.S. Geological Survey at their station (#07344484) located at the dam. Due to heavy rains in August 2022, the lake level began to recover from its minimum elevation of 374.98 feet and reached its conservation pool level of 378.0 feet in February 2023. The lake remained near or above its conservation pool through the middle of July 2023. The lake level began to decline due to the lack of significant rainfall after July 16, 2023.

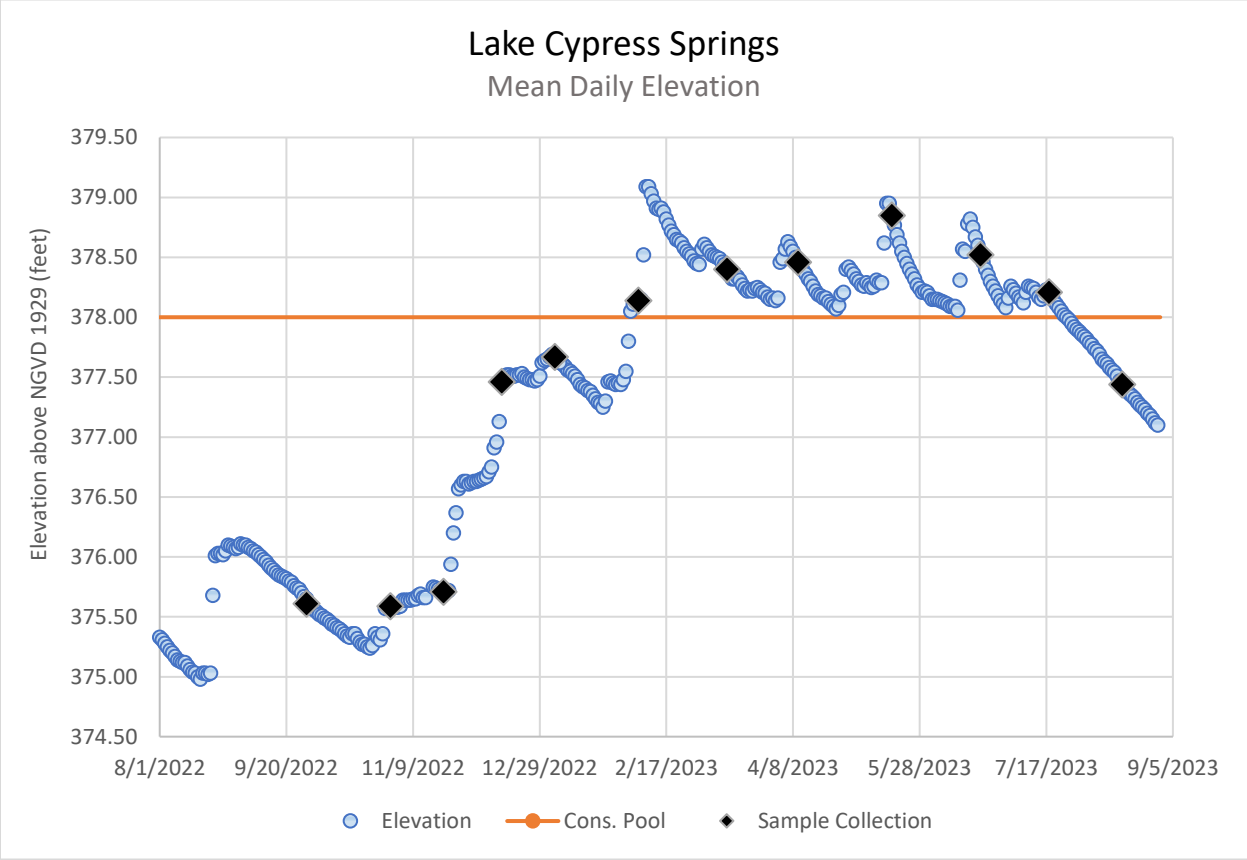

Figure 23: Lake Cypress Springs mean daily elevation

The table below shows the monthly rainfall totals during the study period and the average lake elevation by month during the study period. Because August 2022 had the lowest lake level since 2014, those data were included to illustrate the lake recovery to full conservation pool.

Month	Rainfall (in.)	Mean Elevation (ft.)
August 2022	8.02	375.41
September 2022	0.48	375.89
October 2022	4.70	375.40
November 2022	5.13	375.85
December 2022	3.84	377.19
January 2023	1.83	377.48
February 2023	4.18	378.56
March 2023	2.79	378.35
April 2023	4.71	378.31
May 2023	3.66	378.42
June 2023	5.24	378.19
July 2023	4.69	378.11
August 2023	0.07	377.54

Figure 24: Rainfall and mean lake elevation during the study period

Figure 25: Monitoring buoy deployed in the Panther Arm

RESULTS AND DISCUSSION

Monthly sampling commenced in September 2022 and was completed in August 2023. Sampling was conducted under ambient conditions and on dates when weather did not present any additional safety concerns. The following table lists the dates that sampling was conducted.

Sampling Dates		
2022	**2023**	
September 27 - 28	January 4 - 5	May 16 - 17
October 30 - 31	February 5 - 6	June 21 - 22
November 21 - 22	March 13 - 14	July 17 – 18
December 14 - 15	April 10 - 11	August 16 - 17

Figure 26: Lake Cypress Springs 5n Study sampling dates

Figure 27: Homes along the shoreline of Lake Cypress Springs

AU 0405_01 – Dam Station 10312

Nutrient criteria for Lake Cypress Springs are assessed from samples collected at this station. The mean of the twelve chlorophyll *a* samples collected was 26.06 µg/L, exceeding the 17.54 µg/L criterion. Seven of the samples exceeded the criterion with the highest concentration of 56.3 µg/L collected in September 2022. Although the January 2023 sample was only slightly above the criterion at 17.6 µg/L, the February, March, June, July, and August results were elevated at 24.8, 45.8, 33.10, 47.50, and 40.5 µg/L, respectively. The lowest concentration of 3.03 µg/L was collected in April 2023.

All total nitrogen results between September 2022 and February 2023 exceeded the 0.8 mg/L screening threshold. None of the results from samples collected in March to June 2023 exceeded the threshold. The average of all samples was 1.05 mg/L and ranged from 0.64 mg/L (June 2023) to 1.45 mg/L (November 2022).

Total phosphorus concentrations averaged 0.034 mg/L and were above the screening threshold of 0.03 mg/L for seven results. Samples ranged from undetectable (<0.02 mg/L) in December 2022 to 0.0483 mg/L (October 2022). Samples collected in November 2022, and in May, June, and August 2023 were also below the screening threshold.

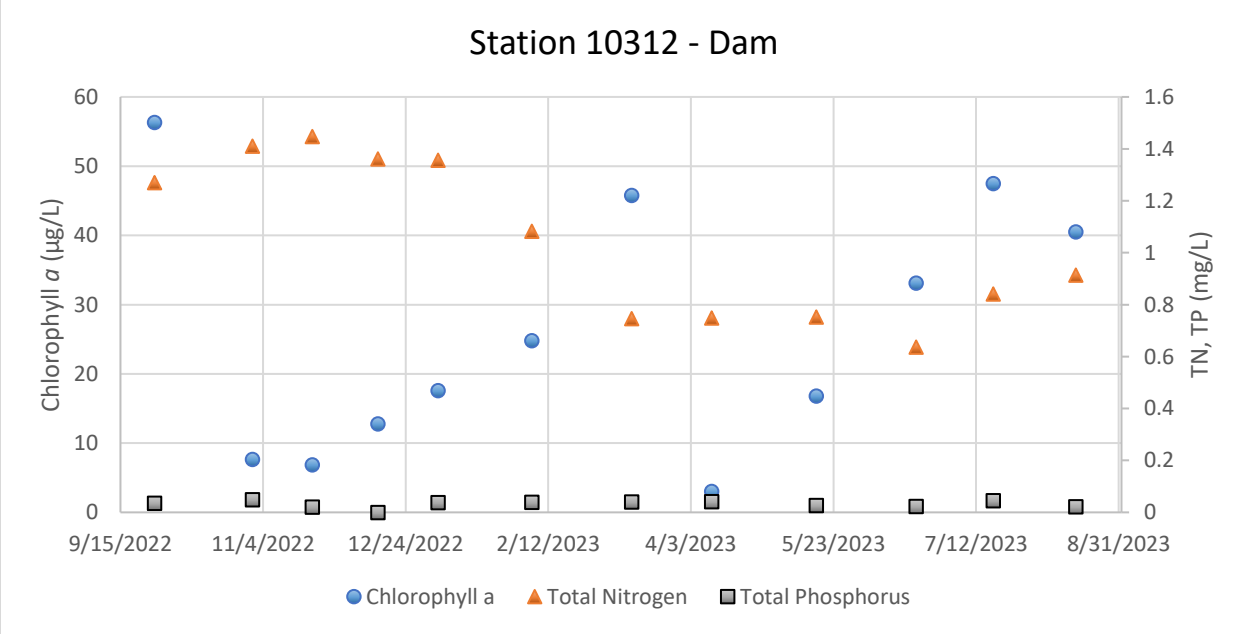

Figure 28: Station 10312 chlorophyll a and nutrient sample results

Secchi transparency had a mean of 0.83 m and ranged from 0.55 m in September 2022 to 1.20 m in December. The December result was the only value recorded above the 1.19 mg/L screening threshold.

Field parameter profiles were collected at the time of sample collection. Profiles were collected at 0.3-meter, 1 meter, and at every following meter to the lake bottom. Field parameters were evaluated based upon the measurements collected in the mixed surface layer. The mixed surface layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases more than 0.5 °C. The mean of the DO and median pH readings were calculated for each profile. The total depth of this station averaged 12.8 meters with a minimum of 10.8 meters and maximum of 13.9 meters. The mixed surface layer averaged 6.7 meters and ranged from 2.0 meters in February 2023 to 13.0 meters in October 2022.

Figure 29: Station 10312 near the dam

The average DO in the mixed surface layer met or exceeded the 5.0 mg/L grab screening level in all months except September 2022 when the mean mixed surface layer DO was 4.7 mg/L. The 0.3-meter measurement was 5.0 mg/L while DO ranged from 4.8 mg/L at 1.0 meter to 4.5 mg/L at 7.0 meters below the water surface. The median pH of all mixed surface layer samples was 7.5 s.u. Samples collected in March, May, and July 2023 were the only months to exceed the 8.5

s.u. criterion with median mixed surface layer pH of 8.7, 8.6, and 9.0 s.u., respectively. In all cases of high pH, DO percent saturation was over one hundred percent.

Sondes recorded DO, pH, conductivity, and temperature every fifteen minutes for a period of 24 hours. Out of 1,152 values collected during these diels, almost one-third (32.2%) of all readings had elevated pH (>8.5 s.u.). All results collected in March, May, and July 2023 were reported above the 8.5 s.u. criterion while 23 of the 96 values reported during the September 2022 and 60 out of 96 in the August 2023 diel were high. DO was greater than one hundred percent saturation in all cases where high pH was observed. None of the diel pH readings collected from October 2022 through February 2023 or in April and June 2023 exceeded the criterion.

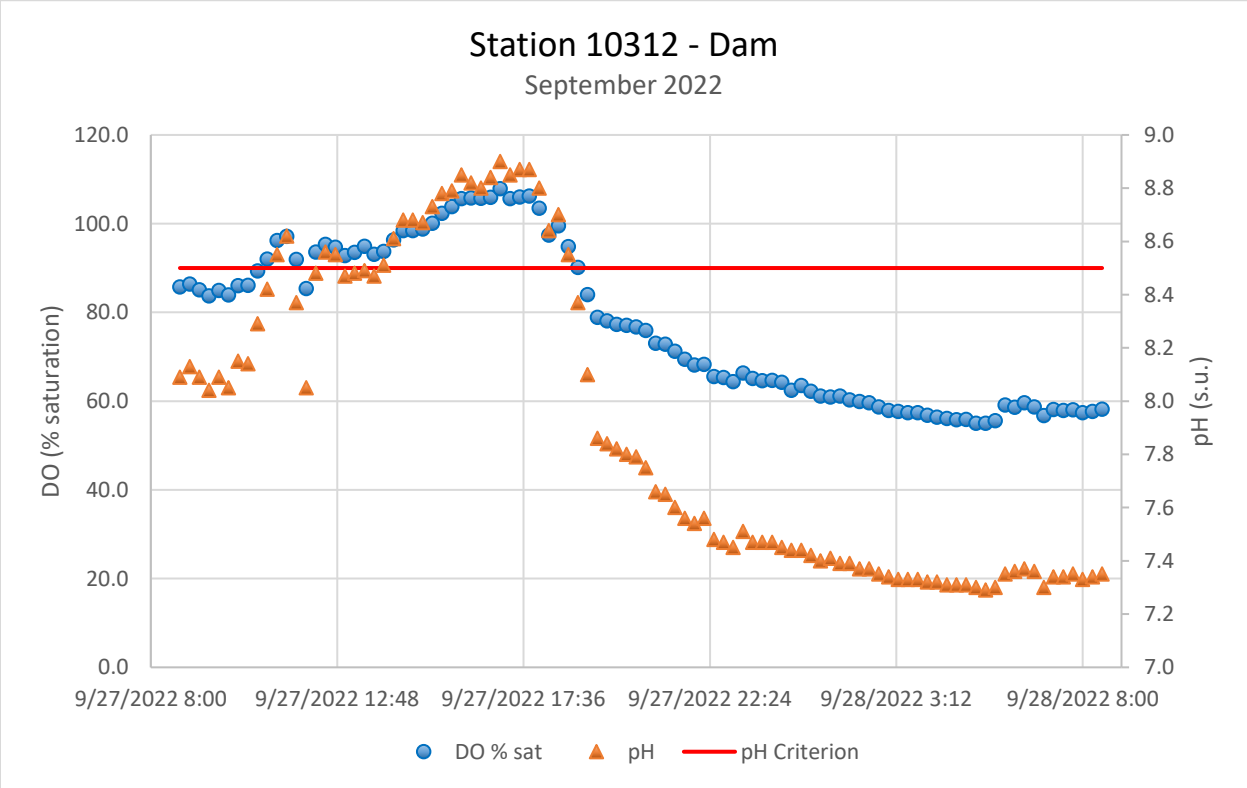

Figure 30: Diel DO percent saturation and pH at station 10312

It should be noted that thirty diel DO measurements fell below the 5 mg/L criterion during the September 2022 deployment with a minimum concentration of 4.4 mg/L. Thirteen DO readings in August 2023 fell below the threshold with a minimum of 3.9 mg/L. No other DO measurements were reported below the criterion during the other deployments. Station 10312 was the only station to have diel DO values reported below 5.0 mg/L.

Correlation analysis was performed to identify relationships between several parameters including grab, diel, and laboratory data. DO percent saturation and pH were strongly

correlated during each monthly diel. The mean correlation coefficient for all diels was 0.91. The highest correlation coefficient of 0.99 was observed in September 2022 followed by 0.98 in March 2023. The lowest coefficient was 0.78 in November 2022.

Using the mixed surface layer grab results, comparison analysis was conducted on DO percent saturation to pH, chlorophyll *a*, and Secchi transparency. Values for DO percent saturation and pH were strongly correlated with a coefficient of 0.90. Both DO percent saturation and pH were weakly correlated with chlorophyll *a* at 0.39 and 0.49, respectively.

Unsurprisingly, transparency and chlorophyll *a* were inversely related with a correlation coefficient of -0.61. This result suggests that as the concentration of chlorophyll *a* increases, water transparency decreases. Of note was that chlorophyll *a* had a weak inverse correlation with total nitrogen and total alkalinity, with a coefficient of -0.33 and -0.27, respectively. Chlorophyll *a* and water temperature were correlated with a coefficient of 0.56. This relationship would be anticipated since primary productivity accelerates in warmer water.

Figure 31: Station 17548 in the Panther Arm

AU 0405_03 – Panther Arm Station 17548

Although the nutrient criteria are only assessed for samples collected at station 10312, the results of sampling at the other stations were compared with these criteria and thresholds. The chlorophyll *a* mean for samples collected at the Panther Arm station 17548 was 32.59 µg/L, exceeding both the 17.54 µg/L criterion and 26.7 µg/L screening level used for reservoirs without numerical nutrient criteria. All but one of the samples exceeded the criterion, with a maximum a concentration of 53.1 µg/L collected in July 2023, while the lowest value of 15.0 µg/L was collected in December 2022.

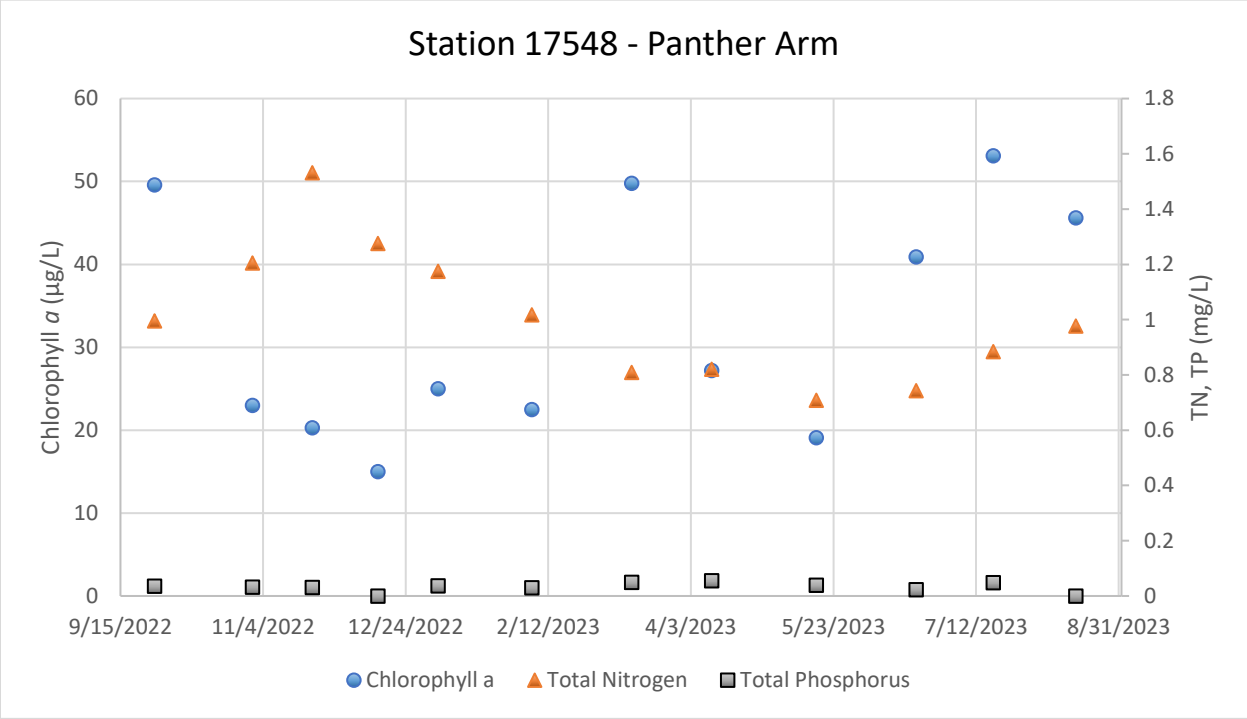

Figure 32: Station 17548 chlorophyll a and nutrient sample results

Ten of the total nitrogen results exceeded the 0.8 mg/L screening threshold with an average of 1.09 mg/L and ranged from 0.71 mg/L (May 2023) to 1.53 mg/L (November 2022).

Total phosphorus values averaged 0.038 mg/L with four results reported below the screening threshold of 0.03 mg/L. Those samples were collected in December 2022, and in February, June, and August 2023. Results ranged from <0.02 mg/L in December 2022 and August 2023 to 0.0556 mg/L in April 2023.

Secchi transparency had a mean of 0.69 m and ranged from 0.51 m in July 2023 to 0.92 m in November 2022.

The total depth of this station ranged from 5.7 to 7.3 meters with a mean of 6.6 meters. The mixed surface layer averaged 4.4 meters and ranged from 2.0 meters in June 2023 to 6.0 meters in September and December 2022 and in February 2023.

Similar to station 10312, the average DO in the mixed surface layer met or exceeded the 5.0 mg/L grab screening level in all months except September 2022 when the DO was 4.6 mg/L. It should be noted that DO in the upper 2.0 meters were above the screening level while the low DO values were obtained at 3.0 to 6.0 meters below the surface. The median pH of all mixed surface layer samples was 7.6 s.u. Samples collected in March and June 2023 were the only months to exceed the 8.5 s.u. criterion with median mixed surface layer pH of 8.6 and 8.7 s.u., respectively. In both cases of high pH, DO percent saturation was above one hundred percent.

Of the 1,152 diel readings collected during the study period, 339 pH measurements exceeded the 8.5 s.u. high pH criterion. All pH readings obtained in June 2023 were reported over the criterion, while 93.8 percent of the July 2023 and 82.3 percent of the August pH measurements exceeded the high pH criterion. None of the diel pH values exceeded the criterion in October 2022 through February 2023. In all but two diel measurements with high pH, DO percent saturation was greater than one hundred percent. Those two values were near full saturation at 98.4 and 98.9 DO percent saturation. Percent saturation and pH were correlated during all deployments with a mean coefficient of 0.89 and ranged from 0.59 in November 2022 to 0.99 in September 2022 and April 2023.

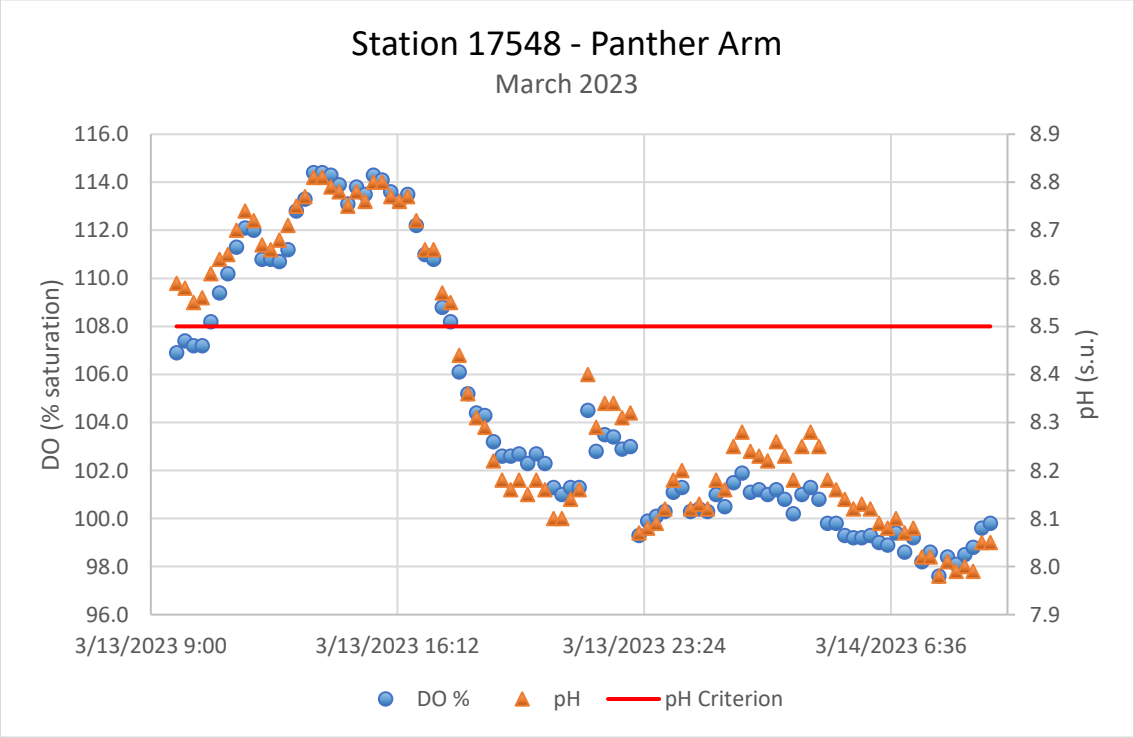

Figure 33: Diel DO percent saturation and pH at station 17548

A correlation analysis of the mixed surface layer grab data was conducted on DO percent saturation to pH, chlorophyll *a*, and Secchi transparency. Values for DO percent saturation and pH correlated well with a coefficient of 0.79. Chlorophyll *a* and pH correlated with a coefficient of 0.60 while transparency and chlorophyll *a* inversely correlated with a coefficient of -0.54. Similar to the results found at station 10312, as the concentration of chlorophyll *a* increases, water clarity decreases. Temperature was also correlated with chlorophyll *a* at 0.65. Chlorophyll *a* and total phosphorus had a weak correlation with a coefficient of 0.29. However, it had an inverse relationship with total nitrogen at -0.48. There was no correlation between chlorophyll *a* and total alkalinity.

Figure 34: Station 10313 - Midlake

AU 0405_02 – Midlake Station 10313

The mean of the chlorophyll *a* samples collected at the Midlake station 10313 was 44.73 µg/L, far exceeding both the 17.54 µg/L criterion and 26.7 µg/L screening level used for reservoirs without numerical nutrient criteria. All samples exceeded the criterion with the highest concentration of 70.5 µg/L collected in October 2022 and the lowest value of 20.0 µg/L collected in May 2023.

Total nitrogen results often exceeded the 0.8 mg/L screening threshold and averaged 1.09 mg/L for the study period. Total nitrogen ranged from 0.74 mg/L in April 2023 to 1.42 mg/L in November 2022.

Total phosphorus values averaged 0.053 mg/L, and all results were reported over the screening threshold of 0.03 mg/L. It should be noted that the November 2022 sample slightly exceeded the screening threshold at 0.0302 mg/L. The highest concentration was collected in March 2023 at 0.071 mg/L followed by 0.0655 mg/L in May 2023.

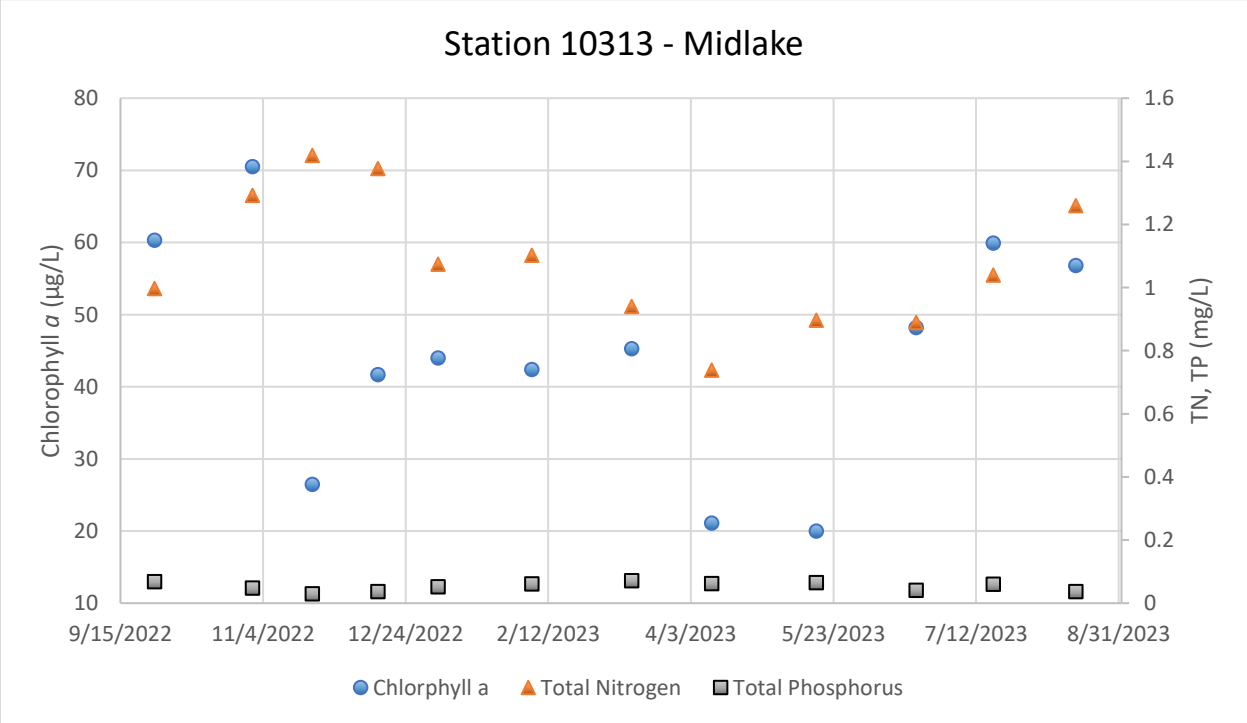

Figure 35: Station 10313 chlorophyll a and nutrient sample results

Secchi transparency had a mean of 0.64 m and ranged from 0.45 m in October 2022 to 0.90 m in February 2023.

The mean total depth of this station was 5.3 meters and ranged from 4.1 to 5.9 meters. The mixed surface layer averaged 3.7 meters and ranged from 1.0 meters in February 2023 to 5.0 meters in December 2022 and in March, April, and August 2023.

The average DO in the mixed surface layer met or exceeded the 5.0 mg/L grab screening level in all months. The mean of all mixed surface layer DO readings was 8.5 mg/L and ranged from 5.2 mg/L in September 2022 to 12.1 mg/L in February 2023. The median pH of all mixed surface layer samples was 7.7 s.u. The only month to exceed the high pH criterion was June 2023 with a median mixed surface layer pH of 8.8 s.u. while the mean DO percent saturation was 112.5 percent.

On average, over forty percent of the diel pH readings exceeded the 8.5 s.u. high pH criterion during the study period. A total of 483 out of 1,152 diel pH measurements exceeded the criterion. All deployments except for November 2022, December 2022, and April 2023 had high diel pH readings.

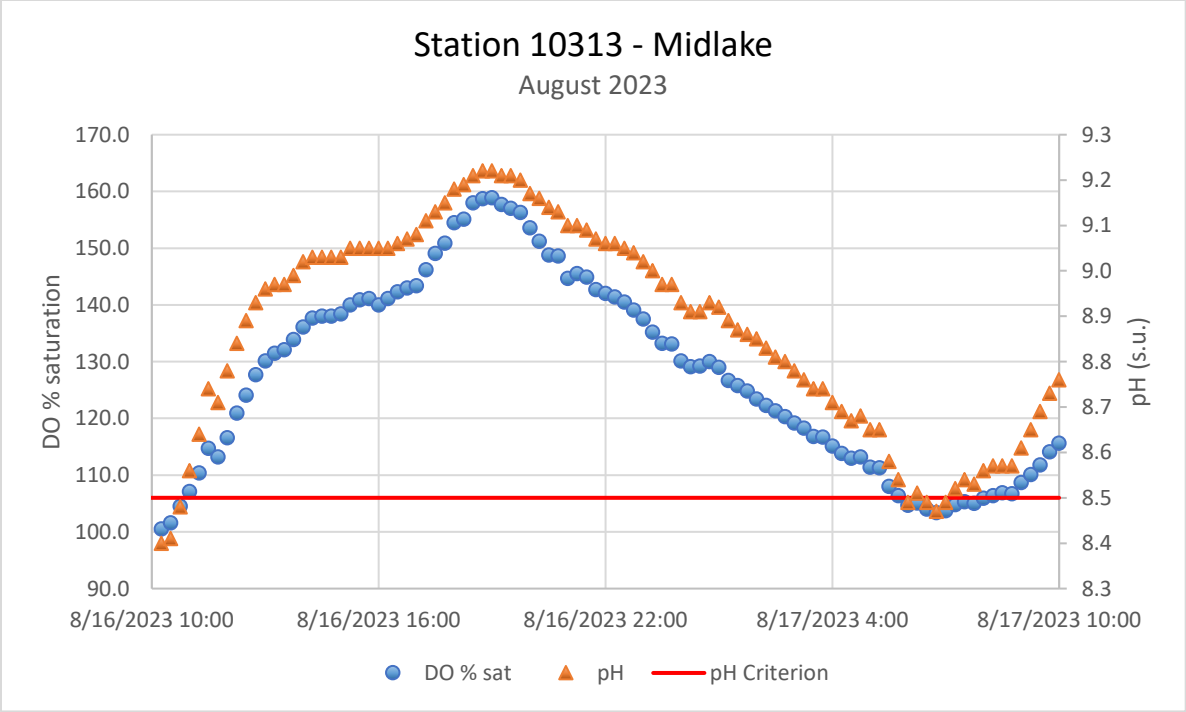

Figure 36: Diel DO percent saturation and pH at station 10313

Unfortunately, a DO sensor failed during the March 2023 deployment, so a comparison between diel pH and DO percent saturation could not be performed. In all other cases of high diel pH, DO was greater than one hundred percent saturation. Diel DO percent saturation and pH were highly correlated during all deployments with a mean coefficient of 0.97 and ranged from 0.87 in December 2022 to a perfect 1.00 in September and October 2022 and in January 2023. These diel DO readings were the only missing data for the entire study.

A correlation analysis of the mixed surface layer data was conducted on DO percent saturation to pH, chlorophyll *a*, and Secchi transparency. Profile values for DO percent saturation and pH were well-correlated with a coefficient of 0.68. DO percent saturation and pH had weak correlations with chlorophyll *a* at -0.21 and 0.13, respectively. As found at the other stations, Secchi transparency and chlorophyll *a* were inversely correlated with a coefficient of -0.57. Chlorophyll *a* did not correlate with total phosphorus; however, it had a weak correlation with total nitrogen at 0.28 and with total alkalinity at 0.47.

Figure 37: Station 20346 - West End

STATION 20346 – WEST END

The West End station is also in AU 0405_02 and is in a transition zone of the reservoir. Since the station is in a transition zone, data collected at this station will not used to assess Lake Cypress Springs. This station was selected for sampling because it is widely believed that much of the nutrient input into the reservoir is likely due to contributions from Big Cypress Creek. Diel monitoring was not conducted at this station since it is in a transition zone.

The mean of the chlorophyll *a* samples collected at this station was 41.73 µg/L which was well above the 26.7 µg/L screening level used for reservoirs without numerical nutrient criteria. All results were above the 17.54 µg/L criterion with September 2022 having the highest concentration at 65.7 µg/L. The lowest value of 19.1 µg/L was collected in January 2023.

All total nitrogen results exceeded the 0.8 mg/L screening threshold with an average of 1.28 mg/L and ranged from 0.92 mg/L in March 2023 to 2.62 mg/L in December 2022.

Total phosphorus averaged 0.148 mg/L and all samples were reported higher than the screening threshold of 0.03 mg/L. Samples ranged from 0.0392 mg/L in November 2022 to 0.524 mg/L in December 2022.

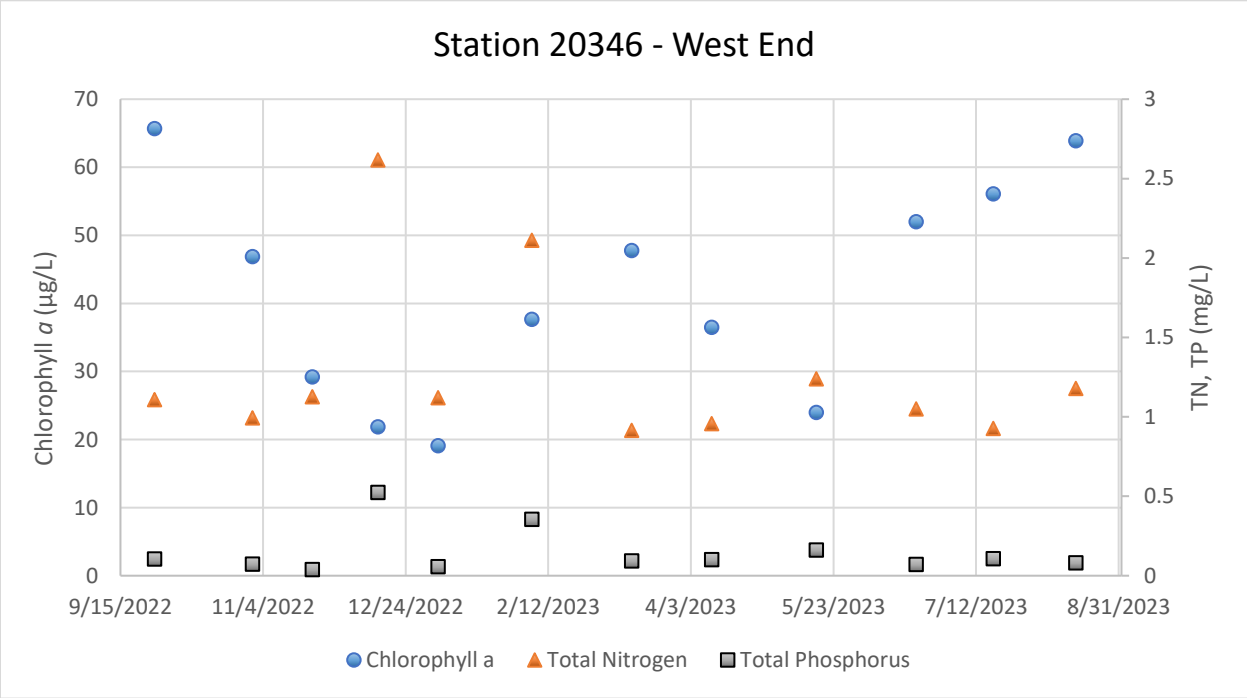

Figure 38: Station 20346 chlorophyll a and nutrient sample results

Secchi transparency had a mean of 0.40 m and ranged from 0.15 m in August 2023 to 0.70 m in November 2022.

Total depth averaged 2.4 meters and ranged from 1.4 to 3.1 meters. The mean mixed surface layer was 1.5 meters. The shallowest mixed surface layer was 0.3 meter in September through November 2022. In all other months, the mixed surface layer was 2.0 meters except for May 2023 at 1.0 meter.

The average DO in the mixed surface layer met or exceeded the 5.0 mg/L grab screening level in all months with a mean of 8.8 mg/L. The lowest mixed surface layer DO was 5.2 mg/L in May

2023 while the highest was in February 2023 at 12.0 mg/L. The median pH of all mixed surface layer samples was 7.9 s.u. The high pH criterion was exceeded in November 2022 and March 2023 at 8.6 and 8.7 s.u., respectively. The mean DO percent saturation in the mixed surface layer was over one hundred percent on both occasions.

A correlation analysis of the mixed surface layer data was conducted on DO percent saturation to pH, chlorophyll *a*, and Secchi transparency. Profile values for DO percent saturation and pH were well-correlated with a coefficient of 0.75. DO percent saturation and pH had correlations to chlorophyll *a* at 0.29 and 0.37. Transparency and chlorophyll *a* had a slightly inverse relationship at -0.22. This was the weakest relationship for all stations. Chlorophyll *a* had an inverse correlation with total nitrogen (-0.42) and with total phosphorus (-0.37) meaning that as chlorophyll *a* increases, total nitrogen and total phosphorus concentrations decrease. Chlorophyll *a* correlated to alkalinity with a coefficient of 0.37.

COMPARISONS ACROSS LAKE CYPRESS SPRINGS

The following discussion is a comparison of the results across all stations in Lake Cypress Springs.

Only seven of the 48 chlorophyll *a* samples collected during the study period did not exceed the 17.54 µg/L chlorophyll *a* criterion with a mean of all samples of 36.28 µg/L. The highest chlorophyll *a* result of 70.5 µg/L was obtained in October 2022 at the Midlake station followed by 65.7 µg/L at the West End in September 2022. All samples collected from both stations were reported above the chlorophyll *a* criterion. The average result was 44.73 µg/L at the Midlake station while the mean value at the West End station was 41.73 µg/L. The average chlorophyll *a* concentration was lowest at the Dam at 26.06 µg/L followed by the Panther Arm with 32.59 µg/L.

A single-factor Analysis of Variance Analysis (ANOVA) test was performed on the chlorophyll *a* data using an alpha value of 0.05. The results of the ANOVA showed that chlorophyll *a* results were statistically significantly different between the stations with a p-value of 0.0267. Further analysis showed that the Dam station had significantly lower chlorophyll *a* concentrations than the other stations, but there was no significant difference between the Panther Arm, Midlake, and West End stations.

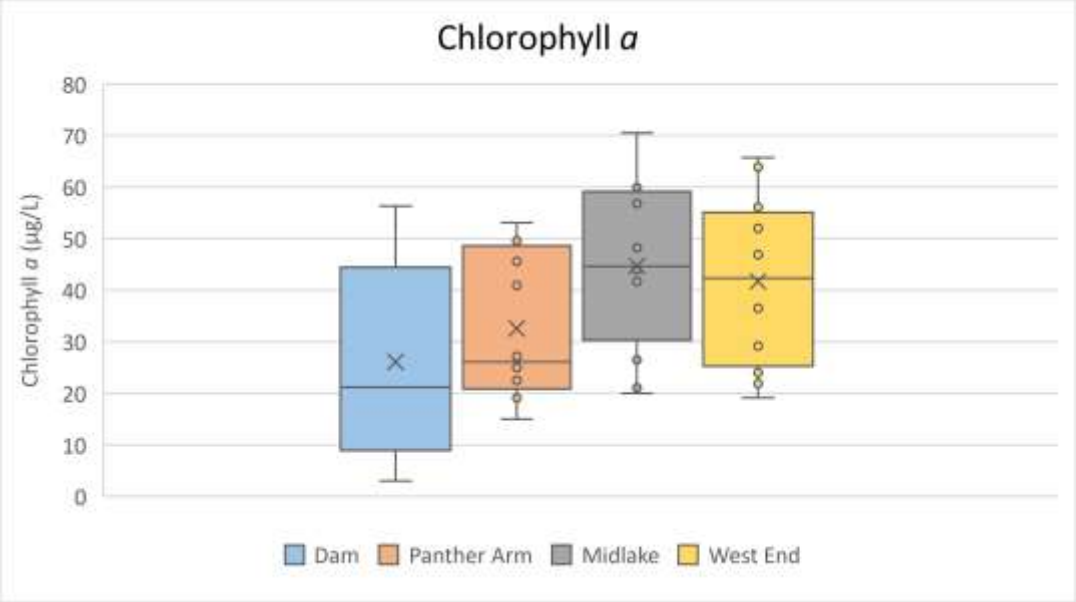

Figure 39: Chlorophyll a results by station

Chlorophyll *a* had an inverse correlation with Secchi transparency at all stations. The correlation coefficients ranged from -0.61 at the Dam to -0.22 at the West End station. The inverse correlation indicated that as the chlorophyll *a* concentration increases the transparency of the water decreases. These results were similar to those discussed in the historical data review.

The average water temperature in the mixed surface layer directly correlated with chlorophyll *a* at all stations. The coefficients ranged from 0.33 at Midlake to 0.68 at the West End station. The Panther Arm had a coefficient of 0.65 whereas the Dam was 0.56. The direct correlation suggested that as water temperature increases, chlorophyll *a* also increases.

Mixed surface layer DO and pH correlated with chlorophyll *a*, although most coefficients were low. For DO, the Dam station had the highest coefficient at 0.39 while the other stations ranged from -0.21 at Midlake to 0.29 at the West End. A correlation between pH and chlorophyll *a* was found at all stations. Although the Midlake station was very low with a coefficient of 0.13, the West End station was 0.37. The Dam and Panther Arm had stronger correlations with a coefficient of 0.49 at the Dam and 0.60 in the Panther Arm.

All but six of the total nitrogen results were reported over the 0.8 mg/L screening threshold. Four of those low values were obtained at the Dam station in March through June 2023 while two were collected at the Panther Arm station in May and June 2023. The highest average was found at the West End station at 1.28 mg/L. In December 2022, the total nitrogen concentration was over three times the threshold with 2.62 mg/L followed by 2.11 mg/L in February 2023. The Panther Arm had the lowest mean total nitrogen concentration of 1.01 mg/L followed by the Dam station at 1.05 mg/L.

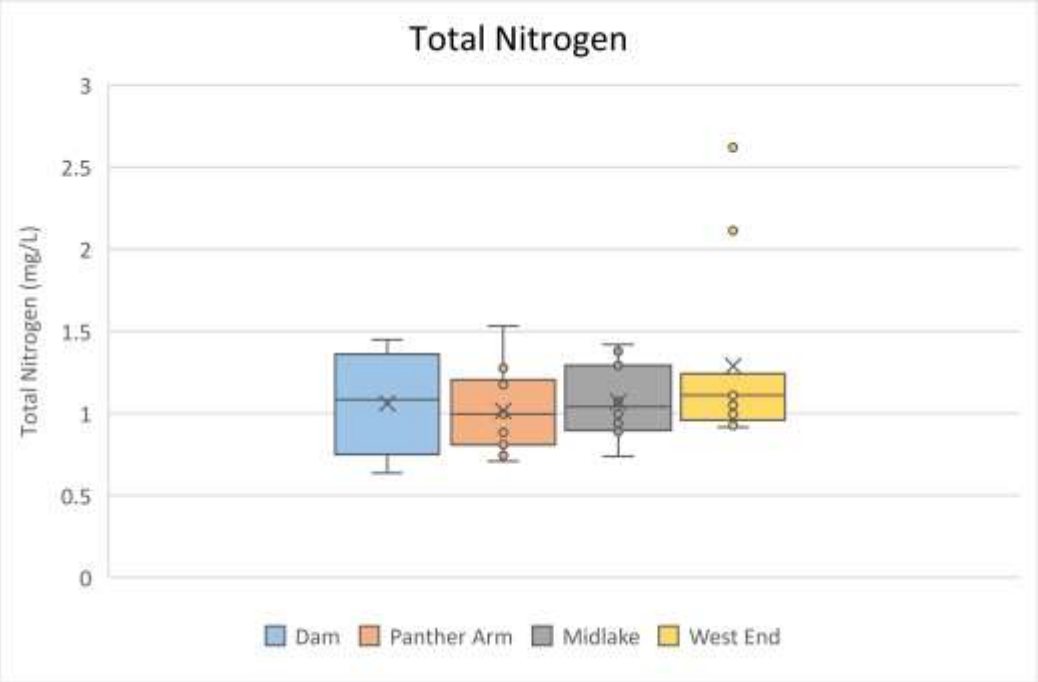

Figure 40: Total nitrogen results by station

A single-factor ANOVA was conducted on the total nitrogen data and no statistically significant difference was identified between the stations. This test was also conducted on the individual nitrogen series parameters of ammonia, nitrate, nitrite, and total Kjeldahl nitrogen. The difference between the stations for total Kjeldahl nitrogen was statistically significant with a p-value of 0.0264. When removing the West End station from the analysis, there was no significant difference between the stations. These results may be influenced by the outlier samples collected at the West End station. It should be noted that since less than half of the ammonia and nitrite results and just over half of the nitrate samples were reported above the laboratory quantitation limits, significant differences between the stations would not be anticipated.

Total nitrogen inversely correlated with chlorophyll *a* at all stations except for Midlake. The coefficients were -0.48 at the Panther Arm, -0.42 at the West End, and -0.33 at the Dam. These results were in contrast with the historical data review where total Kjeldahl nitrogen was directly correlated to chlorophyll *a* at the Dam and Midlake stations.

Nine total phosphorus samples were reported below the 0.03 mg/L screening threshold. Five of the low results were obtained at the Dam station, and four were collected in the Panther Arm. Similar to total nitrogen, total phosphorus was highest at the West End station with a maximum concentration of 0.524 mg/L in December 2022 and with an average of 0.148 mg/L. The Midlake station had a much lower average at 0.053 mg/L, but higher than the averages at the

Dam and Panther Arm station. The Dam station had the lowest mean concentration at 0.034 mg/L closely followed by the Panther Arm at 0.038 mg/L.

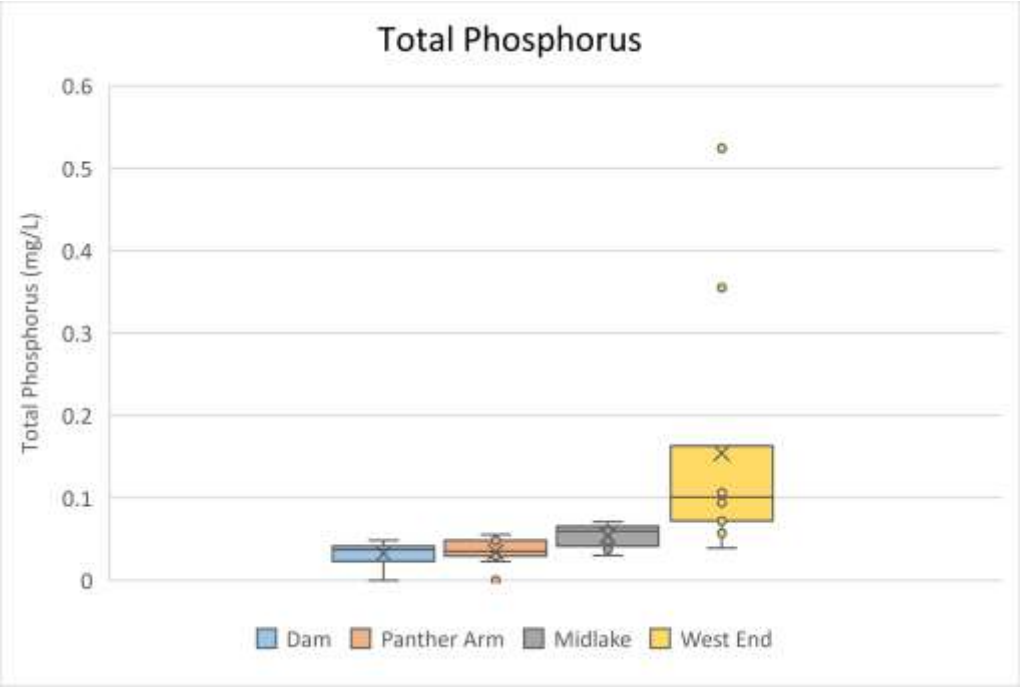

Figure 41: Total phosphorus results by station

A single-factor ANOVA was conducted on the total phosphorus results and statistically significant differences were identified between the stations with a p-value of 0.0007. After removing the West End station from the analysis, the difference continued to be statistically significant with the same p-value of 0.0007.

Total phosphorus had an inverse correlation with chlorophyll *a* at the West End station with a coefficient of -0.37. There was no correlation found at the Midlake or Dam stations; however, the Panther Arm had a slight correlation with a coefficient of 0.29.

Mean Secchi depth was greatest at the Dam station at 0.83 meter. This station also had the greatest range of measurements from 0.55 meter in September 2022 to 1.20 meters in December 2022. The Panther Arm station was second with a mean transparency of 0.69 meter and ranged from 0.51 meter in July 2023 and April 2023 to 0.92 meter in November 2022. The Midlake station had an average Secchi transparency of 0.64 meter and ranged from 0.45 m in October 2022 to 0.90 meter in February 2023. The West End station had the least transparency with a mean of 0.40 meter and ranged from 0.15 meter in August 2023 to 0.70 meter in November 2022.

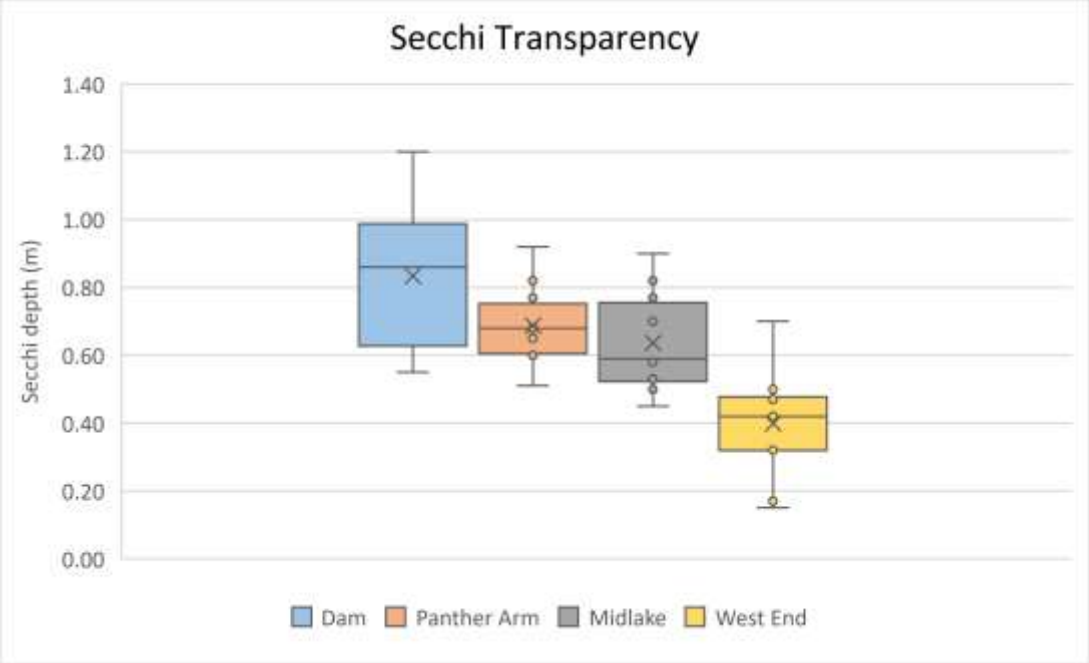

Figure 42: Secchi transparency by station

A single-factor ANOVA was conducted on Secchi transparency and statistically significant differences were identified between the stations with a p-value of 3.853E-07. After removing the West End station from the analysis, the difference continued to be statistically significant with a p-value of 0.0132.

Total alkalinity was consistent across Lake Cypress Springs and ranged from 30.1 to 52.8 mg/L with a mean of 38.73 mg/L. The Dam station had the highest mean at 39.49 mg/L while the West End station had the lowest average at 38.43 mg/L.

Chloride and sulfate had little variation across all stations with means of 13.16 mg/L and 13.36 mg/L, respectively. The lowest chloride concentration was 10.40 mg/L, and the greatest was 13.70 mg/L. Both samples were collected at the West End station. The lowest sulfate concentration of 10.70 mg/L was collected at the Dam station while the highest concentration was collected at the West End with 17.40 mg/L.

The mean total depth of each station ranged from 2.4 meters at the West End to 12.8 meters at the Dam station. The Panther Arm averaged 6.6 meters, and the Midlake station had a mean depth of 5.3 meters. The mixed surface layer was, on average, deepest at the Dam at 6.7 meters and shallowest at the West End station with a mean of 1.5 meters. The Panther Arm and Midlake stations had similar mean mixed surface layers of 4.4 and 3.7 meters, respectively.

In September 2022, the average DO in the mixed surface layer fell below the 5.0 mg/L grab screening level at the Dam and Panther Arm stations. The mean dissolved oxygen concentration

was 4.7 and 4.6 mg/L, respectively. All other grab samples measured in the mixed surface layer were above the 5.0 mg/L screening level throughout the study period.

The median pH in the mixed surface layer was below the 8.5 s.u. high pH criterion during most months across the reservoir. In total, eight median pH grab readings exceeded the criterion during the study. Three of these values were recorded at the Dam station while two high pH grab measurements were reported at the Panther Arm and at the West End station. Only one pH grab exceeded the criterion at the Midlake station. The highest mixed surface layer median pH was recorded at the Dam station in July 2023 at 9.0 s.u. In all cases of high pH grab readings, DO percent saturation was reported over one hundred percent.

Single-factor ANOVA analyses were conducted on the average mixed surface layer DO and median pH measurements. No statistically significant differences were identified between the stations.

Diel measurements were recorded every fifteen minutes over a 24-hour period for a total of 1,152 measurements at each station. The median diel pH ranged from 7.5 s.u. at the Dam station to 8.4 s.u. at the Midlake station. Similarly, the mean pH ranged from 7.9 s.u. at the Dam to 8.3 s.u. at Midlake. At the Dam station, the minimum pH was 6.9 s.u. and maximum was 9.4 s.u. for a pH range of 2.5 s.u. For the Panther Arm, the median pH was 7.9 s.u. with a minimum of 6.6 s.u., a maximum of 9.3 s.u., and range of 2.7 s.u. The Midlake station had the highest diel pH median at 8.4 s.u., a maximum pH of 9.4 s.u., minimum of 7.2 s.u., and range of 2.2 s.u.

High pH during diel measurements were most often observed at the Midlake station with 483 out of 1,152 readings (41.9 percent) exceeding the pH criterion. High pH measurements were recorded in nine out of twelve months at this station. The median of the 96 pH readings of each monthly diel exceeded 8.5 s.u. for five diels ranging from 8.6 s.u. in February to 9.0 s.u. in July 2023.

For the Dam and Panther Arm stations, most of the high diel pH measurements were collected during the warm weather months of September 2022 and in March through August 2023. Diel pH measurements were above the criterion in 32.2 percent of the readings at the Dam station and 29.4 percent in the Panther Arm. The median of the diel pH readings exceeded 8.5 s.u. at the Dam for three months ranging from 8.9 s.u. in May to 9.2 s.u. in July 2023. The median diel pH at the Panther Arm was elevated in each of the months of June through August 2023 ranging from 8.9 to 9.0 s.u.

Percent of High Diel pH Measurements			
Month	**Dam**	**Panther Arm**	**Midlake**
September 2022	24.0%	24.0%	30.0%
October 2022	0.0%	0.0%	26.0%
November 2022	0.0%	0.0%	0.0%
December 2022	0.0%	0.0%	0.0%
January 2023	0.0%	0.0%	35.4%
February 2023	0.0%	0.0%	53.0%
March 2023	100.0%	34.4%	84.4%
April 2023	0.0%	13.5%	0.0%
May 2023	100.0%	5.2%	5.2%
June 2023	0.0%	100.0%	92.7%
July 2023	100.0%	93.8%	88.5%
August 2023	62.5%	82.3%	87.5%
Mean	**32.2%**	**29.4%**	**41.9%**

Figure 43: Percent of high diel pH measurements by station

High diel pH measurements were most common in the warm weather months while no readings exceeded the 8.5 s.u. criterion in the months of November and December 2022 at any station. No high pH values were recorded at the Dam and Panther Arm stations from October 2022 through February 2023. The average percentage of high diel pH readings in the warm weather months of September 2022 and April through August 2023 was 47.8 percent at the Dam, 53.1 percent at Panther Arm, and 50.7 percent at Midlake. For the cooler months of October 2022 through March 2023, the average percentage of diel pH readings exceeding the criterion were 16.7 percent at the Dam, 5.7 percent in the Panther Arm, and 33.1 percent at the Midlake station.

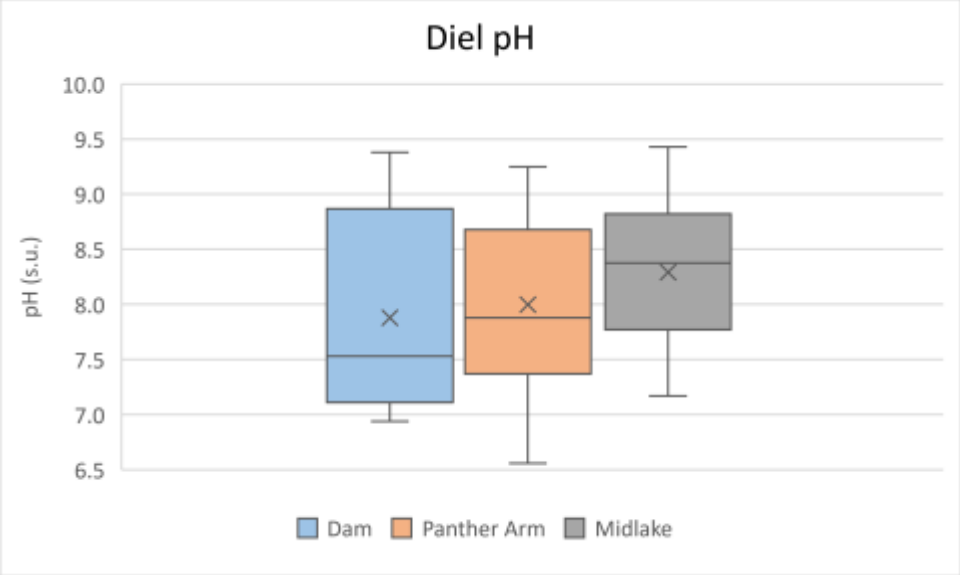

Figure 44: Diel pH measurements by station

A single-factor ANOVA was conducted on the monthly mean diel DO concentration and median diel pH value for the three stations. No statistically significant differences were observed between stations for either parameter.

Figure 45: Deploying a water quality sonde at Midlake station 10313

Diel DO percent saturation and pH values were well-correlated for the entire study period. Measurements made at the Midlake station had the highest correlation with an average coefficient of 0.97. These parameters correlated perfectly (1.00) in September and October 2022 and in January 2023. Both the Panther Arm and Dam stations had strong correlation coefficients with averages of 0.91 and 0.89, respectively.

Correlation DO percent saturation with pH			
Month	**Dam**	**Panther Arm**	**Midlake**
September 2022	0.99	0.99	1.00
October 2022	0.81	0.67	1.00
November 2022	0.78	0.59	0.99
December 2022	0.90	0.77	0.87
January 2023	0.91	0.89	1.00
February 2023	0.82	0.91	0.95
March 2023	0.98	0.98	x
April 2023	0.97	0.99	0.98
May 2023	0.91	0.96	0.96
June 2023	0.96	0.98	0.96
July 2023	0.97	0.97	0.95
August 2023	0.97	0.97	0.99
Mean	**0.91**	**0.89**	**0.97**

Figure 46: Correlation coefficients of DO percent saturation with pH

CONCLUSIONS

Although nitrate and total nitrogen were relatively abundant at the Dam station with averages of 0.30 mg/L and 1.05 mg/L, this station had the lowest mean concentrations of total phosphorus (0.034 mg/L) and chlorophyll *a* (26.06 µg/L). This station also had the highest transparency (0.83 meter) of all stations.

Sample results from the Panther Arm were similar to those found at the Dam station. The mean nitrate was 0.30 mg/L, and total nitrogen concentration were the lowest of all stations at 1.01 mg/L. Total phosphorus was slightly higher than at the Dam with an average of 0.038 mg/L. Chlorophyll *a* had a mean of 32.59 µg/L and transparency of 0.69 meter. These results indicated that nutrient loading in the Panther Arm was much lower than at the West End station.

Laboratory analyses support the assumption that Big Cypress Creek is a significant contributor of nutrient loading into Lake Cypress Springs. The West End station had the highest total nitrogen, total phosphorus, and lowest transparency of the four stations. Total nitrogen averaged 1.28 mg/L and surpassed 2.0 mg/L in December 2022 and February 2023. The mean total phosphorus concentration was 0.148 mg/L, or almost five times the screening threshold of 0.03 mg/L. The average chlorophyll *a* value was 41.73 µg/L, exceeding both the 17.54 µg/L site-specific chlorophyll *a* criterion and the 26.7 µg/L screening level for reservoirs without numeric nutrient criteria. This station also had the least transparency with a mean of 0.40 meter, less than half of the transparency at the Dam station.

Although the mean total nitrogen (1.09 mg/L) and total phosphorus (0.053 mg/L) results at the Midlake station were lower than at the West End station, the Midlake station had the highest chlorophyll *a* concentration in a single sample (70.5 µg/L) and as an average of all samples (44.73 µg/L). Total Kjeldahl nitrogen, total phosphorus, and Secchi transparency were statistically different at the West End station than the other stations. These results suggest that Big Cypress Creek is the primary contributor of nutrients into Lake Cypress Springs.

Diel pH readings were generally consistent across the three stations in Lake Cypress Springs with the median pH of all 1,152 diel measurements ranging from 7.5 s.u. at the Dam, 7.9 s.u. at Panther Arm, to 8.4 s.u. at the Midlake station. The Panther Arm had the greatest pH range of 2.7 s.u. while the Dam station tied with Midlake for the highest individual diel pH reading of 9.4 s.u. Almost 42 percent of the pH measurements at the Midlake station exceeded the high pH criterion whereas approximately 29 percent at the Panther Arm and 32 percent of the readings at the Dam were elevated.

High diel pH measurements were most common in the warm weather months of September 2022 and April through August 2023. About half of all diel pH readings were over the 8.5 s.u.

criterion at all stations. In comparison, the average percentage of diel pH readings exceeding the criterion fell to less than twenty percent at the Dam and Panther Arm stations while about a third of all diel pH readings were high at the Midlake station during the cool weather months of October 2022 through March 2023.

DO percent saturation and pH were well-correlated at all stations. The average correlation coefficient ranged from 0.89 in the Panther Arm, 0.91 at the Dam, to 0.97 at Midlake. The highest correlation coefficient for an individual diel was 1.00 at the Midlake station. The perfect correlation was identified from three individual monthly diels at this station. These strong correlations coupled with a much greater percentage of elevated pH readings in the warm weather months indicate that the high pH impairment is likely a result of primary productivity. This is further supported by the direct correlation between the average mixed surface layer water temperature and chlorophyll *a* concentrations at all stations, in addition to good correlations between chlorophyll *a* and pH at the Dam and Panther Arm.

Excess nutrients found in the West End are likely being converted into algal biomass at the Midlake station. This assertion is supported by the Midlake station having the highest chlorophyll *a* concentrations but much lower total nitrogen and total phosphorus results than found at the West End station. The Dam station chlorophyll *a* and total phosphorus concentrations were forty percent and 34 percent lower than found at Midlake. These results suggest that the reservoir is possibly phosphorus limited. It is recommended that nutrient sampling in Big Cypress Creek above the reservoir should be considered in the future to further evaluate these findings.

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.

The 2022 IR showed that Lake Bob Sandlin was one of the least polluted reservoirs in the state. The reservoir ranked in the top 8 percent for the least amount of phosphorus, top 15 percent for the highest water clarity, and top 30 percent for the lowest concentration of chlorophyll *a*.

There were no impairments or concerns for Lake Bob Sandlin shown in the 2022 IR. Unlike Lake Cypress Springs, chlorophyll *a* concentrations were typically low throughout the assessment period with only two out of 63 samples reported above the 26.7 µg/L screening level. Both high values were obtained in July 2019 with 32.5 µg/L at station 16158 and 50.1 µg/L at station 10329.

Nutrient concentrations were also very low during the assessment period with half of the nitrate and over sixty percent of all total phosphorus samples reported below their respective detection limits while less than fifteen percent of ammonia samples were measurable. Five nitrate samples exceeded the 0.37 mg/L screening level with a mean of 0.42 mg/L. A single ammonia result of 0.27 mg/L was reported over the 0.11 mg/L screening level whereas none of the total phosphorus samples exceeded the screening level of 0.2 mg/L.

Unlike Lake Cypress Springs, pH fell within the criteria during the assessment period in all but two out of 66 surface readings. Both high pH results were 9.1 s.u. and were observed at station 16158 in July 2017 and at station 10329 in September 2017.

Quarterly samples for bacteria, conventionals, and field parameters are collected by TCEQ Region 5 at stations 16158 near Farm to Market Road (FM) 21 and at 10329 (dam).

Figure 47: Lake Bob Sandlin at Titus County Freshwater Supply District Boat Ramp 1 near the Fort Sherman Dam

Water released from the Fort Sherman Dam enters Big Cypress Creek. These releases highly influence the water quality in Big Cypress Creek and Lake O' the Pines. Since there are no in-stream flow requirements, water is only released from the reservoir to maintain freeboard. 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.

Due to flooding, 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. Almost 1.3 million acre-feet were released between 2015 and 2021 which represents about thirty percent of all water discharged from Lake Bob Sandlin since its completion in 1979. However, drought conditions from the summer of 2021 through 2022 resulted in no water being released between July 2021 and the end of 2022.

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. During periods of drought or low flow, the stream flow is primarily composed of treated municipal and industrial wastewater effluent.

The *2022 Texas Integrated Report* showed concerns for nitrate in both assessment units of Segment 0404, Big Cypress Creek below Lake Bob Sandlin, and for chlorophyll *a* in the lower reach of the stream. The table below details impairments (NS), concerns for near non-attainment (CN), and concerns for screening level (CS) for specific waterbodies in Segment 0404 as shown in the 2022 IR.

Segment AU	Description	Parameter	Support
0404_01	Big Cypress Creek from Lake O' the Pines upstream 24 km	Chlorophyll *a*	CS
		Nitrate	CS
0404_02	Big Cypress Creek upstream 37.2 km	*E. coli*	**NS**
		Nitrate	CS
0404B	Tankersley Creek	Habitat; Benthos	CS
		E. coli	**NS**
		Nitrate; Chlorophyll	CS
		DO screening level	CS
0404C	Hart Creek	*E. coli*	**NS**
		Nitrate	CS
0404E	Dry Creek	*E. coli*	**NS**
		Nitrate	CS
0404F	Sparks Branch	*E. coli*	**NS**
		Nitrate	CS

Figure 48: A portion of the table of the 2022 IR in Segment 0404

Station 10310 at US 271 and station 10308 at SH 11 are routinely monitored in the upper assessment unit of Big Cypress Creek while stations 16458 (near the confluence with Greasy Creek) and 13631 at US 259 represent the lower assessment unit. Station 10310 is located downstream of the confluence with Tankersley Creek, and station 10308 is below the confluence with Hart Creek and Walkers Creek. TCEQ Region 5 monitors quarterly at stations 10308 and 13631 for flow, bacteria, and for field and laboratory parameters. NETMWD/WMS samples quarterly for flow, bacteria, and for field and conventional laboratory parameters at

station 16458 located below the confluence with Greasy Creek. In addition, WMS is performing a bioassessment at station 22423 in Big Cypress Creek below the confluence with Walker Creek.

The bacteria impairment in the upper assessment unit of Segment 0404 was first listed in 2002. The geometric mean of the *E. coli* samples collected during the assessment period was 215.7 MPN/100 mL exceeding the 126 MPN/100 mL geometric mean criterion.

Nitrate and chlorophyll *a* were included as concerns in this segment in the 2022 IR. High nitrates were a concern in both assessment units. All but seven of the 88 nitrate samples collected in the upper assessment unit exceeded the 1.95 mg/L screening level with a mean exceedance of 19.09 mg/L. For the lower assessment unit, about 34 percent of all nitrate results exceeded the screening level with an average exceedance of 6.92 mg/L. Since the Pilgrim's Pride wastewater treatment plant upgrade was completed in early 2015, total phosphorus concentrations have noticeably declined with most values falling below the screening level of 0.69 mg/L.

The high nutrient concentrations in Big Cypress Creek resulted in a concern for chlorophyll *a* in the lower assessment unit. About thirty percent of the chlorophyll *a* values exceeded the 14.1 µg/L screening level with an average exceedance of 34.6 µg/L. These excessive nutrients continue into Lake O' the Pines and have also degraded its water quality. These effects are discussed in further detail in the Lake O' the Pines Special Study section of the report.

Figure 49: Stream flow measurement at station 16458 in Big Cypress Creek

Major tributaries of Big Cypress Creek include segments 0404B - Tankersley Creek, 0404C - Hart Creek, 0404E – Dry Creek, and 0404F – Sparks Branch. The 2022 IR had concerns for nitrate and chlorophyll *a* in Tankersley Creek and for nitrate in Hart Creek. Due to high nitrate results collected in Tankersley Creek and in Hart Creek, special studies of these parameters were funded by the CRP in 2018 and 2019. Monthly samples for sulfate, chloride, ammonia, nitrite, nitrate, total Kjeldahl nitrogen, and total phosphorus were collected at three stations in Tankersley Creek and at two stations in Hart Creek to identify potential sources. The nitrate special study monitoring began in July 2018 and was completed in June 2019.

A sulfate special study of Tankersley Creek and the upper assessment unit of Big Cypress Creek commenced in November 2019 and continued through October 2020. The results of both studies showed that the Pilgrim's Pride plant was the primary contributor of these constituents; however, none of the sample results exceeded the plant's permit limits. Results of both studies were detailed in the *2021 Cypress Creek Basin Highlights Report*. Nitrate concerns were also identified in Dry Creek and in Sparks Branch. WMS samples quarterly for field and laboratory parameters, bacteria, and flow at station 10261 in Tankersley Creek and at station 10266 in Hart Creek. No sampling is currently being conducted in Dry Creek or Sparks Branch.

There are eight permitted wastewater treatment plants in the Lake O' the Pines watershed, with half of the plants located in Segment 0404. The total permitted discharge for these systems combined is 9.67 million gallons per day (MGD).The two largest plants are the City of Mount Pleasant and Pilgrim's Pride, permitted at 3.0 MGD 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 Dry Creek plant is only used when specific flow conditions are met. 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

Excessive nutrient inputs into the reservoir from both point and non-point sources have long been a concern for Lake O' the Pines stakeholders. In 2000, the TCEQ found that dissolved oxygen levels in Lake O' the Pines were less than optimal for supporting fish and other aquatic species. Although the amount of dissolved oxygen in water fluctuates naturally, anthropogenic sources can cause unusually or chronically low dissolved oxygen levels. A Total Maximum Daily Load (TMDL) was implemented to reduce oxygen-demanding substances to improve water

quality conditions for aquatic life. The study determined that a 56 percent reduction in phosphorus entering the reservoir was needed to improve dissolved oxygen concentrations in the reservoir. In 2013 and 2014, stakeholders reviewed the 2008 TMDL Implementation Plan and revised the Implementation Plan to continue their efforts in improving its water quality.

Through the revised TMDL Implementation Plan, a group permit for phosphorus was issued to all wastewater treatment plants located in the Lake O' the Pines watershed. This permit, known as the Total Phosphorus Load Agreement (TPLA), is an agreement between NETMWD and entities operating permitted wastewater treatment plants. The TPLA was the first of its kind in the State of Texas.

The TMDL program worked with the TCEQ Water Quality Division through the Water Quality Management Plan update process to specify permit limits and other permit language for these eight permittees. Although the total allocation of phosphorus from these point sources has remained the same, the individual allocations were different than originally allocated in the TMDL Implementation Plan. This change is reflected in the current versions of their permits. In 2012, Pilgrim's Pride agreed to take on the full phosphorus reduction required to meet the TMDL. This meant that its allowable annual discharge is much lower than what appears in the TMDL Implementation Plan and in the TPLA, whereas the allowable allocations for the seven municipal permittees are now higher (matching their observed amounts in the original TMDL) than in the Implementation Plan and in the TPLA. In 2023, all entities renewed the TPLA permit for another ten years.

Permitted Discharger	Permitted Discharge (MGD)	Phosphorus Allocation	2022 Phosphorus Discharged	Difference
Daingerfield	0.7	231	738	507
Lone Star	0.44	204	464	260
Mt. Pleasant	2.91	989	683	-306
Omaha	0.2	118	304	186
Ore City	0.22	453	379	-74
Pilgrim's Pride	3.0	24,127	4,270	-19,857
Pittsburg/Dry Creek	0.2	259	0	-259
Pittsburg/Sparks Branch	2.0	807	282	-525
Total	**9.67**	**27,188**	**7,120**	**-20,068**

Figure 50: TPLA phosphorus discharges in 2022 (in kilograms of phosphorus)

Note that only Pilgrim's Pride Wastewater Treatment Plant (WWTP) has a phosphorus permit limit. The other seven municipal permittees are all required to sample and report their phosphorus discharges. Their allocated amounts are noted in the "Other Requirements" section of their permits, with wording stating that their permits can be amended to include those numbers as permit limits if the group fails to meet the phosphorus goal of the TPLA. In 2022, about one-fourth of the permitted phosphorus allocation was discharged into the watersheds entering Lake O' the Pines. The cities of Daingerfield, Lone Star, and Omaha exceeded their allocations while all other permittees successfully met theirs that year.

The TPLA permitted the Pilgrim's Pride WWTP an annual discharge limit of 24,127 kilograms of phosphorus. In 2014, the plant discharged more than double that amount at 45,813 kilograms. That year, a multi-million-dollar upgrade to the Pilgrim's Pride WWTP was initiated which was completed in April 2015. In 2022, the WWTP released a total of about 4,270 kilograms of phosphorus, or about one-fifth of its permitted allocation.

Stakeholders have also specified voluntary actions aimed at reducing non-point source contributions, such as stormwater runoff, were necessary to achieve the goals of the TMDL. Technical and financial programs were created for agricultural producers; and local/county programs were created to address on-site sewage facilities, marine sanitation, and education.

LAKE O' THE PINES SPECIAL STUDY

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 surface 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. 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 reservoir between January and August 2016 which is enough water to fill Caddo Lake nearly seven times.

Releases 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 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.

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

- AU 0403_01 Lower 5,000 acres near the dam and represented by station 10296
- AU 0403_02 Middle 5,000 acres; station 16156
- AU 0403_03 Middle 5,000 acres below State Highway 155; station 10297
- AU 0403_04 Upper 3,700 acres above State Highway 155; station 17087

The *2022 Texas §303(d) List* identified the three lower assessment units as impaired for high pH. The high pH impairment was due to pH samples exceeding the 8.5 s.u. criterion during the assessment period. For AU 0403_01, fourteen percent of the pH readings were high, and 21 percent of the measurements in AU 0403_02 and 27 percent in AU 0403_03 exceeded the 8.5 s.u. criterion.

The *2022 Texas Integrated Report* defined Lake O' the Pines as an eutrophic reservoir and ranked it in the top twenty percent out of 139 Texas resevoirs for elevated chlorophyll *a*. Although chlorophyll *a* was not shown as concern in the 2022 IR for the three lower assessment

units, data collected during the assessment period revealed many elevated chlorophyll *a* results. Approximately half of all samples collected in the three assessment units exceeded the 26.7 µg/L screening level. The mean of the exceedances was 42.3 µg/L.

For the headwaters assessment unit, AU 0403_04, the 2022 IR included an impairment for 24-Hour DO along with a concern for DO grab screening level. The 24-Hour DO impairment was a carry-forward from previous assessments since no diel studies have been performed in this assessment unit since 2002. Four of the 26 DO grab samples fell below the 5.0 mg/L screening criteria with a mean of 3.66 mg/L. Unlike the other assessment units, none of the pH values exceeded the criterion. However, sixteen percent of nitrate and twelve percent of the total phosphorus results were reported over their screening levels while a third of the chlorophyll *a* samples were high. The mean of the chlorophyll *a* exceedances was more than twice the screening level at 56.83 µg/L.

A review of all pH data collected in Lake O' the Pines from 1998 through 2018 for the *2019 Cypress Creek Basin Summary Report* revealed statistically signficant increasing pH trends in the two middle assessment units of the reservoir. A decreasing trend for transparency was identified in the lower assessment unit (AU 0403_01). Since chlorophyll *a* had been increasing at a statistically significant rate in the 2009 and 2014 basin summary reports, the decreasing transparency trend was possibly a result of increased algal production.

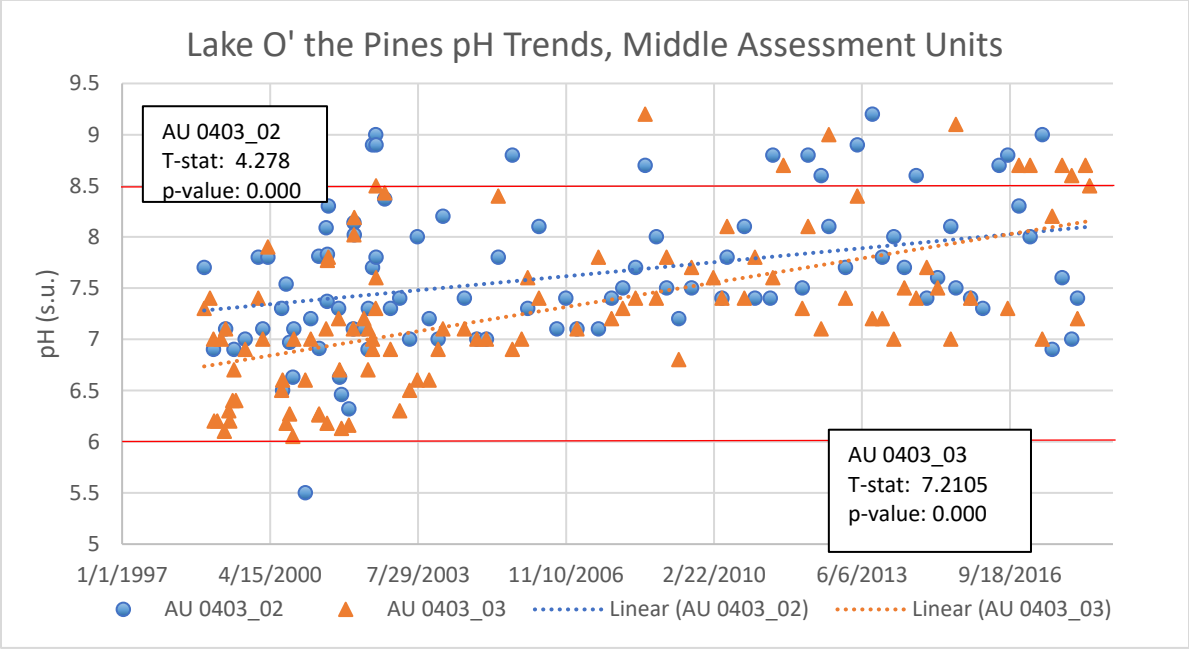

Figure 51: pH Trends shown in the 2019 Cypress Creek Basin Summary Report

The Basin Summary Report also revealed that high pH readings had been rare prior to 2010. Historically, only one pH value was reported above the 8.5 s.u criterion from 1973 through 2009

in AU 0403_01. The report demonstrated that all high pH measurements collected since 2010 corresponded with super-saturated DO. A strong statistical correlation between all pH and DO percent saturation was identified.

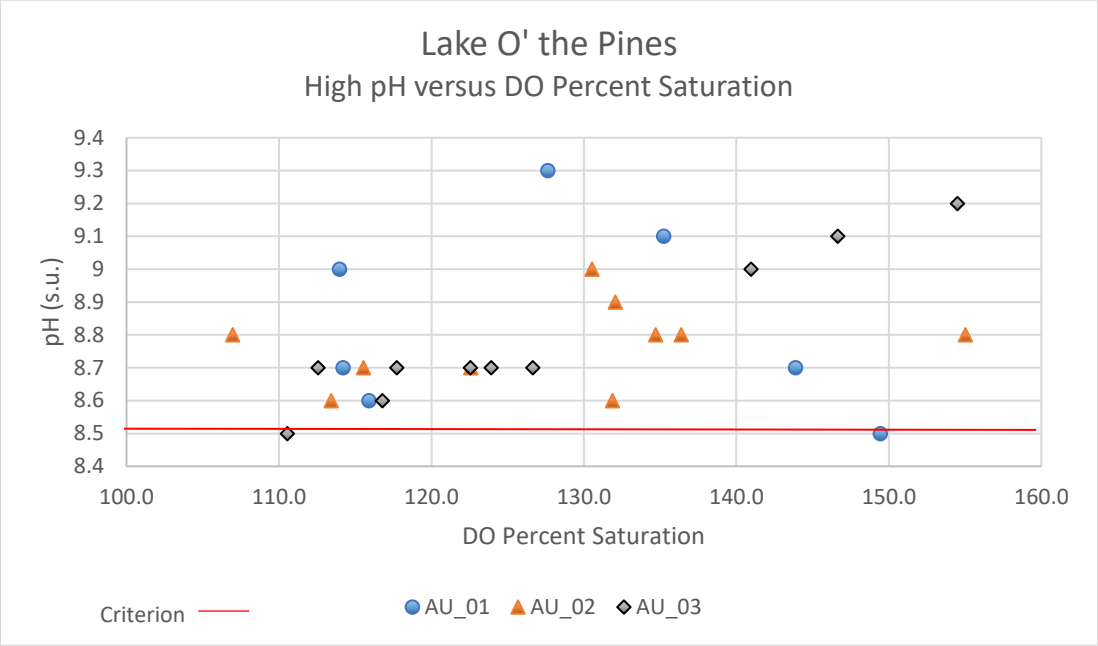

Figure 52: High pH versus DO Percent Saturation shown in the 2019 Cypress Creek Basin Summary Report

In eutrophic reservoirs, algae (phytoplankton) consume available carbon dioxide during the process of photosynthesis. Once the available carbon dioxide is exhausted, carbon dioxide will be broken away from carbonic acid, thereby increasing the pH in the water column. When sunlight is not available for photosynthesis, carbon dioxide, released through respiration, will bond with available hydrogen ions to reform carbonic acid, thereby lowering the pH. Since oxygen production is a product of photosynthesis, DO saturation can serve as a surrogate indicator for chlorophyll *a* sample analysis.

The combination of elevated chlorophyll *a* and super-saturated DO supported the assumption that the high pH readings were a direct result of phytoplankton productivity since all of the data reported were grab samples collected between 10 AM and 2 PM, the peak hours of primary production. The report suggested that diel pH cycling was likely to be occurring; however, no recent diel data were available for review to test the hypothesis. Due to the pH impairments and data needs in order to validate these assumptions, two special studies were funded by the CRP. A Continuous Water Quality Monitoring Special Study incorporated the use of two continuous water quality monitoring stations located in the upper portion of the reservoir. The monitor at US 259 was used to represent AU 0403_04 while the NETMWD intake station represented AU 0403_03. A Diel Special Study incorporated targeted diel monitoring in the lower assessement units. Data collected at the City of Longview intake represented AU 0403_02

and the Dam station represented AU 0403_01. A complete discussion of these studies are available in the *2022 Cypress Creek Basin Highlights Report*.

The continuous monitoring sondes revealed that pH did not exceed the 8.5 s.u. criterion very often. At the US 259 station, pH was reported above 8.5 s.u. in less than 0.11 percent of the measurements whereas the NETMWD intake was above the criterion in 1.22 percent of the readings. Most high pH values measured by the continuous water quality monitors were recorded in the warm weather months. The warm weather months also exhibited the greatest diel range between minimum and maximum pH. The highest monthly pH range at the US 259 station was 2.4 s.u. while it was 3.1 s.u. at the NETMWD intake. These pH ranges occurred in June and July 2020 at both stations.

Figure 53: Lake O' the Pines continuous water quality monitoring stations; US 259 station (left), NETMWD intake (right)

For the Diel Special Study, high pH was most often obtained at the City of Longview intake (AU 0403_02), exceeding the criterion in over 36 percent of all samples collected while pH at the

Dam was high in approximately 31 percent of the readings. The greatest percentage of high pH values were collected during the July 26, 2021 deployments where the City of Longview intake and Dam stations exceeded the criterion in over 94 percent and 85 percent of the readings, respectively. The only deployment where none of the pH values exceeded the criterion at either station was the August 25, 2020 study.

Figure 54: Lake O' the Pines Diel Monitoring Stations; City of Longview intake (left), swimming area near the Dam (right)

The studies suggested that there is a close relationship between DO percent saturation and pH throughout the reservoir. Most high pH results were collected during super-saturated DO conditions. Further, DO percent saturation and pH correlated well at both continuous monitoring stations as well as at both diel stations. A comparison of the data collected at the NETMWD intake continuous monitor with the diel data from the City of Longview intake and Dam stations revealed that DO percent saturation and pH were almost perfectly correlated with the mean coefficients ranging from 0.93 at the NETMWD intake to 0.95 at Dam station and 0.96 at the Longview intake.

The results of these special studies indicated that the high pH impairments in Lake O’ the Pines are a result of eutrophication. This assertion is supported by the study findings which showed that all high pH values were obtained when DO was super-saturated; the high pH readings primarily occurred during warm weather months; and pH correlated closely with DO saturation.

SPECIAL STUDY DESIGN

The Lake O' the Pines Special Study was designed to target the warm weather months of May through August when pH tends to exceed its criterion most often. Five sampling efforts were conducted during these months in 2023. Sampling included deploying sondes in each of the four assessment units along with the collection of lake profiles and laboratory samples during each effort. Field observations such as Secchi transparency, water color, wind speed, wave activity, etc. were made. Laboratory samples for total Kjeldahl nitrogen, nitrate, nitrite, ammonia, total phosphorus, chlorophyll *a*, chloride, sulfate, and total alkalinity were collected. All sampling was conducted under an approved Quality Assurance Project Plan and by following the procedures detailed in Volume 1 of the TCEQ Surface Water Quality Monitoring Procedures Manual.

Sampling was conducted at one station in each of the four assessment units. The assessment units are defined by surface area:

Assessment Unit	Surface Acres	Description	Station #
0403_01	Lower 5,000	near the Dam	10296
0403_02	Middle 5,000	Midlake, Alley Creek area	16156
0403_03	Middle 5,000 below SH 155	NETMWD Intake	10297
0403_04	Upper 3,700	above SH 155	17087

Figure 55: Description of the assessment units

As detailed in the previous section, data obtained from the targeted diel special studies in 2020 and 2021 showed that pH and DO percent saturation were strongly correlated and may be an indication of eutrophication. One of the limitations of the continuous monitors special study was the inability to maintain the sonde in the mixed surface layer. The mixed surface layer is defined as the portion of the water column from the surface to the depth at which water temperature decreases more than 0.5 °C.

Due to releases from Lake Bob Sandlin and runoff events, the sondes were regularly submerged over a meter deep in the water column. Since the completion of these 2020 - 2021 special studies, the NETMWD has acquired buoys to allow the sonde to be deployed at 0.3 - 0.5 meters below the water surface for diel measurements.

Diel measurements were made at each of the four stations during each sampling effort. Sondes were programmed to record DO, pH, temperature, and specific conductance every fifteen minutes for a period of 24 hours. Water quality profiles for these parameters were collected

during each sampling effort at 0.3 meters below the surface, 1 meter, and at each meter afterwards. Laboratory samples were collected at 0.3 meters below the surface. Field observations and Secchi transparency were also recorded at the time of sample collection. Field parameters, lake profiles, and laboratory samples were collected at the time of sonde retrieval.

Data collected throughout this special study were reported to SWQMIS; however, these results will not be used in the assessment of the watershed since sampling did not represent ambient conditions, rather sampling was targeted towards a specific season. The data were coded as "BSWD", meaning "biased to season, watershed characterization". However, these data will be useful to the Standards team in the development of nutrient criteria of the reservoir, as well as the analysis of water quality issues in the reservoir. These data will also be of value to the TMDL team in their evaluation of the success of the TMDL Implementation Plan.

Figure 56: Sonde deployed from a buoy at the Midlake station 16156

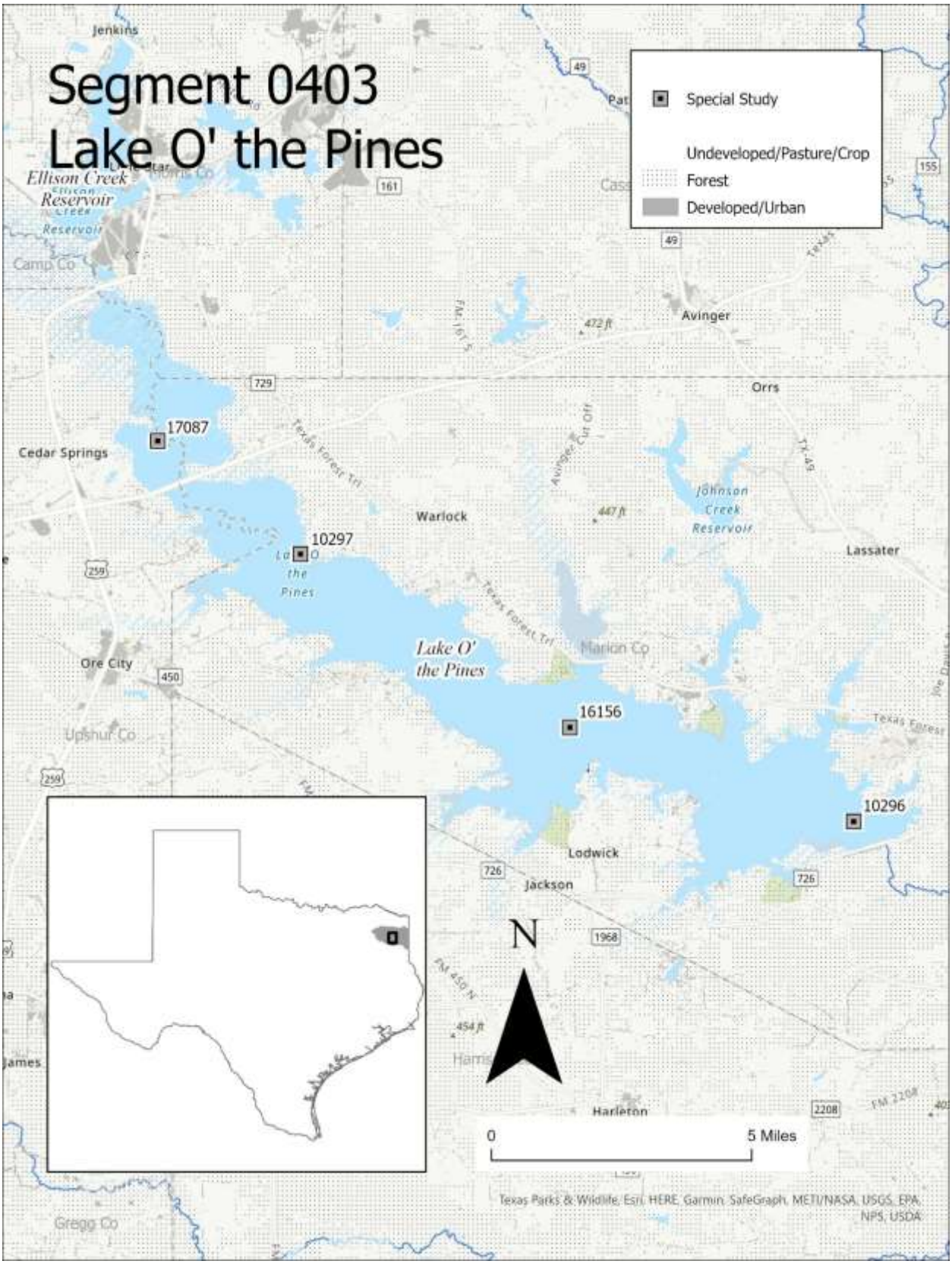

Figure 57: Map of the Lake O' the Pines Special Study monitoring stations

Lake O' the Pines has two conservation pool elevations. From October 1 through April 30, the conservation pool is 228.5 feet. The lake has a seasonal conservation pool of 230.0 feet from May 1 through September 30. Mean daily lake elevation, wind speed, wind direction, and rainfall is recorded by the U.S. Geological Survey (USGS) at their gage #7345900 located near the dam. Due to heavy rains in early June, the lake level recovered from its minimum elevation for the study period of 228.74 feet on June 10th and reached its seasonal conservation pool level of 230.0 feet on June 17th. The lake remained above its conservation pool for the remainder of the study.

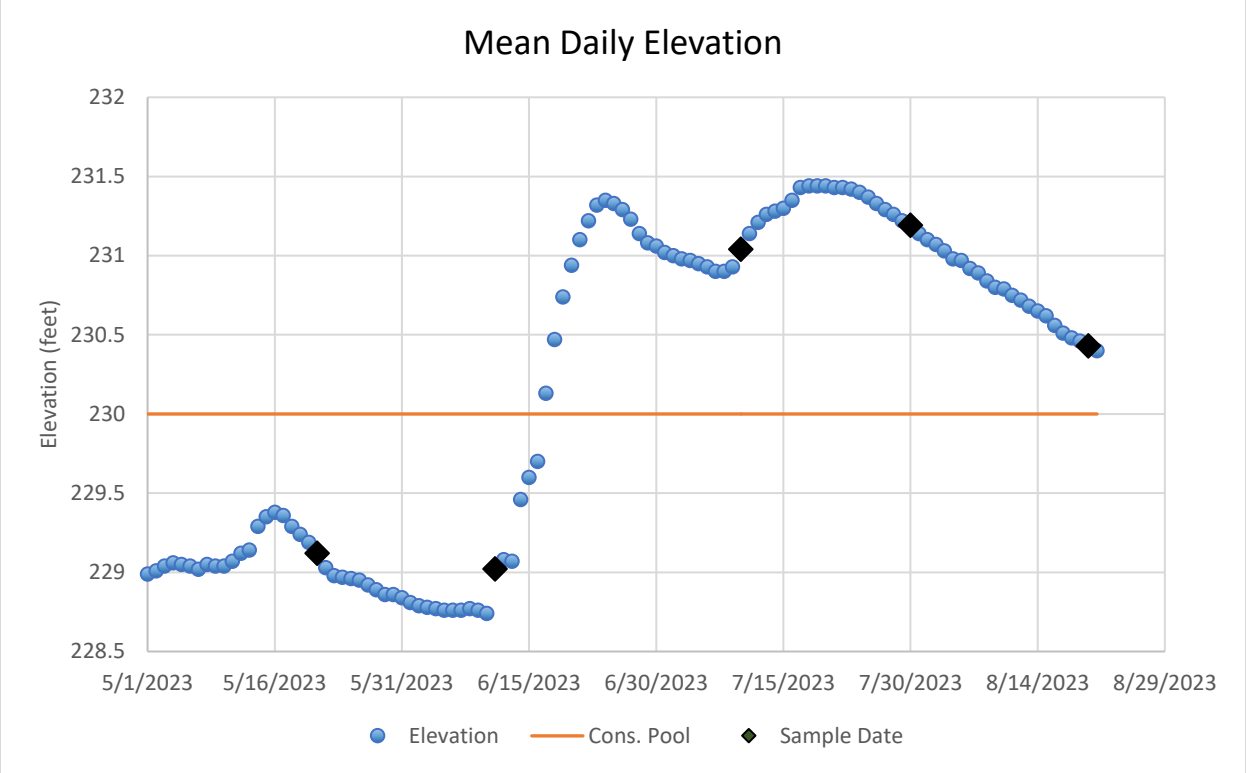

Figure 58: Lake elevation during the study period

The watershed above the reservoir received regular rainfall through late spring and early summer. Thunderstorms occurred during both the June and early July studies. Monthly rainfall totals recorded by the USGS gauge at the dam and stream flow in Big Cypress Creek at SH 11 reported for the study period are shown in the table below.

Month	**Rainfall** (inch)	**Flow** (acre-feet)
May	3.59	15,396
June	4.82	35,335
July	3.26	10,547
August	0.05	322
TOTAL	**11.76**	**61,600**

Figure 59: Lake O' the Pines rainfall and inflow totals by month

Consistent rains in the watershed of the reservoir during the study period generated regular runoff periods in Big Cypress Creek throughout much of the study period. Flow recorded by USGS gage #07344500 showed that a total of approximately 61,000 acre-feet of water in Big Cypress Creek passed the SH 11 gage between May 1 and August 20, 2023. These results were similar to the over 58,000 acre-feet inflows estimated by the U.S. Army Corps of Engineers (USACE). This amount of water represents slightly under one-quarter of the 254,000 acre-feet storage capacity of the reservoir.

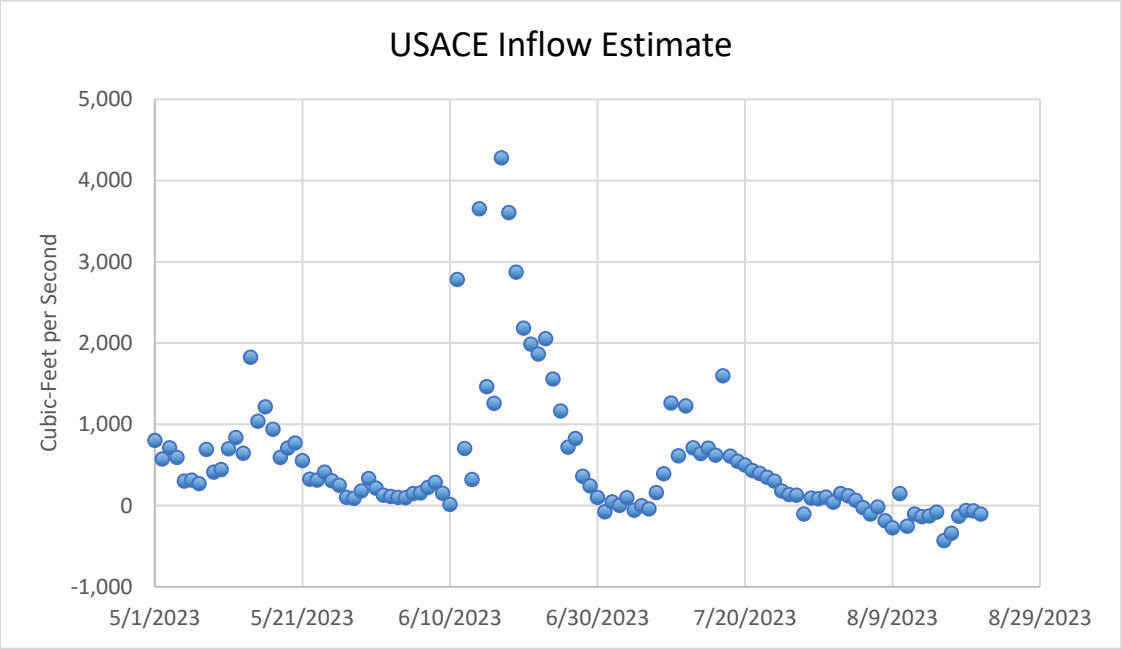

Figure 60: Lake O' the Pines Inflow as estimated by the USACE

Field notes show that the wind was calm to slight during most field efforts. The USGS wind gauge reported median wind speeds ranging from 2.8 miles per hour during the August deployment to 3.8 miles per hour in both June and early July. The average wind speed ranged from 3.42 miles per hour in May to 4.53 miles per hour in early July.

RESULTS

Sampling commenced on May 21 and was completed on August 20, 2023. Sampling was conducted under ambient conditions and on dates when weather did not present boater safety concerns. Sampling was conducted on the following dates:

2023 Sampling Dates
May 21 – 22
June 11 – 12
July 9 – 10
July 29 - 30
August 19 - 20

Figure 61: Lake O' the Pines Special Study sampling dates

Figure 62: Station 10296 near the Dam

AU 0403_01 –Station 10296, near the Dam

Station 10296 is located approximately 1.16 km north-northwest of the dam. Total depth at this station ranged from 8.6 to 9.6 meters with an average of 9.1 meters. Field parameter profile data were collected at the time of laboratory sample collection. The mixed surface layer was 1.0 meters. None of the average DO readings from the mixed surface layer were less than the 3.0 mg/L grab criterion. The lowest average mixed surface layer DO value of 7.7 mg/L was collected in early July, and the highest was 9.1 mg/L in May. DO saturation of the mixed surface layer was greater than one hundred percent in all months with an average of 123.9 percent.

The median mixed surface layer pH exceeded 8.5 s.u. in all events except early July. The pH ranged from 8.3 s.u. in early July to 9.1 s.u. in May. The median pH was 8.6 s.u. in June, 8.7 s.u. in late July, and 8.8 s.u. in August. The average of all pH measurements was 8.7 s.u. Mixed surface layer average DO and median pH were directly correlated with a coefficient of 0.78.

This station had the most diel observations that exceeded the 8.5 s.u. high pH criterion. Out of 480 diel measurements, 73.3 percent (352) of the pH readings exceeded 8.5 s.u. All diel measurements made in May and June and 78 readings in late July and in August exceeded the criterion whereas only three pH values were elevated in early July. The median pH of all diel measurements was 8.8 s.u. with a maximum value of 9.3 s.u. In every case of a high pH, DO saturation was greater than one hundred percent. It should also be noted that none of the diel DO readings fell below 5.0 mg/L during any deployment. The mean of all diel DO measurements was 8.7 mg/L with a maximum concentration of 11.4 mg/L.

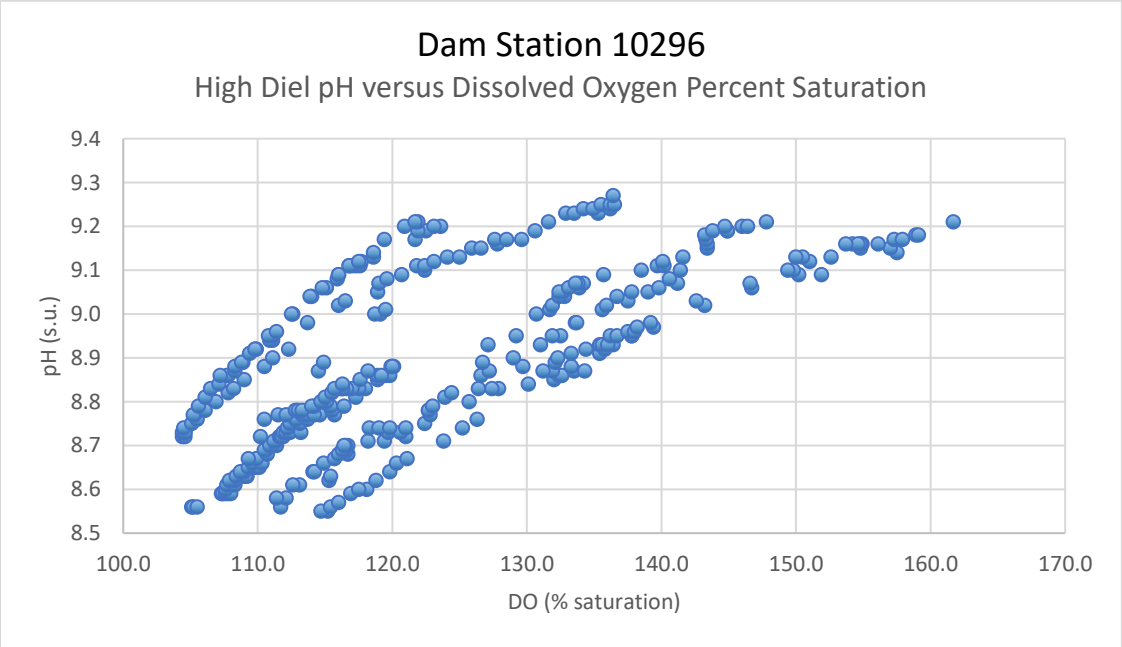

Figure 63: High diel pH versus DO percent saturation at station 10296

Similar to the findings of the special studies conducted in 2020 and 2021, diel DO percent saturation and pH were highly correlated. The average correlation coefficient of each diel was 0.96, ranging from 0.93 in May to 0.99 in early July.

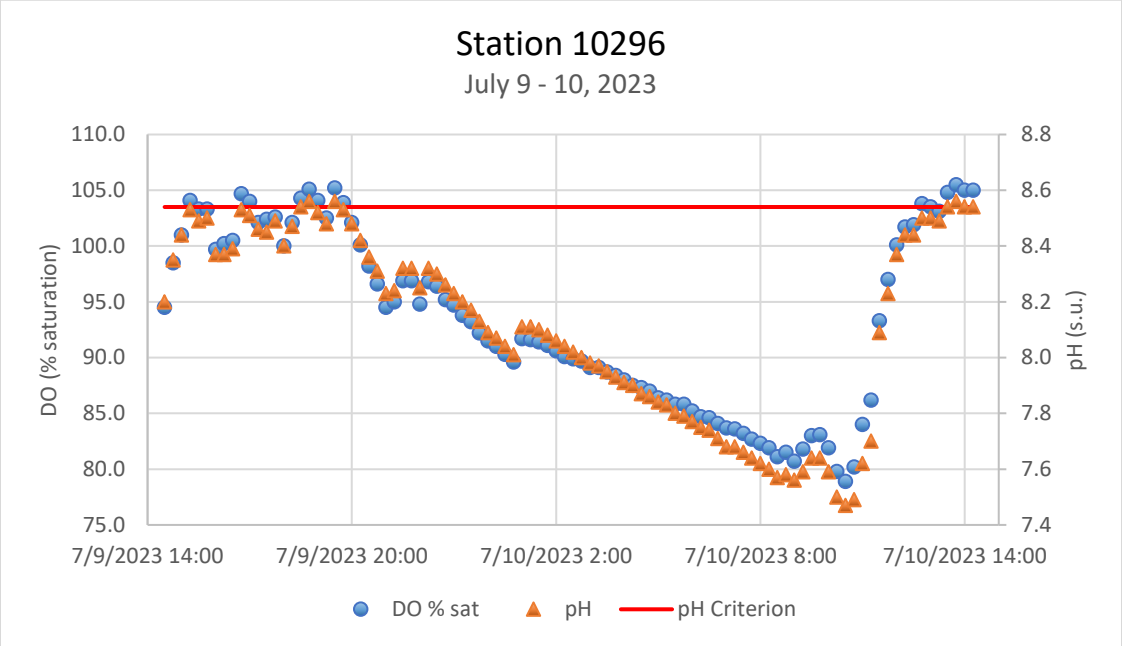

Figure 64: Station 10296, DO percent saturation and pH

The mean of the Secchi transparency measurements was 0.86 meter which was the highest average transparency of the four stations. May had the greatest transparency at 1.10 meters while the other events were measured at 0.79 or 0.80 meter. Secchi transparency was directly correlated to pH with a coefficient of 0.77.

Most of the nitrate, nitrite, and ammonia results were reported below the limit of quantification (LOQ) of 0.02 mg/L. None of the nitrite samples were reported above the laboratory detection limit. One nitrate and two ammonia samples were reportable with a nitrate concentration of 0.036 mg/L and an average ammonia result of 0.023 mg/L. It should be noted that nitrate and nitrite were not reported for August due to the laboratory analyzing the samples past the hold time.

TKN analysis measures the amount of organic nitrogen which is a form of nitrogen that is not available for uptake by plants and algae. The process of mineralization converts organic nitrogen into inorganic nitrogen forms such as ammonia, nitrite, and nitrate. The TKN concentration at station 10296 was, on average, the lowest in the reservoir with 0.72 mg/L and ranged from 0.53 mg/L in June to 0.94 mg/L in early July.

Total phosphorus results were well below the 0.20 mg/L screening level with an average of 0.07 mg/L. The May and late July samples were below the laboratory detection limit. The June

sample of 0.12 mg/L was the highest result followed by 0.051 mg/L in early July and 0.043 mg/L in August.

Despite having very low available nutrients, the mean chlorophyll *a* concentration was 30.80 µg/L. This was the lowest average concentration out of all stations but was above the 26.7 µg/L screening level. The May and late July results were reported below the screening level at 15.1 µg/L and 24.2 µg/L, respectively. Samples for June was 30.6 µg/L; early July, 56.5 µg/L; and August, 27.6 µg/L. Secchi transparency had a moderate inverse correlation to chlorophyll *a* with a coefficient of -0.58. This correlation indicates that as chlorophyll increases, transparency decreases.

Figure 65: Station 16156, Midlake

AU 0403_02 – STATION 16156, MIDLAKE

Station 16156 is generally located in the middle of the reservoir near the confluence with Alley Creek. The station is equidistant between the north and south shorelines and approximately 2.2 km southwest of FM 729. Total depth at this station ranged from 5.2 to 7.8 meters with an average of 7.0 meters.

The profile pH readings did not exceed the criterion in June or early July; however, pH was elevated at each measurement point to a depth of 2.0 meters in May and late July. The median pH readings in the mixed surface layer ranged from 8.4 s.u. in June and early July to 9.2 s.u. in August. The mean mixed surface layer pH for all five site visits was 8.7 s.u. In all instances where profile readings exceeded the pH criterion, DO saturation was greater than one hundred percent. It should be noted that the mixed surface layer DO saturation was greater than one hundred percent in all months with an average of 129.9 percent. All mixed surface layer DO concentration values were above the 3.0 mg/L grab criterion with an average of 9.6 mg/L. Mixed surface layer average DO and median pH were strongly correlated with a coefficient of 0.93.

Station 16156 had the second most diel observations that exceeded the 8.5 s.u. high pH criterion. Out of 480 diel measurements, 64.4 percent (309) of the pH readings exceeded the criterion. All diel measurements made in late July and August exceeded the criterion while only thirteen pH values were elevated in early July. The median pH of all diel measurements was 8.8 s.u. with a maximum value of 9.5 s.u. collected in August. In every case of a high pH, DO saturation was greater than one hundred percent. None of the diel DO readings fell below 5.0 mg/L during any deployment. The mean of all diel DO measurements was 9.1 mg/L with a maximum concentration of 13.6 mg/L.

Diel DO percent saturation and pH were highly correlated at this station. The average correlation coefficient of the diels was 0.97 and ranged from 0.93 in May to 0.99 in early July.

The mean Secchi transparency measurement was 0.74 meter which was the second highest of the four stations. June had the greatest transparency at 0.92 meter whereas the other measurements ranged from 0.62 in August to 0.79 meter in in May. Unlike station 10296, Secchi transparency was inversely correlated to pH with a coefficient of -0.60. This relationship indicates that as pH increases, transparency decreases.

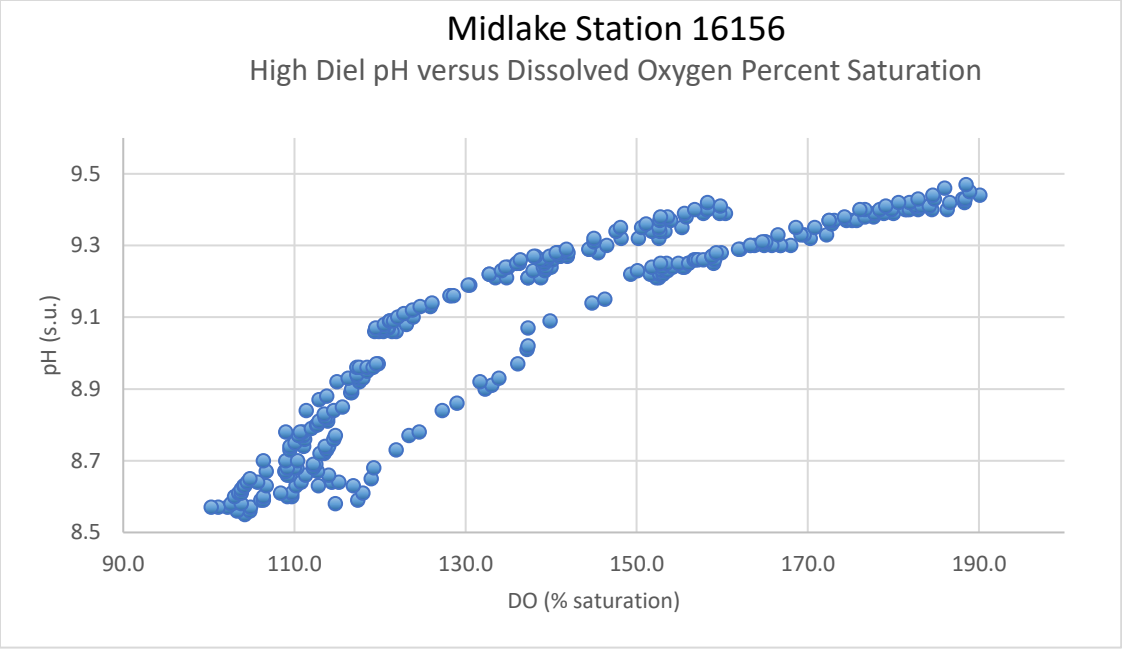

Figure 66: High diel pH versus DO percent saturation at station 16156

Similar to the lower assessment unit, most samples for ammonia, nitrate, and nitrite were well below screening levels. None of the nitrate or nitrite-nitrogen samples were reported above the LOQ. Ammonia values were also low with only two reportable results. A concentration of 0.0212 mg/L was reported in early July while the May sample was 0.02 mg/L. TKN had an average concentration of 0.73 mg/L and ranged from 0.53 mg/L in May to 0.90 mg/L in early July.

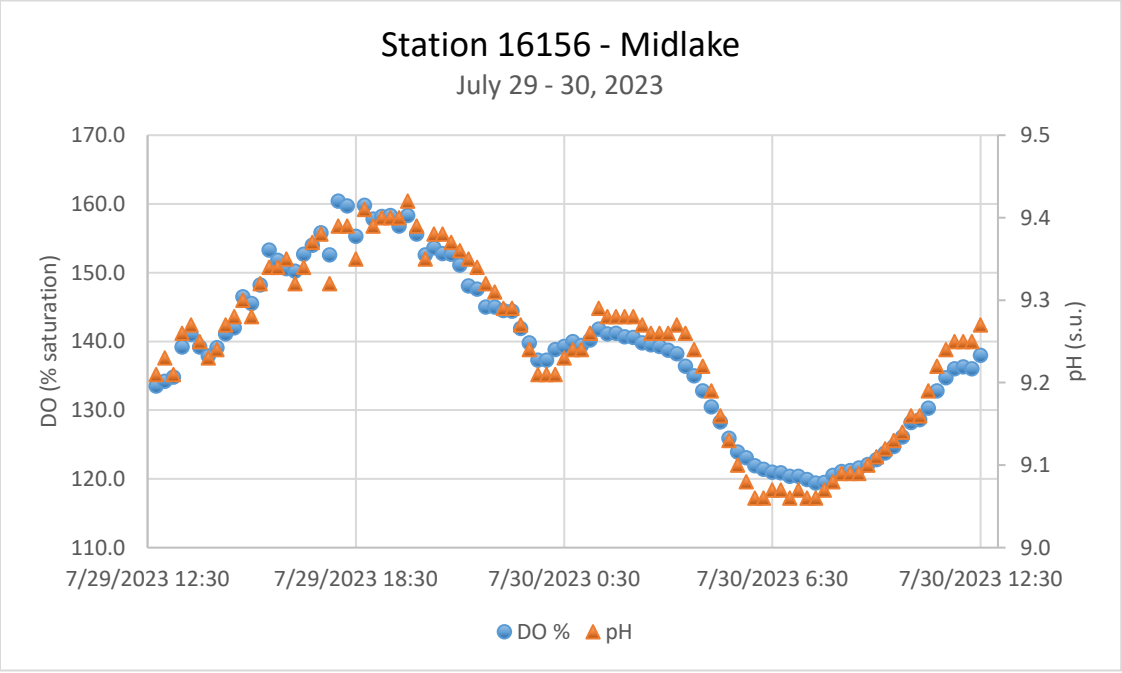

Figure 67: Station 16156, DO percent saturation and pH

Total phosphorus values were also well below the 0.20 mg/L screening level. The highest concentration was collected in May at 0.06 mg/L. The June and late July samples fell below the LOQ. The average of all total phosphorus samples was 0.05 mg/L.

Despite having very low available nutrients, the mean of the chlorophyll *a* samples was 30.98 µg/L, above the 26.7 µg/L screening level. The lowest result was 20.6 µg/L in May and the highest was 50.0 µg/L in early July. This station had the second lowest chlorophyll *a* mean and second highest Secchi transparency of the study stations; however, the parameters were not correlated.

Figure 68: Station 10297, NETMWD intake

AU 0403_03 – Station 10297, NETMWD Intake

Station 10297 was the shallowest site monitored. It is located on a boat lane about 30 meters from the NETMWD intake and near the north shore. The depth ranged from 2.2 to 2.9 meters with an average of 2.5 meters. The profile pH readings did not exceed the criterion in June or early July; however, median mixed surface layer pH was elevated in May, late July, and in

August. The median pH readings in the mixed surface layer ranged from 7.9 s.u. in June to 9.1 s.u. in August. The mean for all site visits was 8.6 s.u.

In all instances where profile readings exceeded the pH criterion, DO saturation was greater than one hundred percent. DO saturation of the mixed surface layer was greater than one hundred percent in all months with an average of 137.4 percent. All average mixed surface layer DO concentration values were above the 3.0 mg/L grab criterion with an average of 9.9 mg/L. Mixed surface layer average DO and median pH were strongly correlated with a coefficient of 0.83.

The Intake station had the second fewest diel observations that exceeded the 8.5 s.u. high pH criterion. Out of 480 measurements, 49.0 percent (235) of the pH readings exceeded the criterion. All 96 measurements in the August study had high pH whereas only twelve pH values were elevated in early July and fourteen in May. The median pH of all diel measurements was 8.5 s.u. with a maximum value of 9.5 s.u. in late July. In every case of high pH, DO saturation was greater than one hundred percent.

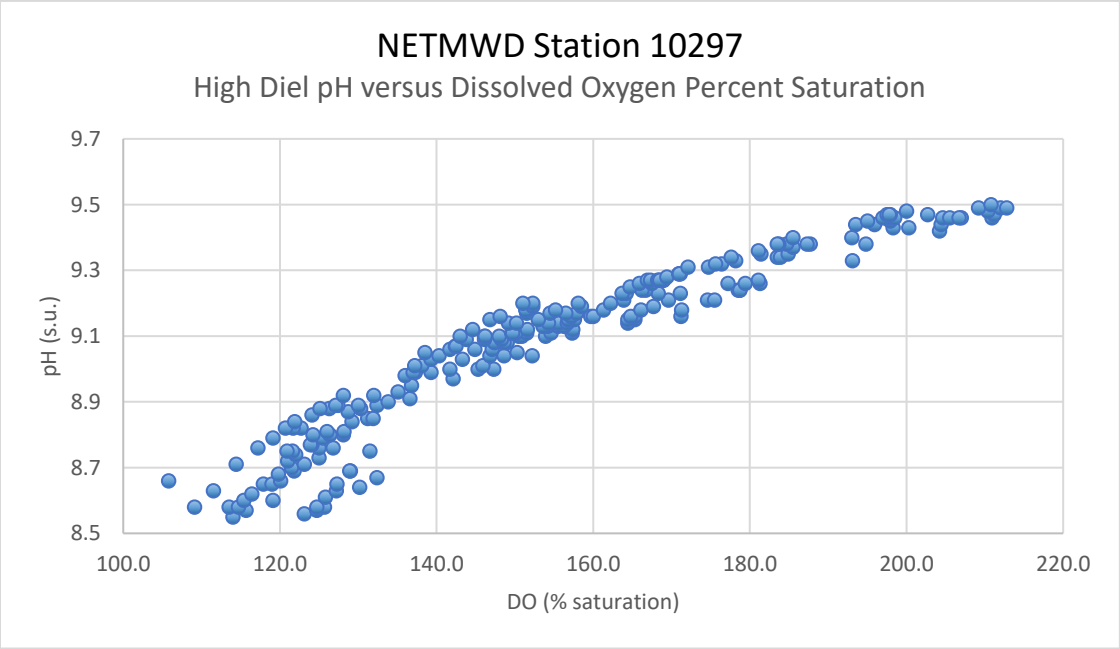

Figure 69: High diel pH versus DO percent saturation at station 10297

Diel DO percent saturation and pH were highly correlated with an average correlation coefficient of 0.97 and ranged from 0.95 in late July and August to 0.99 in May and June. Unlike the stations in the lower assessment units, several individual diel DO readings fell below 5.0 mg/L. Fifteen of the DO readings were below 5.0 mg/L in May while ten were low in early July. All low DO readings occurred in the early morning hours. The lowest DO reading of 4.5 mg/L was recorded on May 22nd at 4:00 AM. It should be noted that all of these DO readings below

5.0 mg/L were still well over the 24-Hour DO Minimum criterion of 3.0 mg/L. The mean of all diel DO measurements was 8.7 mg/L with a maximum concentration of 15.2 mg/L.

Station 10297 had the lowest transparency of the four stations with a mean Secchi transparency of 0.69 meter. May had the greatest transparency at 0.80 meter whereas the other measurements ranged from 0.58 in late July to 0.75 meter in early July. Secchi transparency did not correlate with DO or pH readings.

Like the other stations, all ammonia, nitrite, and nitrate samples were well below their screening levels. None of the nitrate or nitrite-nitrogen samples were reported above the LOQ. Only the June and early July ammonia samples were above the LOQ with the highest result of 0.0386 mg/L. TKN had an average concentration of 0.98 mg/L and ranged from 0.88 mg/L in May to 1.26 mg/L in early July.

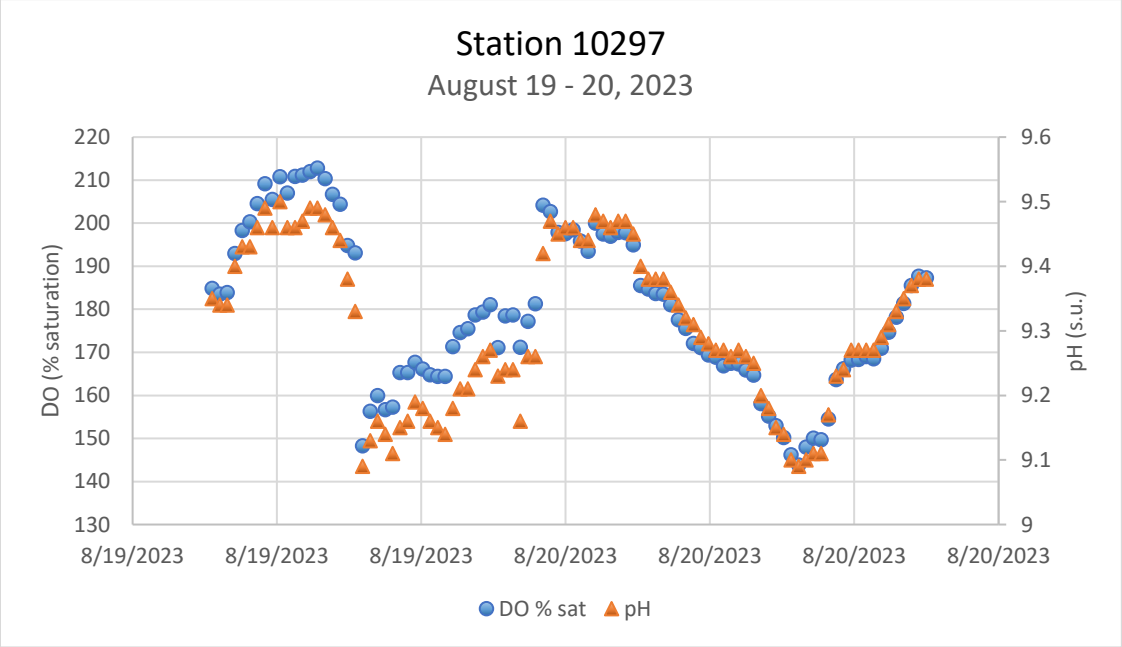

Figure 70: Station 10297, DO percent saturation and pH

It should be noted that due to a holding time issue, there were no nitrate, nitrite, chloride, sulfate, or total alkalinity results reported for this station in May. All total phosphorus results were reported below the 0.20 mg/L screening level. The highest concentration was collected in early July at 0.064 mg/L and had an average of 0.05 mg/L. The June sample was reported as less than the LOQ.

Despite having very low available nutrients, the mean of all chlorophyll *a* samples was 34.86 µg/L which was the highest of the four stations. Both the June and early July concentrations

were reported above the 26.7 µg/L screening level with a maximum of 53.2 µg/L in June and minimum of 24.4 µg/L in May and late July.

Figure 71: Station 17087, above SH 155

AU 0403_04 – Station 17087, 1.4 km Above SH 155

Station 17087 is located approximately 1.4 km above the SH 155 bridge on a marked boat lane. Like station 10297, this site was also very shallow. The depth ranged from 2.8 to 3.6 meters with an average depth of 3.1 meters.

The profile pH readings exceeded the criterion in May, June, and August but fell below 8.5 s.u. during both July field efforts. The median pH readings in the mixed surface layer ranged from 7.6 s.u. in early July to 8.9 s.u. in May and June. The mean of all pH profile readings was 8.5 s.u.

All mixed surface layer DO concentration values were above the 3.0 mg/L grab criterion with an average of 9.6 mg/L. The mixed surface layer DO profile readings ranged from 7.7 mg/L in early July to 12.0 mg/L in May. In all instances where profile readings exceeded the high pH criterion,

DO saturation was greater than one hundred percent. DO saturation of the mixed surface layer was greater than one hundred percent in all months with an average of 131.4 percent. The average mixed surface layer DO and median pH were correlated with a coefficient of 0.59. This was the lowest correlation for these parameters out of the study stations.

Station 17087 had the fewest diel observations that exceeded the 8.5 s.u. high pH criterion. Out of 480 measurements, 44.2 percent (212) of the pH readings exceeded the criterion. All diel pH readings exceeded the criterion in June while none were high in early July. The median pH of all diel measurements was 8.4 s.u. with a maximum result of 9.3 s.u. In all cases of a high pH, DO saturation was greater than one hundred percent.

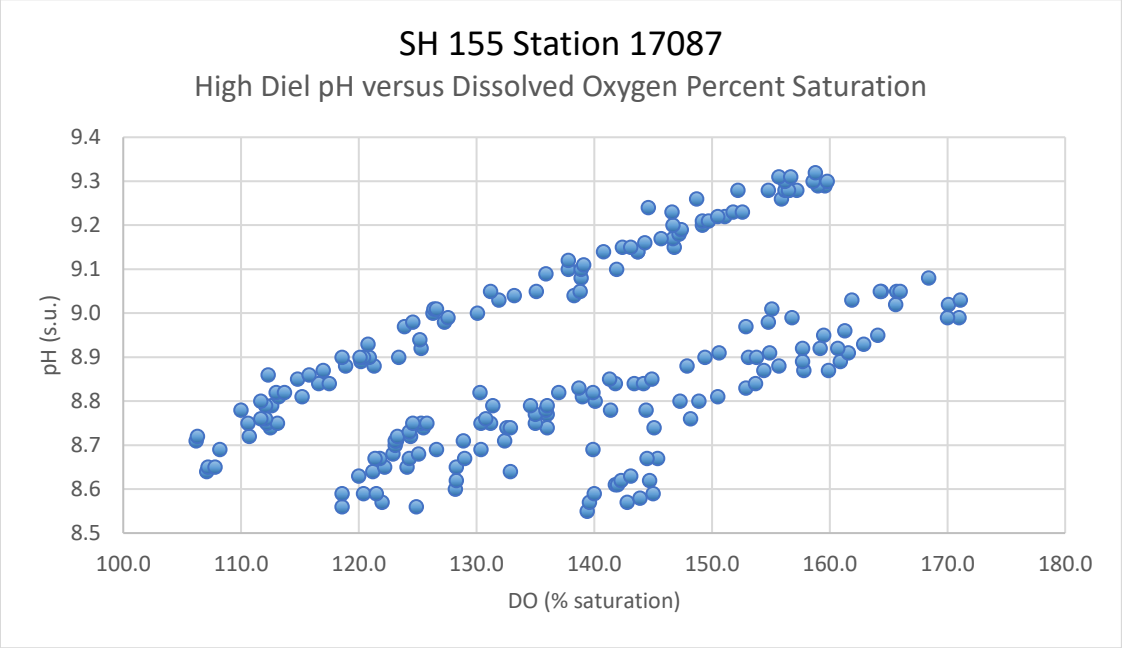

Figure 72: High diel pH versus DO percent saturation at station 17087

Diel DO percent saturation and pH were highly correlated with an average correlation coefficient of 0.97 and ranged from 0.93 in May to 0.99 in June. Thirty-eight of the diel DO readings fell below 5.0 mg/L in early July. The minimum DO value of 4.3 mg/L was recorded three times on July 10th between 7:30 and 10:00 AM. It should be noted that these DO readings were above the 24-Hour DO Minimum criterion of 3.0 mg/L. The mean of all diel DO measurements was 8.5 mg/L with a maximum concentration of 12.8 mg/L.

The average Secchi transparency at station 17087 was only slightly higher than at the Intake station (10297) with a mean of 0.71 meter making it the second lowest in transparency. Early July had the greatest transparency at 0.80 meter whereas the other measurements ranged from 0.62 in June to 0.77 in August. Secchi depth inversely correlated to pH with a coefficient of

-0.67 suggesting that as transparency decreases, the pH increases. It also inversely correlated to DO concentration with a coefficient of -0.50.

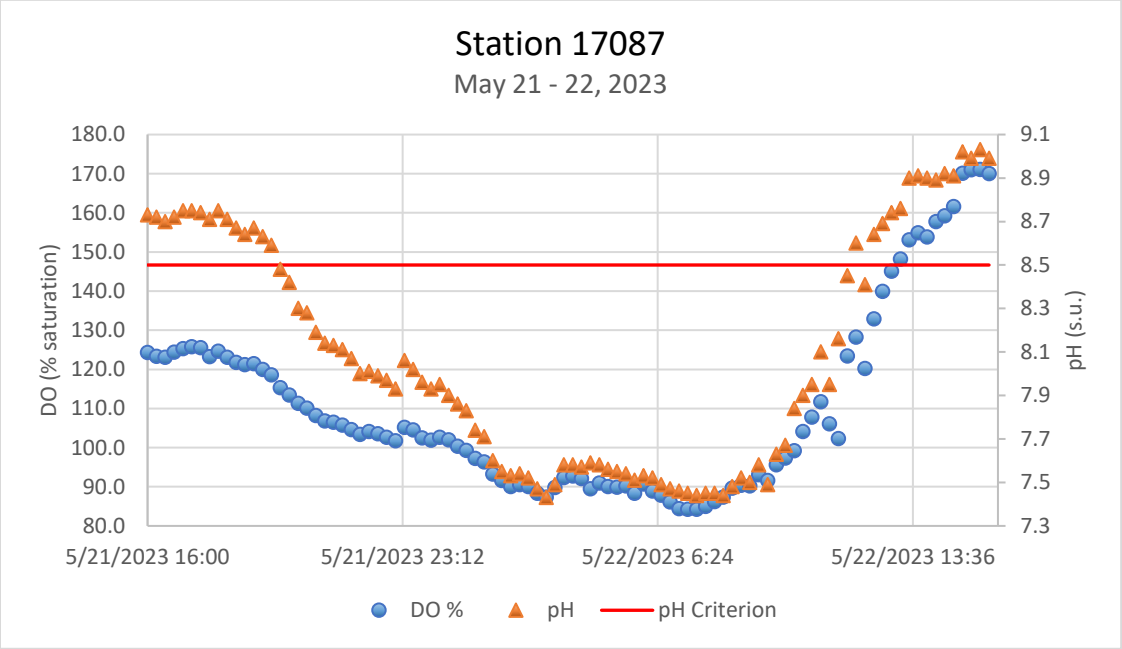

Figure 73: Station 17087, DO percent saturation and pH

As found at the other stations, ammonia, nitrite, and nitrate samples were well below their screening levels. Only one nitrate sample was reported above the LOQ with a concentration of 0.04 mg/L. None of the nitrite results were reported over the LOQ. It should be noted that due to the samples exceeding the holding time, there were no nitrate, nitrite, chloride, sulfate, or total alkalinity results reported in May.

Four of the ammonia samples were measurable with the highest concentration of 0.0339 mg/L, collected in early July. The mean ammonia result was 0.026 mg/L. TKN had an average concentration of 0.98 mg/L and ranged from 0.79 mg/L in late July to 1.14 mg/L in May.

The mean total phosphorus result was 0.07 mg/L, well below the 0.20 mg/L screening level. The highest concentration was collected in May at 0.0912 mg/L followed by 0.0866 mg/L in early July. The June sample was below the laboratory detection limit while early July was 0.04 mg/L and 0.07mg/L in August.

Chlorophyll *a* values averaged 31.34 µg/L which was the second highest of the stations. Except for late July, all samples were reported above the 26.7 µg/L screening level. The highest concentration of 46.3 µg/L was collected in early July. Like station 10296, Secchi was directly correlated with chlorophyll *a* with a coefficient of 0.52.

COMPARISONS ACROSS LAKE O' THE PINES

The grab sample median pH readings in the mixed surface layer exceeded the criterion at every station in May and August. The median pH ranged from 8.8 to 9.1 s.u. in May and 8.8 to 9.2 s.u. in August. None of the profile readings were over the 8.5 s.u. high pH criterion in early July. In June, the median mixed surface layer pH reading at station 10296 (Dam) was 8.6 s.u. and 8.9 s.u. at station 17087 (SH 155). The Midlake and NETMWD intake stations were below the criterion. In late July, all stations except 17087 exceeded the high pH criterion and ranged from 8.7 at the Dam to 8.9 s.u. station 16156.

The average DO concentration in the mixed surface layer was well over the 3.0 mg/L DO grab criterion at all stations for all events. The average of the mixed surface layer DO readings for all sampling efforts ranged from 9.2 mg/L at station 10296 to 9.9 mg/L at station 10297. The DO average was 9.6 mg/L at stations 16156 (Midlake) and 17087 (SH 155). All DO percent saturation readings in the mixed surface layer were above one hundred percent. The lowest value of 101.8 percent was measured at station 17087 in early July whereas the highest value was collected in August at station 16156 (Midlake) with a saturation of 169.5 percent. The average of all DO percent saturation readings by station ranged from 123.9 percent at the Dam to 137.4 percent at the NETMWD station.

Diel pH readings exceeded the high pH criterion of 8.5 s.u. at all stations. Except for the early July deployment at station 17087, high diel pH readings were observed during every 24-hour study. In total, almost sixty percent of the diel pH readings exceeded the pH criterion. High pH was most frequently recorded at station 10296 with 352 out of 480 measurements (73.3 percent) exceeding the criterion. Station 16156 was next with 309 exceedances followed by station 10297 with 235 and station 17087 at 212 (44.2 percent).

High Diel pH Readings				
Deployment	**10296**	**16156**	**10297**	**17087**
22-May	96	40	14	30
12-Jun	96	64	36	96
10-Jul	3	13	12	0
30-Jul	78	96	77	13
20-Aug	79	96	96	73
TOTAL	352	309	235	212

Figure 74: Number of high diel pH measurements

The median of all diel pH readings combined for each station ranged from 8.4 s.u. at station 17087 (SH 155) to 8.8 s.u. at stations 10296 (Dam) and 16156 (Midlake). The median pH at station 10297 (NETMWD) was 8.5 s.u. The maximum diel pH value was 9.5 s.u. at stations

16156 and 10297. The Dam and SH 155 stations both had a maximum pH of 9.3 s.u. The greatest pH range, or difference between the minimum and maximum readings, was at station 10297 with a range of 2.4 s.u. while the smallest pH range was at the Dam with 1.8 s.u.

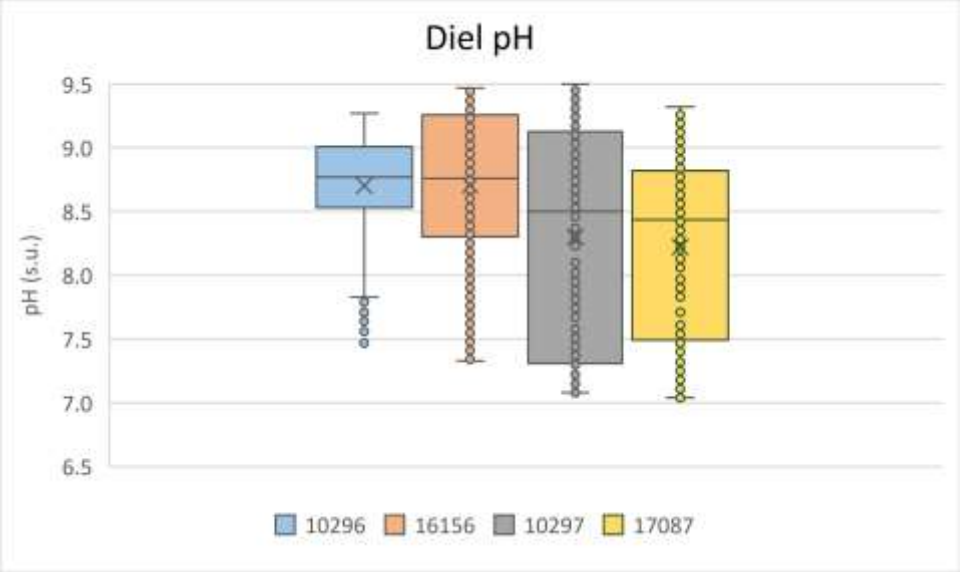

Figure 75: Diel pH measurements by station

In all cases where high pH readings were observed, DO saturation was greater than 100 percent. All diel DO percent saturation readings were combined for each station. The highest average DO percent saturation was recorded at station 16156 (Midlake) with 121.9 percent whereas the lowest mean was at station 17087 (SH 155) at 113.5 percent. However, the highest maximum diel DO percent saturation reading was recorded at station 10297 (NETMWD Intake) with 212.8 percent. In addition to having the highest diel DO reading, the NETMWD Intake also had the widest diel DO percent saturation range at 158.4 percent. The Dam station had the smallest DO saturation range at 82.8 percent.

The upper assessment unit (0403_04) is impaired for low DO. The early July diel at station 17087 was the only deployment where any diel DO reading fell below 5.0 mg/L. During this deployment, 38 (39.6%) of the DO readings were reported below 5.0 mg/L with a minimum concentration of 4.3 mg/L. Most of these low readings were recorded in the morning hours; however, these readings were all above the 24-Hour DO Minimum criterion of 3.0 mg/L. It should be noted that thunderstorms passed through the area on the mornings of July 9 and 10. The sky remained mostly cloudy throughout the entire sampling period. This weather event likely limited the amount of photosynthetic activity during the deployment.

DO readings of less than 5.0 mg/L were also recorded at station 10297 (NETMWD Intake) in both May and in early July. Fifteen DO readings were low in May while ten were low in early July. All DO readings less than 5.0 mg/L occurred in the early morning hours, but all were over

the 3.0 mg/L 24-Hour DO Minimum criterion. The lowest DO reading of 4.5 mg/L was recorded on May 22nd at 4:00 AM.

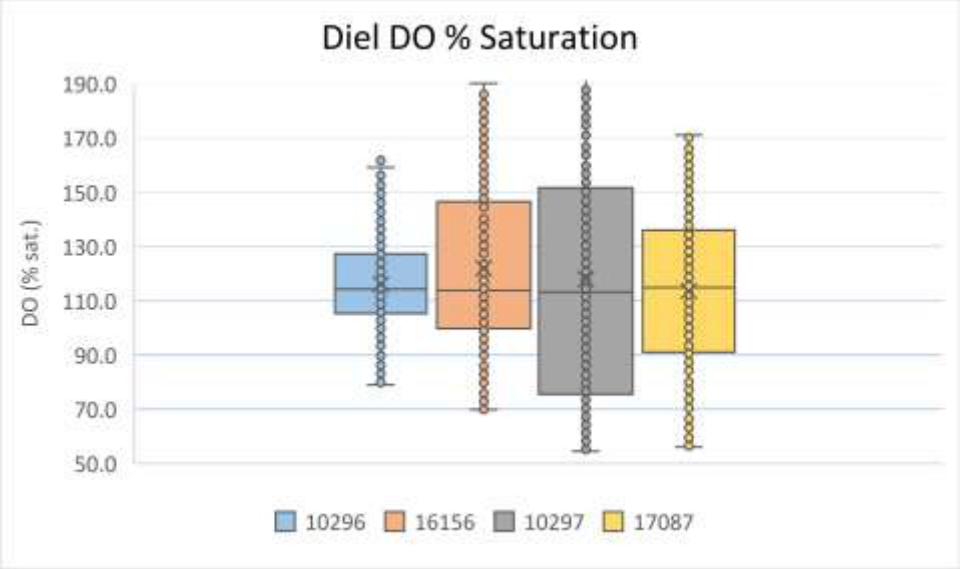

Figure 76: Diel DO percent saturation measurements by station

Diel DO percent saturation and pH values showed very strong correlations at all stations for all deployments at all stations. The lowest correlation of 0.93 was observed in May at all stations except 10297 (NETMWD Intake). Many deployments had nearly perfect correlations of 0.98 or 0.99. These correlations indicated that DO percent saturation and pH were closely related throughout the study period. Except for the Dam (station 10296), the mean correlation coefficient of the diel studies was 0.97 at all stations. The Dam had a coefficient of 0.96.

Diel Correlation DO% saturation with pH				
	10296	**16156**	**10297**	**17087**
22-May	0.93	0.93	0.99	0.93
12-Jun	0.94	0.98	0.99	0.99
10-Jul	0.99	0.99	0.98	0.98
30-Jul	0.98	0.98	0.95	0.98
20-Aug	0.97	0.98	0.95	0.96
MEAN	0.96	0.97	0.97	0.97

Figure 77: Diel DO percent saturation and pH correlation coefficients

The mean Secchi transparency generally increased from the upper to the lower assessment units. The average transparency was 0.69 and 0.71 meter at stations 10297 and 17087 and increased to 0.86 meter at station 10296. The greatest Secchi depth of the study period was observed at station 10296 (Dam) in May at 1.10 meters while the least transparency of 0.58 meter was observed in late July at station 10297 (NETMWD Intake).

Secchi Transparency (m)				
	10296	16156	10297	17087
22-May	1.10	0.79	0.80	0.67
12-Jun	0.80	0.92	0.61	0.62
10-Jul	0.79	0.70	0.75	0.80
30-Jul	0.79	0.65	0.58	0.70
20-Aug	0.80	0.62	0.71	0.77
MEAN	0.86	0.74	0.69	0.71

Figure 78: Secchi transparency by station

Due to a holding time issue, nitrate, nitrite, chloride, sulfate, and total alkalinity analysis were not performed at stations 10297 and 17087 in May and nitrate and nitrite were not analyzed in August at station 10296. Only four samples were available for analysis of these parameters at these stations.

Nitrogen concentrations were very low at all stations during the study period. Only two of the seventeen nitrate samples were reported above the limit of quantitation. Those values were 0.036 mg/L at the Dam (station 10296) in early July and 0.038 mg/L at the SH 155 (station 17087) in June. All nitrite results were reported below the 0.02 mg/L LOQ whereas half of the ammonia samples were less than the 0.02 mg/L LOQ.

Four of the ammonia samples at station 17087 were above the LOQ with a mean of 0.026 mg/L. The other stations had two samples each reported over the LOQ. Station 10297 (NETMWD Intake) had the highest average ammonia concentration at 0.034 mg/L followed by the Dam at 0.023 mg/L and Midlake with 0.021 mg/L. All samples were reported far below the screening level for each parameter.

Total Kjeldahl nitrogen at stations 17087 and 10297 averaged 0.98 mg/L while station 16156 had a mean of 0.73 mg/L and station 10296 was 0.72 mg/L. These results suggest that much of the nitrogen in the reservoir is entering through Big Cypress Creek.

Total phosphorus concentrations were generally low across the reservoir. The mean total phosphorus results ranged from 0.050 mg/L at station 16156 to 0.072 mg/L at station 17087. The highest single sample value of 0.117 mg/L was collected at station 10296 in June. In contrast, all other total phosphorus samples were reported below the 0.02 mg/L LOQ that month. Station 10296 had the second highest mean at 0.070 mg/L despite two samples being reported below the LOQ. The average of all samples collected from the four stations during the study period was 0.062 mg/L, far below the 0.20 mg/L screening level.

The nutrient results were possibly diluted from the high amount of inflow from Big Cypress Creek from May through mid-July. Over 33,000 acre-feet of water was released from Lake Bob

Sandlin during the study period. The USACE estimated that approximately 58,000 acre-feet of inflow entered the reservoir during the study period. That estimate is consistent with the amount of flow reported by the USGS gage in Big Cypress Creek at SH 11. This amount of water represents almost one-quarter of the storage capacity of the reservoir.

Despite low nutrient levels, almost two-thirds of all chlorophyll *a* results exceeded the 26.7 µg/L screening level. Two samples from each station were reported below the screening level. The mean of all chlorophyll *a* samples collected during the study period was 32.0 µg/L. Both the lowest and the highest single sample values were collected at the Dam (10296) with 15.1 µg/L in May and 56.5 µg/L in early July. The mean of the chlorophyll samples by station was highest at 10297 (NETMWD Intake) at 34.86 µg/L while the lowest average was at the Dam with 30.8 µg/L. The mean for station 16156 (Midlake) was 30.98 µg/L and averaged 31.34 µg/L at station 17087 (SH 155).

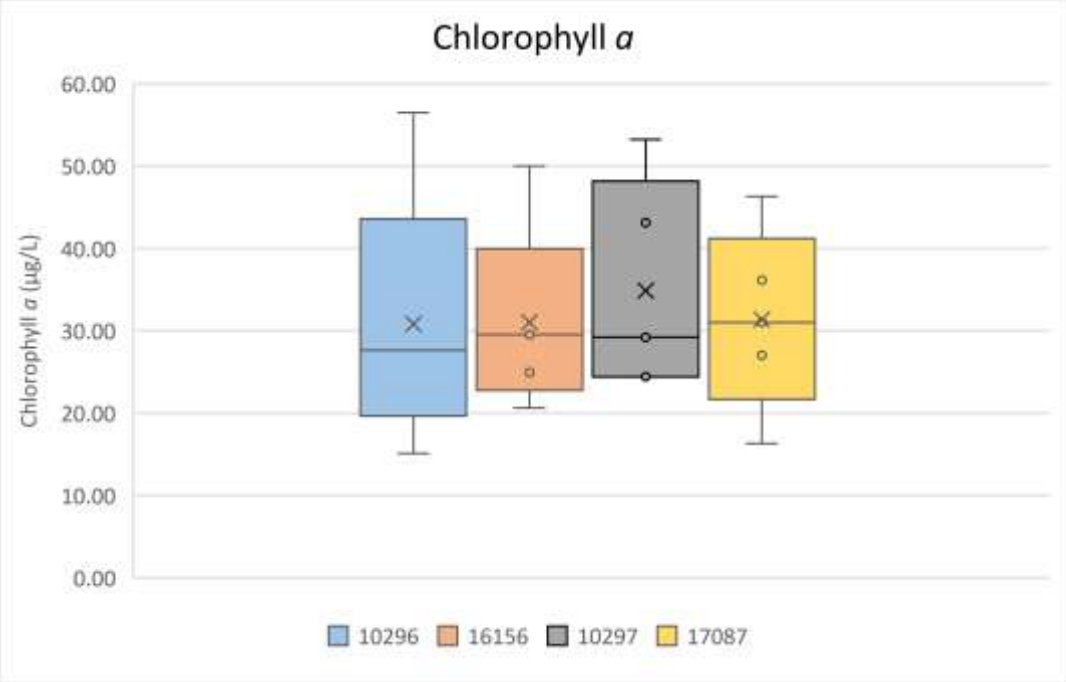

Figure 79: Chlorophyll a by station

Chloride and sulfate had little variation across all stations with lake-wide means of 11.59 mg/L and 13.91 mg/L, respectively. Total alkalinity was mostly consistent across the lower assessment units and ranged from 33.50 mg/L at station 10296 to 35.20 mg/L at the Midlake station. Station 17087 (SH 155), located in the headwaters assessment unit, had the highest mean for these three parameters. These results are consistent with expectations as these constituents are typically transported with sediments during runoff events and tend to become diluted as water moves toward the dam.

CONCLUSIONS

The findings of the Lake O' the Pines pH Special Study indicate that the reservoir is eutrophic. Both grab samples and diel readings corroborate this conclusion. The median pH of in the mixed surface layer was often over the 8.5 s.u. high pH criterion. The average of all pH readings in the mixed surface layer ranged from 8.5 s.u. at station 17087 to 8.7 s.u. at station 10296 and 16156.

The mean grab DO percent saturation in the mixed surface layer was over one hundred percent for all readings. The average of the DO grab measurements ranged from 123.9 percent at the Dam station (10296) to 137.4 percent at the NETMWD Intake (10297).

It should be noted that, since none of the diel DO readings fell below the 24-Hour DO Minimum criterion, the low DO impairment in the upper assessment unit should be reevaluated. No diel studies have been conducted in this assessment unit in two decades. Based upon the findings of this study, the assessment unit meets its high Aquatic Life Use designation. Diel monitoring in this assessment unit should be considered in the future to address this DO impairment.

Diel measurements showed similar results as the profile readings. Almost sixty percent of all diel pH readings were reported above the 8.5 s.u. high pH criterion. The median pH for all diel measurements ranged from 8.3 s.u. at station 10297 to 8.8 s.u. at stations 16156 and 10296. In all cases of a high diel pH value, DO was reported over one hundred percent saturation. The average DO percent saturation for all diel readings ranged from 113.5 percent at station 17087 to 121.9 percent at the Midlake station (16156).

Laboratory analysis revealed that nutrient concentrations were low throughout the reservoir. None of the nitrite and only two nitrate samples were analyzed above the 0.02 mg/L LOQ. Only half of the ammonia samples were measurable and averaged between 0.02 and 0.03 mg/L at each station. TKN was relatively low with the highest average of 0.98 mg/L collected in the upper reservoir stations. Both lower stations averaged 0.73 mg/L. The highest mean concentrations of total phosphorus came from the upper and lower stations, both with averages of 0.07 mg/L. Both middle stations averaged 0.05 mg/L. The low nutrient values were likely due to dilution from high amounts of inflow during the study period. It is estimated that over 58,000 acre-feet of water, or roughly one-quarter of the Lake O' the Pines storage capacity, entered the reservoir during the study period.

Despite low nutrient concentrations, the average chlorophyll *a* value for all samples combined exceeded the 26.7 µg/L screening level with 32.0 µg/L. The highest chlorophyll *a* mean came from the NETMWD Intake at 34.86 µg/L whereas the lowest average was at the Dam station

with 30.80 µg/L. These results suggest that available nutrients were readily being converted into algal biomass.

As a result, the super-saturated DO and elevated pH readings were likely the result of primary productivity. Since the wind speed was relatively low during all field efforts, wind was not a primary factor creating super-saturated DO conditions. No aquatic vegetation was observed at any station during the site visits, so macrophytes were also not contributing to the high DO measurements. Primary productivity from algae, as evidenced by the elevated levels of chlorophyll *a*, was likely responsible for the high pH readings. Correlation analysis supports this assertion since diel pH and DO percent saturation were strongly correlated, with average coefficients ranging from 0.96 to 0.97 across all stations. These results support the assumption that the high pH impairment in Lake O' the Pines is a result of the process of eutrophication of the reservoir.

Figure 80: Great blue heron with channel catfish in Lake O' the Pines near SH 155

BIOASSESSMENTS AND SPECIES OF CONCERN

Currently, the following species found in the Cypress Creek Basin are being studied by the U. S. Fish and Wildlife Service for possible listing as Threatened and Endangered Species:

- **Louisiana Pigtoe Mussel**
- **Kisatchie Painted Crawfish**

This section also discusses threatened and endangered species listed by the TPWD and Aquatic Life Monitoring studies performed by NETMWD/WMS in 2022 and 2023.

RARE, THREATENED, AND ENDANGERED SPECIES

Rare, Threatened, and Endangered species are taxa that are listed on the state and/or federal level. Endangered species are at serious risk of becoming extinct while Threatened species are organisms that are likely to become endangered in the near future. On the state level, TPWD also includes species that are considered Imperiled or Vulnerable of becoming Threatened.

The TPWD maintains a list of state and federally listed rare, threatened, and endangered species. There are currently eleven aquatic species in the Cypress Creek Basin that are listed as threatened or imperiled by the State of Texas including nine fish, six mollusk, one crustacean, and two reptile species.

The statewide list of aquatic threatened (T) and imperiled (S) species in the Cypress Creek Basin is shown below. Imperiled species are identified as S1 – Critically Imperiled, S2 – Imperiled, and S3 – Vulnerable.

Taxon	Scientific Name	Common Name	State Listing
Fish	*Pteronotropis hubbsi*	bluehead shiner	T
	Percina maculata	blackside darter	T
	Erimyzon claviformis	western creek chubsucker	T
	Polyodon spathula	paddlefish	T
	Notropis maculatus	taillight shiner	S1
	Notropis chalybaeus	ironcolor shiner	S3
	Ammocrypta clara	western sand darter	S3
	Notropis atrocaudalis	blackspot shiner	S3
	Notropis sabinae	Sabine shiner	S3
Mollusk	Pleurobema riddellii	Louisiana pigtoe	T
	Lampsilis satura	sandbank pocketbook	T
	Potamilus amphichaenus	Texas heelsplitter	T
	Lampsilis satura	sandbank pocketbook	T
	Obovaria arkansasensis	southern hickorynut	T
	Fusconaia askewi	Texas pigtoe	T
Crustacean	*Orconectes maletae*	Kisatchie painted crawfish	S2
Reptile	*Macrochelys temminckii*	alligator snapping turtle	T
	Deirochelys reticularia miaria	western chicken turtle	S2, S3

Figure 81: Threatened and Imperiled aquatic species in the Cypress Creek Basin

Threatened fish species include the bluehead shiner (*Pteronotropis hubbsi*), blackside darter (*Percina maculate*), western creek chubsucker (*Erimyzon claviformis*), and the paddlefish (*Polyodon spathula*). The only critically imperiled fish is the taillight shiner (*Notropis maculatus*) while vunerable species are the ironcolor shiner (*Notropis maculatus*), western sand darter (*Ammocrypta clara*), blackspot shiner (*Notropis atrocaudalis*), and Sabine shiner (*Notropis sabinae*).

KISATCHIE PAINTED CRAWFISH

Crayfish, in general, are keystone species that may indicate the health of a watershed, and nearly half of crayfish species are vulnerable, threatened, or endangered. The Kisatchie painted crayfish (*Faxonius maletae)* has few historical records and is believed to be restricted to the Kisatchie Bayou and Bayou Teche watersheds in Louisiana and the Cypress Creek watershed in Texas. Historical collecting locations were obtained from TPWD, and recent field surveys determined that the Kisatchie painted crayfish was absent from 60 percent of its historical range in Texas. It is characterized by an olive carapace or hard, upper shell and the red marks on the chelae (claws), legs, and above the eyes. The size of Kisatchie painted crayfish appears to be influenced by water depth. Individuals found in deep water have been documented to reach lengths of 101.6 mm whereas those found in shallow water rarely reach lengths over 50.8 mm.

Little is known about the habitat requirements of the Kisatchie painted crayfish. They were historically collected in freshwater streams with sand, gravel, mud, or silt; however, the Texas habitat tended to be more stagnant and muddier than in Louisiana. The Kisatchie painted crayfish may prefer streams with varying water depth, heavy leaf litter, and cobble-lined stream bottoms.

In 2021, researchers from Stephen F. Austin State University collected and confirmed the identification of Kisatchie painted crawfish in Prairie Creek, a tributary of Big Cypress Creek. NETMWD and WMS staff collected six individuals in Hart Creek and one individual in Big Cypress Creek while both seining and electroshocking. Three individuals were collected in 2021 by Texas Tech researchers in Little Cypress Creek and its tributaries.

Figure 82: Kisatchie painted crayfish (Faxonius maletae) collected by NETMWD and WMS staff in Big Cypress Creek

AQUATIC LIFE MONITORING

The TSWQS establishes the criteria for water quality conditions that need to be met in order to support and protect designated uses as detailed in Title 30 Texas Administrative Code, Chapter 307. To evaluate support of existing Aquatic Life Uses, the TCEQ established an index period, representing the warm-weather seasons, during which most bioassessments of aquatic assemblages in freshwater river and stream systems should be conducted. Bioassessment sampling for freshwater streams must be conducted during the non-critical period of March 15 to June 30 and from October 1 to October 15. A subset of the samples should be collected during critical conditions (July 1–September 30) when minimum stream flows, maximum temperatures, and minimum dissolved oxygen concentrations typically occur in Texas streams. These data help determine whether the criteria set for the designated uses are being met and maintained when streamflow is at or above critical low flow. The assessors work under the assumption that criteria met under these conditions would also be met during other seasons when stream flow is expected to be greater, water temperatures are lower, and dissolved oxygen is higher.

The non-critical period was established to:

- Minimize year-to-year variability resulting from natural events.
- Maximize gear efficiency.
- Maximize accessibility of targeted assemblages.
- Ensure that a portion of the samples is collected during critical low-flow and temperature conditions.

Aquatic Life Monitoring consists of collecting and evaluating habitat, fish species, and benthic macroinvertebrate organisms. Water quality parameters, diel monitoring, and stream flow measurements accompany these data. Habitat analysis includes the measurement of stream width, depth, bank slope, and tree canopy at five to six transects throughout the stream reach. Observations such as bed substrate type(s), channel sinuosity, erosion potential, instream cover, riparian vegetation, and riparian buffer width are also recorded.

Due to the low prevalence of riffles in East Texas streams, benthic macroinvertebrates are most often collected using a five-minute kicknet technique with a D-frame net. The kicknet technique consists of sweeping the net for five minutes over habitat such as aquatic macrophytes, overhanging vegetation, root mats, undercut banks, leaf packs, and woody debris. The sample is placed on a sorting tray and up to 210 invertebrates are collected and placed in ethanol. The organisms are then identified and enumerated in the laboratory. In cases where fewer than 100 organisms are collected, the kicknet technique is repeated for another five minutes. If the

sample size is still inadequate, then snag sampling is conducted which involves searching for organisms attached to woody debris such as logs and limbs.

Fishing is conducted using seining and electroshocking techniques. A minimum of six seine hauls of ten meters each are performed. Seining is continued until no new species are collected. Woody debris, snags, Cypress knees, and logjams frequently obstruct the seine net in East Texas streams so seine hauls of less than ten meters are not uncommon. As a result, ALM studies in the Cypress Creek Basin often have more than six seine hauls.

The electroshocking method is non-lethal and is used to stun and turn fish. Shocking is performed for a minimum of 900 seconds or until no new species are collected. During collection, fish are netted and placed in an aerated bucket. Unless requiring a microscope for identification, all fish are returned to the stream after identification, enumeration, and photo-vouchering.

Figure 83: Electrofishing (left) and seining (right)

Once collected, these data are processed and scored using a set of metrics specific to the ecoregion where the stream is located. The results of these analyses are then categorized as Exceptional, High, Intermediate, or Limited. It should be noted, however, that habitat is scored using state-wide metrics. Until recently, benthic analysis was also scored using state-wide metrics. For the purposes of this study, benthic data are presented using both regionalized and statewide scores. The scoring tables included in this section identifies statewide benthic scores as “Ben. State” and regionalized benthic scores are shown as “Ben. Region”. Although regionalized benthic scores tend to be lower than statewide, both the regionalized and statewide benthic scores generally fell within the same Aquatic Life Use (ALU) category. Regionalized fish scoring metrics have been in use for about two decades.

Bioassessments of benthic organisms often fall into the Intermediate category in the Cypress Creek Basin (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 diverse with over 285 species collected in the Basin. 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 the benthic populations in the basin.

The average habitat score of the basin is on the borderline of Intermediate and High. Some components of the statewide habitat assessment metrics include the number of riffles, substrate type, and emergent vegetation. Many streams in the basin will have an artificially reduced habitat 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 systems. 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 uncommon 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.

It should be noted that high flow events, also referred to as scouring events, can negatively affect benthic populations. These disturbances can redistribute the organisms which may take several days to weeks to become reestablished in the stream. Further, aquatic insects typically complete two to three stages of their life cycle (egg, nymph, larvae, pupae) in the water prior to emergence as a terrestrial species. Due to this process, immature insects may not be abundant during certain times of year. Most insects emerge as adults during the late spring and summer before returning to lay eggs. As a result, the absence or low abundance of these species may be due to their life cycle rather than an indication of water quality conditions.

Although 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 in 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., 2002). 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.

Although 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 (Omernik, 2014).

Louisiana Pigtoe Mussel

The Northeast Texas Municipal Water District has long recognized the importance and value of biological monitoring in the Cypress Creek Basin. The NETMWD has performed aquatic life monitoring in numerous watersheds over the years to gain an understanding of the biological integrity of the streams within the Basin. At present, over thirty stations have been studied.

Freshwater mussels play an important role in aquatic ecosystems. They provide a food source for many organisms, and as filter feeders, help clean the waters in which they reside by collecting organic particulate, bacteria, and algae, as well as accumulating contaminants in their soft tissues. Because they have limited mobility and are typically long-lived, freshwater mussels are sensitive to changes in their environment and can serve as bioindicators of water quality. Unfortunately, severe declines in freshwater mussel populations have been documented prompting broader population studies and focus on potentially endangered and threatened species.

The decline of freshwater mussel populations has become an important topic for research over the past decade as fifteen Texas species are being considered for listing as threatened or endangered. Current literature suggests that of the three East Texas species under consideration by the U.S. Fish and Wildlife Service (USFWS), the Louisiana pigtoe (*Pleurobema riddellii*) is found in the Cypress Creek Basin. The Louisiana pigtoe occurs only in stream and river habitats with low to moderate flow and with silty sand, clay, and sand with gravel substrates. They are often relatively small, but individuals about five inches in length have been collected in Texas.

Over the past few years, the USFWS engaged river authorities and water districts to review and comment on the proposed listings of these East Texas species for the current Species Status Assessment (SSA). However, responding to the request was difficult as there is a limited amount of sampling data available in the literature.

Figure 84: Louisiana pigtoe (Pleurobema riddellii) photo by U.S. Fish & Wildlife Service

At present, TCEQ has not established a mussels sampling protocol; however, all

collection methods include tactile sampling, meaning that the sampler must reach into the sediments and feel for the mussels. Depending upon the depth of the water body, sampling may require the use of snorkels and/or diving gear. Since most waters in East Texas are tannin-laden, visibility is often very limited. As a result, mussels sampling is typically labor-intensive and time-consuming.

Fish play a significant role in the life-history of freshwater mussels, as the immature form, or glochidia, of most species become encysted on their fish hosts. Research suggests that glochidia will only successfully attach to specific fish species. Glochidia that fail to attach to a suitable host or attach to the wrong location will die. The glochidia will implant into the host fish and develop into juvenile mussels over a period of weeks to months. Once fully developed, the juvenile mussel detaches from the host fish and matures on the stream bed. The dispersal of most mussels is dependent upon the distribution of suitable host fish, and therefore, the distribution of a mussel species is likely heavily influenced by the effectiveness and breadth of host fish utilized (Schwalb *et al*. 2013).

In a 2018 study of wild-caught East Texas fishes (Marshall, *et. al.* 2018), the Louisiana pigtoe glochidia were found at low prevalence and intensities suggesting that the conservation status of the mussel is strongly influenced by its ability to successfully encounter and attach to a suitable host fish. Glochidia were only found on the Blacktail Shiner (*Cyprinella venustra*), Bullhead Minnow (*Pimephales vigilax*), and Red Shiner (*Cyprinella lutrensis*) making them suitable host species (Ford and Oliver, 2015; Ford, Plants-Paris, Ford, 2020).

Due to this relationship, sampling fish populations and abundance in streams may be used as an indicator for the potential presence or absence of the Louisiana pigtoe. If these host fish species are not present, or not present in relative abundance, then the Louisiana pigtoe is less likely to be found at this location. In this way, the fish sampling data can be used to prioritize watersheds for mussels sampling efforts to use mussels sampling funds efficiently.

A review of the TCEQ database showed that these potential host fish species have been collected in several streams within the Cypress Creek Basin, although in very low abundance. For example, out of the four sampling events conducted in Tankersley Creek in 1997, 1998, and 2003, a combined total of 18 individuals from the host species were collected. However, the sampling effort in Tankersley Creek in 2020 and 2021 indicated that the present sampling techniques and electrofishing technology may yield better sampling efficiencies than that of past decades. The Tankersley Creek sampling demonstrated that the host fish species for the Louisiana pigtoe were in relative abundance at this station. The June 2021 effort alone yielded 209 individuals. These results suggested that stations last sampled in the late 1990’s and early

2000's should be reevaluated to provide a better representation of the overall health of the biotic community.

Figure 85: Bullhead minnow, Pimephales vigilax; Blacktail shiner, Cyprinella venusta; Red Shiner, Cyprinella lutrensis

The NETMWD identified six priority watersheds that are suspected to support the Louisiana pigtoe mussel. Five of these streams are in Segment 0404 (Big Cypress Creek below Lake Bob Sandlin) or are tributaries to Big Cypress Creek. The most recent bioassessment was conducted in 2003. These fish data were used to evaluate the prevalence and abundance of known host species of the Louisiana pigtoe mussel. If the host species were not collected or the individuals were not in abundance, then one can assume that the Louisiana pigtoe mussel is unlikely to be found in the watershed.

The Coordinated Monitoring Committee agreed that ALMs should be performed in Hart Creek and Frazier Creek in 2022 and 2023. In July 2022, the TCEQ CRP awarded the NETMWD with funding to support ALM studies in four additional watersheds that are tributaries to Big Cypress Creek above Lake O' the Pines. In addition to gathering the information needed to assess whether the streams met their Aquatic Life Use designations, these studies also assisted NETMWD in identifying and prioritizing streams for potential Louisiana pigtoe mussel sampling in the future, thereby using their funds more efficiently and effectively. Bioassessments were conducted during the index and critical periods of 2022 and 2023 in these priority streams:

Segment	Description
0404	Big Cypress Creek
0404C	Hart Creek
0404I	Boggy Creek
0404J	Prairie Creek
0404L	Swauano Creek
0404M	Greasy Creek
0407B	Frazier Creek

Figure 86: Aquatic Life Monitoring watersheds in FY 2022 - 2023

In the summer of 2023, we were disappointed to learn that genetic testing revealed that several individual mussels collected in Big Cypress Creek from 2016 to 2018 were actually Wabash pigtoe (*Fusconaia flava*). This information was reported by the University of Texas Tyler and noted that both species share over 99 percent of their genetic identities (Dickinson and Greenwold, 2023). This information called into the question the identification of all Louisiana pigtoe mussels in the historical record for Big Cypress Creek.

The USFWS released a draft document, Environmental Assessment for the Designation of Critical Habitat for the Louisiana Pigtoe (*Pleurobema riddellii*), in August 2023. Due to the lack of genetically identified Louisiana pigtoe mussels, the Cypress Creek Basin was not included as a critical habitat of the species.

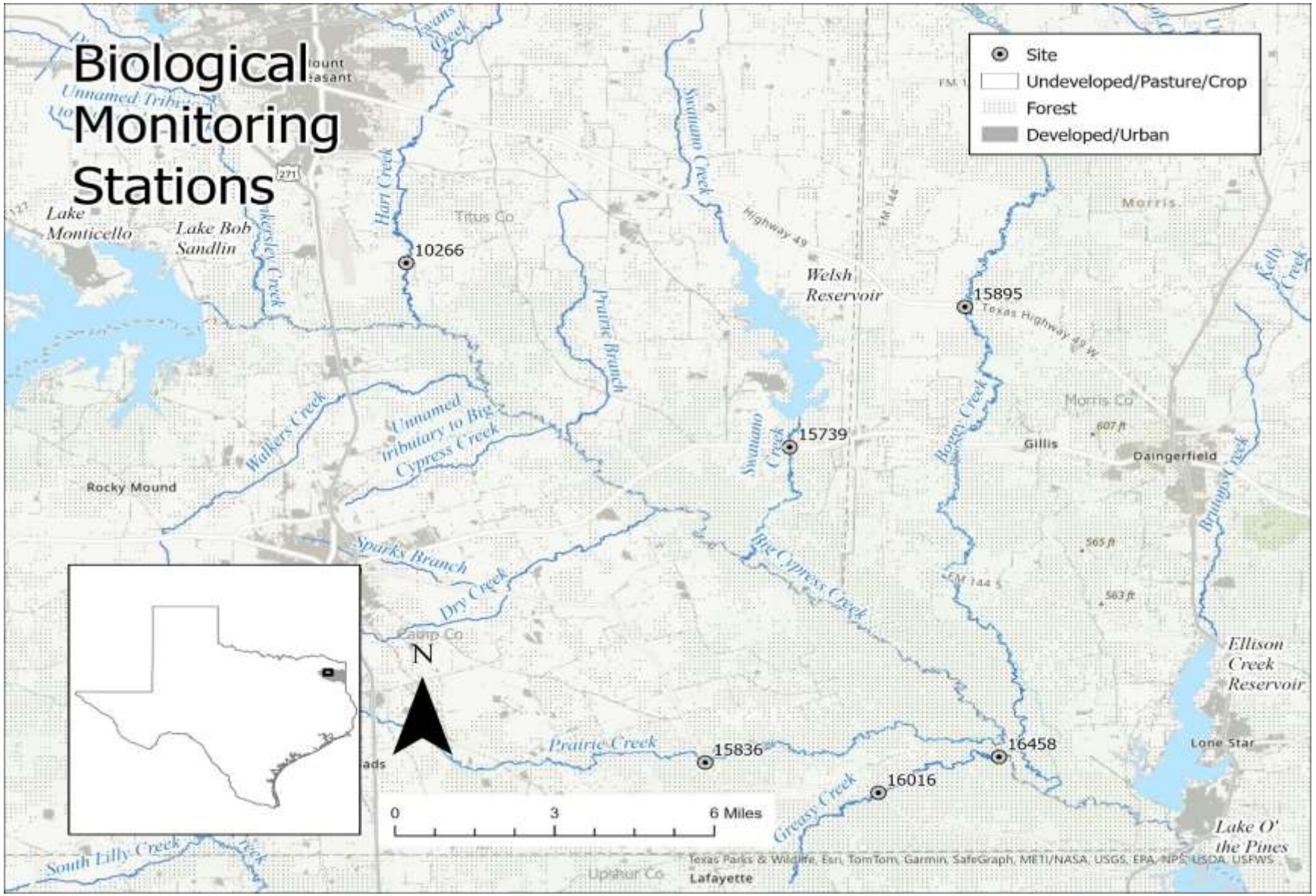

Figure 87: Map of ALM stations in Segment 0404

Drought conditions were prevalent throughout the summer and fall of 2022, so some of the scheduled monitoring was not performed. Critical period sampling was not conducted in Frazier Creek and Prairie Creek since both streams were completely dry within the study reach. No sampling was conducted in Swauano Creek in 2022 because it was dry during the entire monitoring period. Bioassessments were completed in Hart Creek, Boggy Creek, and Greasy Creek during both index and critical periods of 2022.

Conversely, heavy rainfall in the late spring and early summer of 2023 delayed sampling at several locations. Stream flow increased during sampling Frazier Creek in June 2023 due to overnight rainfall. The reduced water clarity and rising stream levels during sampling decreased fishing efficiency. Benthic sampling had to be postponed until the end of the month to allow time for the organisms to recover from habitat disturbance. This rainfall event and resultant releases from Lake Bob Sandlin prevented benthic sampling in Big Cypress Creek during the entire index period. Stream flows remained high until late July 2023 delaying critical period sampling until mid-August in order to allow enough time for the biotic communities to become reestablished in the stream.

Despite these weather-related obstacles, a total of 26 bioassessments were conducted in seven streams in the Cypress Creek Basin between June 20, 2022 and August 12, 2023. Considering the drought/flood cycle that was experienced during the study period, the results were somewhat unexpected. In total, 3,581 individuals from fifty taxa were collected with all results combined. On average, 29 fish species with 512 individuals were identified in each stream.

Approximately fifteen percent of the individuals collected were from the Louisiana pigtoe mussel host fish species. It should be noted that these species were not equally distributed across all streams. For example, only 0.5% of the total fish collected in Prairie Creek represented the Louisiana pigtoe mussel host fish species as compared with over seven percent of the individuals collected in Hart Creek.

Regardless of the basin not being designated as critical habitat, some very interesting findings were discovered through these bioassessments. At least one spotted sucker (*Minytrema melanops*), identified by TPWD as a species of greatest conservation need, was collected in each of the study streams. A total of fourteen individuals were collected over the study period. Even more unexpected was that the most individuals, six, were found in Swauano Creek, a stream that had been completely dry during the summer and on into the winter of 2022. All six were collected during the July 2023 bioassessment with five obtained while electroshocking.

Further, the fish of East Texas appear to be adapted to the low dissolved oxygen environments experienced during summer low-flow/no flow conditions. Dissolved oxygen concentrations in Boggy Creek ranged between 0.8 and 1.0 mg/L during the August 2022 bioassessment. None of

the 271 fish collected during this field effort were noted as stressed or having difficulties that would be expected in low dissolved oxygen conditions. The nineteen taxa collected during this event included sport fishes such as black crappie and largemouth bass and also included a slough darter (*Etheostoma gracile*), a spotted sucker (*Minytrema melanops*), and a flier (*Centrarchus macropterus*).

Finally, perennial pools are vital to the survival of fish populations in intermittent streams. The data from Swauano Creek were especially notable. The stream was dry throughout the entire study reach in 2022 and recovered with the winter rains in late-2022. During the March 4, 2023 field effort, 119 individuals from eleven taxa were collected. For a stream that had been completely dry only three months prior, these findings were quite unexpected.

All stations except Frazier Creek and Big Cypress Creek were sampled four times during the study period. Due to the 2022 drought, a total of three bioassessments were performed in Frazier Creek. Two sampling events in Big Cypress Creek were added to the 2023 monitoring schedule. These exceptions are denoted as "*" with Frazier Creek and as "**" next to Big Cypress Creek in the following table. It should be noted that Frazier Creek is located outside of the Louisiana pigtoe mussel habitat range.

Stream	# Fish Taxa	# Individuals	# Host Fish
Big Cypress**	28	265	110
Boggy	30	667	19
Frazier*	25	279	13
Greasy	29	414	61
Hart	34	669	257
Prairie	29	687	18
Swauano	26	600	47
Total	**50**	**3,581**	**525**
Mean	29	512	75

Figure 88: Number of fish taxa, individuals, and host fish by stream collected in FY 2022 - 2023

Taxonomic lists of fish species collected from each stream can be found in the Appendix. The following is a discussion of the study findings and ALU scores for each stream as identified in the table below.

ALU	Fish	Benthos	Habitat
Exceptional	≥52	≥36	26 - 31
High	42 - 51	29 - 36	20 - 25
Intermediate	36 - 41	22 - 28	14 - 19
Limited	≤36	≤22	≤13

Figure 89: Table of ALU scores

Figure 90: Confluence of Greasy Creek (left) and Big Cypress Creek (right)

SEGMENT 0404 – BIG CYPRESS CREEK

Big Cypress Creek was sampled at station 16458 located downstream of the confluence with Greasy Creek. The station is heavily forested and is only accessible through private property near Couch Mountain. In fact, access to the approximately 26-mile reach of Big Cypress Creek between SH 11 and Sand Crossing is only possible through landowner access. The Couch Mountain landowner has made enormous and expensive efforts to restore the approximately 7,500-acre tract to natural conditions through practices such as controlled burns and removing culverts from stream crossings. These actions have resulted in the landowner receiving state and national recognition and awards. It should be noted that this is the only station monitored in the lower assessment unit of Big Cypress Creek except for the US 259 station which transitions from riverine to lacustrine depending upon the elevation of Lake O' the Pines.

Despite the habitat being in a mostly natural condition, habitat scored on the border between Intermediate and High. Habitat scored 20 in June and 19.5 in August. For a stream that has had little impact from anthropogenic sources, habitat scoring in or near the Exceptional range would be expected. These results exemplify the limitations of the statewide scoring metrics discussed previously in this section.

Station 16458 - Big Cypress Creek				
	6/3/2023	8/12/2023		
	Index	**Critical**	**Average**	**ALU**
Fish	49	47	48.0	H
Ben. Region	NA	22	22.0	I
Ben. State	NA	25	25.0	I
Habitat	20	19.5	19.8	I/H

Figure 91: ALU Scores at station 16458 – Big Cypress Creek

Similarly, benthic macroinvertebrates scored in the Intermediate category using both regional and statewide metrics whereas fish was well within the High range. As detailed earlier in this section, benthics tend to score Intermediate in East Texas. This is partly due to the habitat types found in these streams. Due to the sandy sediments that are readily suspended in the water column, this limits some species' ability to establish viable populations. These lower scores than the statewide metrics may also suggest that adjustments to the regionalized scoring metrics may need to be considered.

During the TPWD Bio-blitz in October 2019, 31 taxa and 309 individuals were collected at this station. The combined effort of both WMS bioassessments yielded similar results with a total of 269 individuals representing 28 species. Although the TPWD bio-blitz methods include both electroshocking and seining efforts, their sampling efforts include extended sampling times and the employment of other catchment methods depending upon the waterbody.

Of interest was that not only did TPWD collect three more species in total than WMS, but there were also a number of different taxa that were exclusive to each collection. TPWD collected ten species that were not part of the WMS taxa list while WMS collected seven taxa that TPWD did not find. For example, TPWD reported collecting a dollar sunfish (*Lepomis marginatus*), harlequin darter (*Etheostoma histrio*), and slough darter (*Etheostoma gracile*). WMS captured a bluntnose darter (*Etheostoma chlorosomum*), Cypress darter (*Etheostoma proeliare*), and spotted gar (*Lepisosteus oculatus*). In combination, a total of 38 fish species have been reported for this station demonstrating the remarkable diversity of this waterbody.

Although the Louisiana pigtoe mussel is not expected to be encountered in this watershed, Big Cypress Creek had the second highest number of host fish species found in this study and represented over three percent of the total fish collected at this station. It should also be noted that during the August 2023 bioassessment, a Kisatchie painted crawfish was collected while electroshocking. The individual was photographed and returned unharmed to the stream.

SEGMENT 0404C - HART CREEK

Hart Creek arises near CR 1635, north of interstate 30 and generally travels along the eastern border of the City of Mount Pleasant. The stream traverses through a mostly rural area with improved pastures and forested land. The City of Mt. Pleasant WWTP, which is permitted to discharge up to three million gallons per day, is located approximately 0.34-mile upstream of the monitoring station.

Biological sampling was conducted at station 10266 at CR 4550 in June and August 2022 and in April and July 2023. Due to discharges from the WWTP, Hart Creek had flows of approximately 2.5 cfs during both 2022 events. Flows were much higher in 2023 with 9.9 cfs in April and 4.8 cfs in July.

Figure 92: Station 10266 - Hart Creek at CR 4550

The habitat results were on the border between the Intermediate and Limited categories, and the benthos fell into the Intermediate classification using both the state-wide and regionalized scoring metrics. As previously discussed, the average statewide benthic score (27) was much higher than the score using the regionalized metrics (23.3).

Despite the low habitat and benthic scores, fish populations scored in the High and Exceptional categories during all sampling events. The lower score in April 2023 was likely the result of the higher stream flow making the stream deeper and easier for the fish to evade capture. The average fish score for all four events was 50 placing the stream in the High category.

Station 10266 - Hart Creek						
	6/20/2022	8/22/2022	4/14/2023	7/1/2023		
	Index	**Critical**	**Index**	**Critical**	**Average**	**ALU**
Fish	55	51	45	49	50.0	H
Ben. Region	23	26	24	20	23.3	I
Ben. State	22	30	30	26	27.0	I
Habitat	13.5	10	16.5	14.5	13.6	I/L

Figure 93: ALU scores at station 10266 - Hart Creek

A combined total of 669 individuals representing 34 fish species were collected from all four events combined. Hart Creek was the most diverse stream in this study and had the second highest number of individuals collected. Twelve individuals from six darter species were collected including the cypress darter (*Etheostoma proeliare*), redfin darter (*Etheostoma whipplei*), dusky darter (*Percina sciera*), and logperch (*Percina caprodes*). Of note was the collection of bantam sunfish (*Lepomis symmetricus*) which is an extremely rare find in this part of the state.

Figure 94: Bantam sunfish (Lepomis symmetricus) collected in Hart Creek on July 1, 2023

All three Louisiana pigtoe host fish species were identified and represented a combined 7.2 percent of all individuals collected in the stream. Coupled with the sandy loam stream bed of Hart Creek, these results suggest that Hart Creek would be a good candidate for future mussels sampling.

While seining and electrofishing during the August 2022 event, six Kisatchie painted crawfish were collected. Photos were taken of the individuals before returning them unharmed to the stream. The identification was confirmed by TPWD River Studies staff. No Kisatchie painted crawfish were collected in 2023.

Figure 95: Station 15895 - Boggy Creek at SH 49

SEGMENT 0404I - BOGGY CREEK

Boggy Creek is classified as intermittent with perennial pools and has an Aquatic Life Use designation of limited. The stream travels through mostly unpopulated and forested lands from its origination near the City of Omaha to its confluence with Big Cypress Creek west of Ellison Creek Reservoir.

Sampling at station #15895 at SH 49 was conducted on August 6 and on September 30, 2022 and on April 15 and July 1, 2023. The stream was intermittent during both 2022 monitoring events but had water throughout the majority of the 200-meter reach. The stream flow was 11 cfs in April and 2.6 cfs in July 2023. Due to being intermittent, dissolved oxygen was extremely low with 0.6 mg/L in August and 1.5 mg/L in September in 2022. In 2023, the oxygen concentrations were 6.4 mg/L in April and 4.4 mg/L in July.

Similar to other stations in this study, Habitat scored as Intermediate, and the benthos scored in the Limited category using regionalized metrics and Intermediate with statewide metrics. Benthic data were not scored in July 2023 due to not collecting enough organisms for the ALU assessment. Since the fish scored in the High category, it is unlikely that the abundance of benthics was due to water quality conditions. The low number of organisms collected may have been due to the emergence of adult insects.

Station 15895 - Boggy Creek						
	8/4/2022	9/30/2022	4/15/2023	7/1/2023		
	Critical	**Index**	**Index**	**Critical**	**Average**	**ALU**
Fish	51	42	37	47	44.3	H
Ben. Region	21	17	23	NA	20.3	L
Ben. State	23	20	26	NA	23.0	I
Habitat	13.5	14.5	16.5	17.5	15.5	I

Figure 96: ALU scores at station 15895 - Boggy Creek

Despite the low DO readings, the fish were abundant, diverse, and scored in the High category during both 2022 events. Fish scored in the Intermediate category in April 2023. This was possibly due to the higher flow rate and deeper water conditions that were not experienced during the other sampling events. Overall, fish scores averaged 44.3, or around the middle of the High range.

Thirty fish species and 667 individuals were collected in Boggy Creek. A spotted sucker (*Minytrema melanops*), a species of greatest conservation need, was captured along with four slough darters (*Etheostoma gracile*) and two bluntnose darters (*Etheostoma chlorosomum*). Sport fish included one white crappie (*Pomoxis annularis*), seven black crappies (*Pomoxis nigromaculatus*), and four largemouth bass (*Micropterus salmoides*). Other notable finds were a flier (*Centrarchus macropterus*), tadpole madtom (*Noturus gyrinus*), freckled madtom (*Noturus nocturnus*), and gizzard shad (*Dorosoma cepedianum*). Nineteen red shiners (*Cyprinella lutrensis*) were the only Louisiana pigtoe host fish species collected from this station.

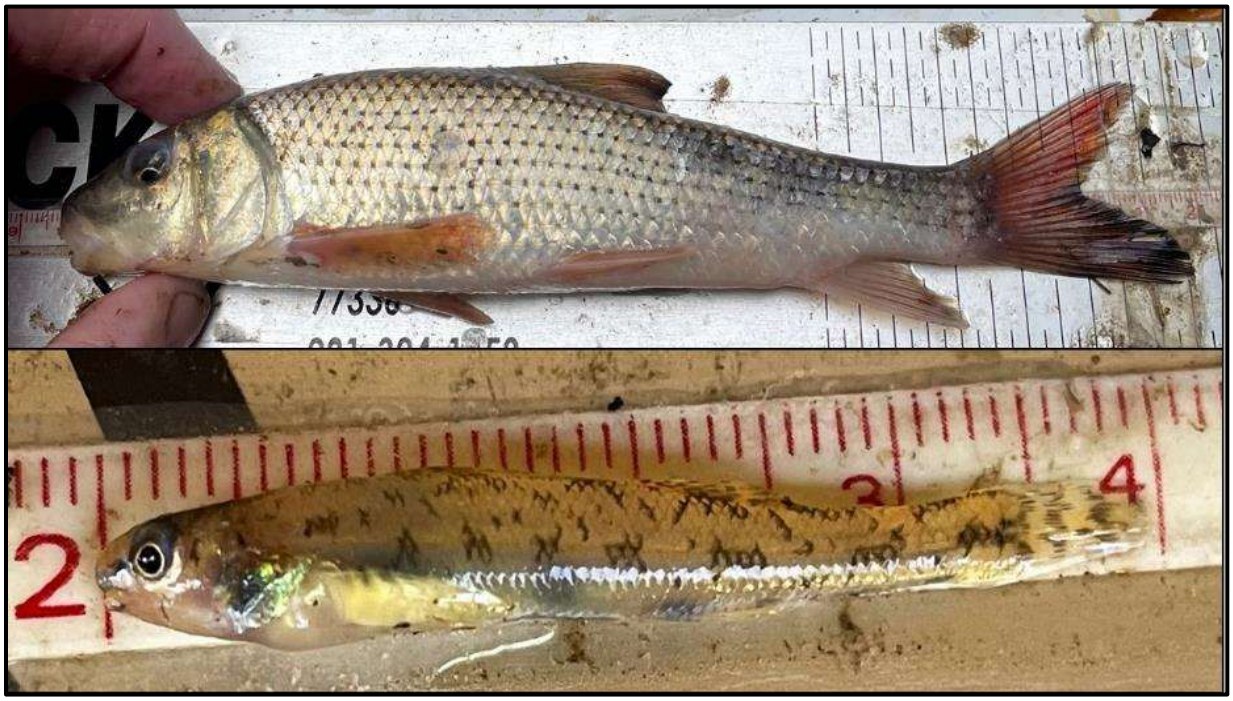

Figure 97: Spotted sucker (Minytrema melanops) – top; Bluntnose darter (Etheostoma chlorosomum) – bottom

SEGMENT 0404J - PRAIRIE CREEK

The headwaters of Prairie Creek are located south of Pittsburg and travel through developed areas in the upper reaches near US 271. The stream traverses over mostly unpopulated forested land interspersed with some improved pastures for the remainder of its journey to the confluence with Big Cypress Creek. Prairie Creek is classified as intermittent with perennial pools and has a limited Aquatic Life Use designation.

Critical period sampling was not conducted at station #15836 at FM 557 in 2022 because the stream was dry throughout the study reach. Enough rain had fallen in early October to reconnect the stream to Big Cypress Creek allowing fish to move upstream to the station by late October. Although there was no flow, water was connected throughout most of the study reach. Stream flow was high with 22 cfs in March 2023. These two events were outside of the non-critical period; however, the environmental conditions were representative of those periods and used in the analysis. Two critical period sampling events were conducted in 2023. The stream flow was 2.2 cfs in July and there was no flow in August.

Station 15836 - Prairie Creek						
	10/21/2022	3/4/2023	7/2/2023	8/12/2023		
	Index	**Index**	**Critical**	**Critical**	**Average**	**ALU**
Fish	51	41	53	51	49.0	H
Ben. Region	19	NA	24	20	21.0	L
Ben. State	28	NA	27	28	27.7	I
Habitat	14.5	19	18	17	17.1	I

Figure 98: ALU scores at station 15836 - Prairie Creek

Due to having little to no flow, dissolved oxygen was extremely low during October 2022 and both critical period bioassessments in 2023. The dissolved oxygen concentration in October 2022 was 1.2 mg/L, 2.6 mg/L in July, and 1.2 mg/L in August 2023. Despite the low dissolved oxygen concentrations, the fish scored in the High category for these events and as an average of all sampling efforts. As with most stations, habitat scored as Intermediate, and the benthos scored in the Intermediate category using state-wide metrics and Limited using regionalized metrics. Benthic data were not scored in March 2023 due to not collecting enough organisms for the ALU assessment. Since the area had received several large runoff events in the months prior to sampling, the lack of organisms may have been due to scouring.

In total, 687 individual fish were collected from all four events combined with almost three hundred individuals collected during the October 2022 effort. A total of 29 fish species were collected from this stream. A single spotted sucker (*Minytrema melanops*) was captured along with ten bluntnose darters (*Etheostoma chlorosomum*), three Cypress darters (*Etheostoma proeliare*), and a dozen logperch (*Percina caprodes*). Other species collected include the orangespotted sunfish (*Lepomis humilis*), pugnose minnow (*Opsopoeodus emiliae*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*). Only eighteen individuals from the Louisiana host fish species were collected.

Research studies being conducted in Prairie Creek and Big Cypress Creek by Dr. Carmen Montana at Stephen F. Austin State University were discussed in the *2022 Cypress Creek Basin Highlights Report*. The project is designed to understand spatial connectivity of waterways and the organization of fish communities. Surveys were conducted in September 2021 at five sites in or associated with Big Cypress Creek. Overall, they recorded 439 individuals from 35 fish species including the spotted sucker (*Minytrema melanops*) and the ironcolor shiner (*Notropis chalybaeus*) which are both species of greatest conservation need. They also collected and verified the identification of the Kisatchie painted crawfish. Their work continued into 2022 but results were not available at the time of this writing.

Figure 99: Electrofishing at station 15836 - Prairie Creek

SEGMENT 0404L - SWAUANO CREEK

Swauano Creek is classified as intermittent with perennial pools and has an Aquatic Life Use designation of limited. The stream originates east of Mt. Pleasant and south of Cookville and is the primary tributary of Welsh Reservoir. Welsh Reservoir serves as a source of cooling water for the Welsh Power Plant. Releases from the reservoir into Swauano Creek continue downstream through mostly unpopulated and forested lands to its confluence with Big Cypress Creek.

Monitoring was conducted at station 15739, located on SH 11 about a mile west of Cason. Due to Swauano Creek being completely dry in the 2022 monitoring period, all four bioassessments were performed in 2023. Index period sampling events were conducted in March and April, and critical period monitoring was completed in July and August. As with Prairie Creek, the March event was outside of the non-critical period, but environmental conditions were representative of the period and used in the analysis. Stream flow was highest in March at 20.6 cfs while no flow was reported in August. Similarly, dissolved oxygen ranged from 9.7 mg/L in March to 2.3 mg/L in August.

As found with the other study stations, habitat scored in the Intermediate range. The riparian area of the Swauano Creek site had the most human influence out of the study. The width of the natural vegetative buffer on the right bank of the stream was limited to five or ten meters for about half of the study reach. The pasture along the right bank was unimproved but was not forested like the other stations.

Unlike the other stations, both regionalized and statewide benthic scores fell into the Limited category. It should be noted that benthic data were not scored in March or April 2023 due to not collecting enough organisms for the ALU assessment. While scouring may have played a role in the low abundance of organisms in the spring of 2023, the fact that the stream had been dry from the summer of 2022 through the early winter was likely the most significant factor. Adult insects laid their late-summer eggs elsewhere since there was no water in the stream; therefore, there were very few immatures to be collected.

Swauano Creek was the only station in the study where fish did not score in the High category. This was not surprising considering the stream had been completely dry during the previous year and connectivity to Big Cypress Creek is limited by the upstream reservoir. However, fish were abundant and diverse in the stream with a total of six hundred individuals from 26 species collected during these sampling events combined. It should also be noted that due to battery failure, electroshocking was limited to only 600 seconds during the August bioassessment which may have limited the total number of individuals and species collected and possibly reduced the fish ALU score.

There were several interesting fish collected during the bioassessments including the collection of a slough darter (*Etheostoma gracile*), a creek chub (*Semotilus atromaculatus*), six spotted suckers (*Minytrema melanops*), and 37 gizzard shad (*Dorosoma cepedianum*). This was the only creek chub collected in the entire study. The gizzard shad collected in April were suspected to have been released from Welsh Reservoir during the heavy rains in March. Overall, 47 or about 1.3 percent of the total fish collected were members of the Louisiana pigtoe host fish species.

Station 15739 - Swauano Creek						
	3/4/2023	4/15/2023	7/1/2023	8/13/2023		
	Index	**Index**	**Critical**	**Critical**	**Average**	**ALU**
Fish	37	37	41	35	37.5	I
Ben. Region	NA	NA	22	19	20.5	L
Ben. State	NA	NA	20	23	21.5	L
Habitat	14	18	16	15.5	15.9	I

Figure 100: ALU scores at station 15739 - Swauano Creek

Figure 101: Station 15739 - Swauano Creek at SH 11

SEGMENT 0404M - GREASY CREEK

Greasy Creek is an intermittent with perennial pools stream and has a limited ALU designation. Apart from the Lafayette community near its headwaters, the watershed of Greasy Creek is almost entirely forested and unpopulated. The riparian buffer along the study reach was forested with little evidence of human activity.

Monitoring was conducted at station #16016 at FM 557 on August 6 and on September 30, 2022, and on June 3 and August 12, 2023. Due to the intermittent nature of the stream, sampling in 2022 was moved downstream of the bridge to an area where water was present along the entire reach. A portion of this reach had been channelized at some point in the distant past, and this section generally had uniform width, depth, and substrate which reduced the habitat scores. With regular rainfall in 2023, sampling was able to be conducted above the bridge in a reach that had more diverse habitat. Habitat scored near the Limited - Intermediate border for these reasons.

As found at the other stations in this study, benthic macroinvertebrates scored in the Intermediate category with higher scores found using the statewide metrics.

Station 16016 - Greasy Creek						
	8/4/2022	9/30/2022	6/3/2023	8/12/2023		
	Critical	**Index**	**Index**	**Critical**	**Average**	**ALU**
Fish	43	47	43	43	44.0	H
Ben. Region	19	27	25	17	22.0	I
Ben. State	22	27	30	25	26.0	I
Habitat	10	10	19.5	15	13.6	I/L

Figure 102: ALU scores at station 16016 - Greasy Creek

Although there was no flow during either bioassessment in 2022, and there was only 0.57 cfs in August 2023, sampling was conducted where water was connected throughout the entire reach length. Due to having no flow or low flow, dissolved oxygen was extremely low during both August sampling events with 0.7 mg/L in August 2022 and 2.2 mg/L in August 2023.

Although dissolved oxygen readings were very low, the fish scored in the High category for all events. Over four hundred individuals from 29 taxa were collected for all bioassessments combined. A single spotted sucker (*Minytrema melanops*) was captured during the September 2022 event and at least one darter species was collected from each sampling effort. In total,

five darter species were collected with thirteen total individuals. These species were bluntnose darter (*Etheostoma chlorosomum*), logperch (*Percina caprodes*), mud darter (*Etheostoma asprigene*), slough darter (*Etheostoma gracile*), and dusky darter (*Percina sciera*). Only 1.7 percent or 61 individuals from the Louisiana pigtoe host fish species were collected for all sampling combined.

Figure 103: Station 16016 - Greasy Creek at FM 557

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. Frazier Creek has a relatively low level of human disturbance, serves as an ecoregion reference stream for the watershed, and is considered a Least Disturbed Stream. The stream is divided into two assessment units with the upper unit extending from its headwaters east of SH 8 and south of Douglassville for fifteen miles to US 59. The lower assessment runs 24 miles from US 59 to the confluence with James Bayou. The watershed of the stream is almost entirely unpopulated, consisting of forested land interspersed with a few small tracts of improved pastures. Both assessment units of Frazier Creek are classified as intermittent with perennial pools and have Aquatic Life Use designations as limited.

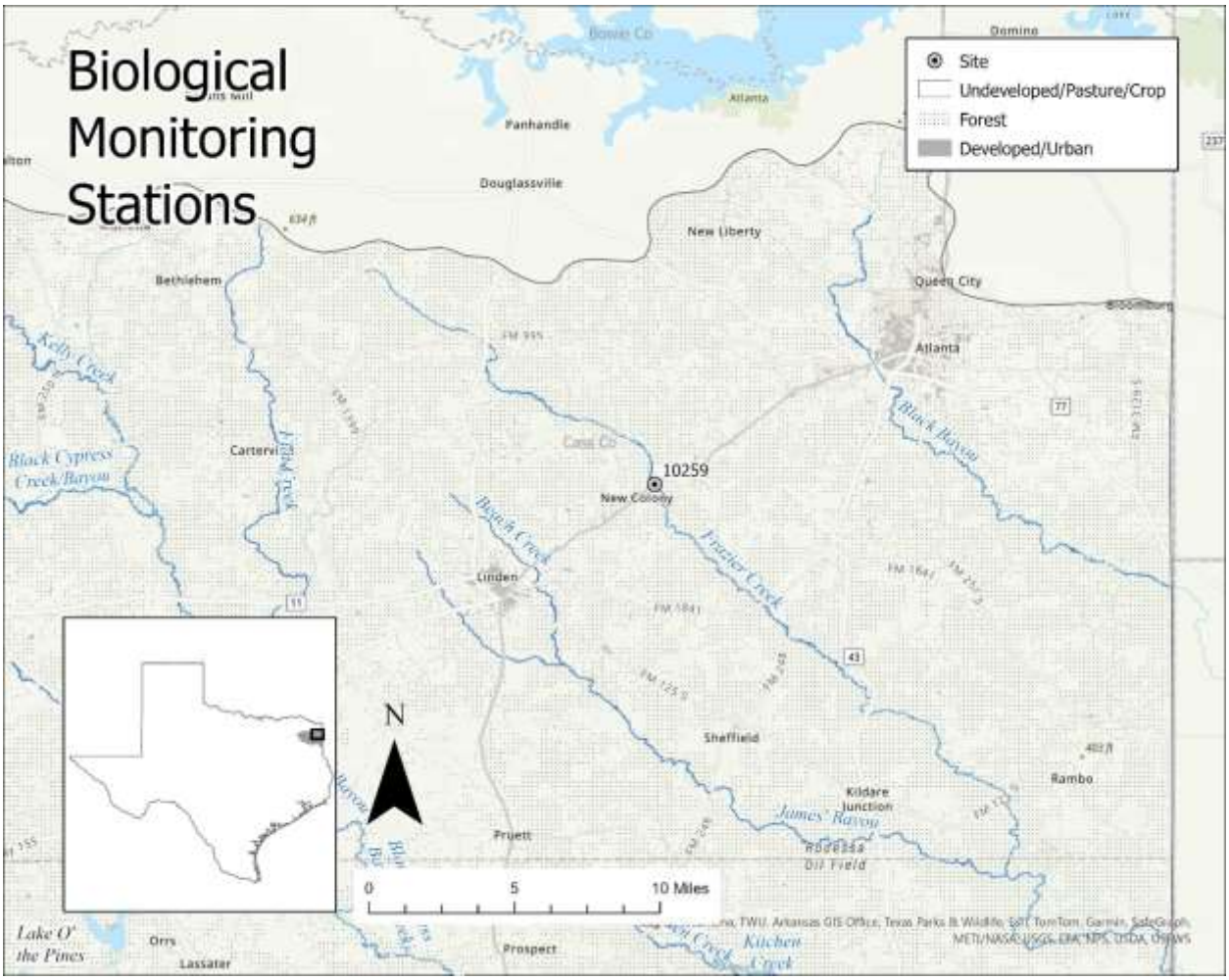

Figure 104: Map of Frazier Creek ALM station 10259

Index period monitoring was conducted in June 2022 at station 10259 at US 59. Critical period sampling was not performed due to the study reach being dry through September 2022. In 2023, bioassessments were performed in June and in August.

Figure 105: Station 10259 - Frazier Creek at US 59

Overnight rainfall in the headwaters of the stream in June 2023 caused stream flow to rise while fishing which reduced catch efficiency. These storms were unexpected as they were not in the forecast the previous day. By the time fishing activities were completed, the increased stream flow likely disturbed benthic habitats. Benthic collection was delayed until late June to allow time for populations to recover and to become reestablished. Frazier Creek was the only study stream with benthics scoring in the High ALU category. As with the other stations, habitat scored Intermediate.

Despite low stream flows of 0.4 cfs in June 2022 and 0.8 cfs in August 2023, the dissolved oxygen was relatively high with a concentration of 4.8 mg/L for both events. Fish scored in the High category based upon the average of the three bioassessments. Frazier Creek had the fewest number of fish taxa with 25 species and the second lowest number of individuals at 279.

Station 10259 - Frazier Creek						
	6/20/2022	8/22/2022	6/4/2023	8/13/2023		
	Index	**Critical**	**Index**	**Critical**	**Average**	**ALU**
Fish	47	NA	37	53	45.7	H
Ben. Region	31	NA	25	29	28.3	H
Ben. State	34	NA	27	32	31.0	H
Habitat	13.5	NA	37	16	22.2	I

Figure 106: ALU scores at station 10259 - Frazier Creek

Four darter species including the bluntnose darter (*Etheostoma chlorosomum*) and dusky darter (*Percina sciera*) were collected along with a spotted sucker (*Minytrema melanops*). Unique to Frazier Creek were the striped shiner (*Luxilus chrysocephalus*) and banded pygmy sunfish (*Elassoma zonatum*). It should be noted that this station was outside of the presumed habitat range of the Louisiana pigtoe mussel.

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APPENDIX

The following are taxonomic lists of fishes collected by station number during the ALM studies in 2022 to 2023.

Common Name	Scientific Name	16458	10266	15895	15836	15739	16016	10259	Total
banded pygmy sunfish	*Elassoma zonatum*							1	1
bantam sunfish	*Lepomis symmetricus*		1						1
black bullhead	*Ameiurus melas*		4		4	5			13
black crappie	*Pomoxis nigromaculatus*	1	4	7	1		6		19
blackspot shiner	*Notropis atrocaudalis*	1	15	2			6		24
blackstripe topminnow	*Fundulus notatus*	20	41	80	27	12	45	31	256
blacktail shiner	*Cyprinella venusta*	99	128			15			242
bluegill	*Lepomis macrochirus*	22	43	182	94	143	44	9	537
bluntnose darter	*Etheostoma chlorosomum*	2		2	10		6	7	27
bowfin	*Amia calva*							1	1
brook silverside	*Labidesthes sicculus*			1		1			2
bullhead minnow	*Pimephales vigilax*	11	106		18	5	20		160
channel catfish	*Ictalurus punctatus*	3	1	3	1		2		10
common carp	*Cyprinus carpio*			1		2			3
creek chub	*Semotilus atromaculatus*					1			1
cypress darter	*Etheostoma proeliare*	2	1		3				6
dusky darter	*Percina sciera*		2				2	3	7
fathead minnow	*Pimephales promelas*	1	3		1		1		6
flathead catfish	*Pylodictis olivaris*	1	1						2
flier	*Centrarchus macropterus*		4	2	12			2	20
freckled madtom	*Noturus nocturnus*			1	2		1	1	5
gizzard shad	*Dorosoma cepedianum*	3		7		37	7		54
golden shiner	*Notemigonus crysoleucas*				39	1	14	1	55
green sunfish	*Lepomis cyanellus*		10	7	8	11	3		39
inland silverside	*Menidia beryllina*	6		49		1	3		59

Common Name	Scientific Name	16458	10266	15895	15836	15739	16016	10259	Total
largemouth bass	*Micropterus salmoides*	8	4	4	26	7	2	3	54
logperch	*Percina caprodes*	3	1	85	12		2	2	105
longear	*Lepomis megalotis*	15	81		44	30	73	26	269
mud darter	*Etheostoma asprigene*	1	1				1		3
orangespotted sunfish	*Lepomis humilis*				5				5
pirate perch	*Aphredoderus sayanus*	14	12	23	29	17	23	30	148
pugnose minnow	*Opsopoeodus emiliae*				2				2
red shiner	*Cyprinella lutrensis*		23	19		27	41	13	123
red spotted	*Lepomis miniatus*	1	6	1	1	2	1	2	14
redear sunfish	*Lepomis microlophus*	3	5	5	173		54	2	242
redfin darter	*Etheostoma whipplei*		2						2
redfin pickerel	*Esox americanus*	2	14	4	8	1	4	16	49
redfin shiner	*Lythrurus umbratilis*		24		2	6		54	86
ribbon shiner	*Lythrurus fumeus*	19	70	28	75	46	16	51	305
slough darter	*Etheostoma gracile*		5	4		1	2	13	25
spotted gar	*Lepisosteus oculatus*	2		2		1			5
spotted sucker	*Minytrema melanops*	2	2	1	1	6	1	1	14
striped shiner	*Luxilus chrysocephalus*							3	3
tadpole madtom	*Noturus gyrinus*		3	1					4
threadfin shad	*Dorosoma petenense*	1							1
W mosquito fish	*Gambusia affinis*	18	25	87	69	198	27	3	427
warmouth	*Lepomis gulosus*	3	6	31	2	7	1	1	51
weed shiner	*Notropis texanus*	1		9	3				13
white crappie	*Pomoxis annularis*		1	1					2
yellow bullhead	*Ameiurus natalis*		20	18	15	17	6	3	79
	Total	**265**	**669**	**667**	**687**	**600**	**414**	**279**	**3581**