2022 CYPRESS CREEK BASIN HIGHLIGHTS REPORT

SPECIAL CONTRIBUTIONS:

Northeast Texas Aquatic Turtle Surveys

Mandi Gordon, Environmental Institute Houston

University of Houston – Clear Lake

Invasive Aquatic Species Update

Tim Bister, Texas Parks and Wildlife Department

Alligator Snapping Turtle (*Macrochelys temminckii*) Repatriation Project

Connor S. Adams, MS, and Christopher M. Schalk, PhD

Stephen F. Austin State University

Cover photo: Station 13631 - Big Cypress Creek at US 259 in the headwaters of Lake O' the Pines

GET INVOLVED!

The Texas Clean Rivers Program (CRP) is a water quality monitoring, assessment, and public outreach program administered by the Texas Commission on Environmental Quality (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 Texas Clean Rivers Program, NETMWD submits its Basin Highlights Report to the TCEQ and CRP partners.

Under the CRP, biologists and field staff collect water and biological samples, field parameters, and measure flow at sites throughout the Cypress Creek Basin. Monitoring and analysis are the basis for protecting and improving water quality in the Cypress Creek Basin. Within the cooperative program, directed by the NETMWD, these activities are an integral part of the CRP. The NETMWD plans and coordinates monitoring efforts with other basin entities, the TCEQ monitoring staff, 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. The data collected are analyzed and used to produce an annual report. These reports are then used to develop and prioritize programs that will protect the quality of healthy waterbodies and improve the quality of impaired waterbodies.

Each spring, the 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 Basin 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 CRP 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. This meeting is typically held in March or April at the NETMWD executive office in Hughes Springs. Due to COVID-19 precautions, the 2021 CRP Steering Committee meeting was held virtually. The topics included a compliance report with the Total Phosphorus Load Agreement, Invasive Aquatic Plant species, Threatened and Endangered Species, and a discussion of the 2021 Cypress Creek Basin Highlights Report.

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

The 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

The TCEQ CRP provides funding to and contracts with NETMWD to fulfill the responibilities of the Cypress Creek Basin Clean Rivers Program. The NETMWD contracts with Water Monitoring Solutions, Inc. (WMS) to perform the quality assurance, sampling, data analysis, and reporting tasks of the CRP.

Figure 1: Clean Rivers Program Steering Committee Meeting

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LIST OF ACRONYMS AND ABBREVIATIONS

ALM	Aquatic Life Monitoring
AU	Assessment Unit
cfs	cubic feet per second (measurement of stream flow)
CR	County Road
CRP	Clean Rivers Program
DO	Dissolved Oxygen
eDNA	Environmental DNA
EIH-UHCL	Environmental Institute Houston – University of Houston - Clear Lake
ESA	Endangered Species Act
FM	Farm-to-Market Road
FY	Fiscal Year
IR	Integrated Report
mg/L	milligrams per liter
NETMWD	Northeast Texas Municipal Water District
QAPP	Quality Assurance Project Plan
SSA	Species Status Assessment
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
UAV	Unmanned Aerial Vehicle
USACE	United States Army Corps of Engineers
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, 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 Highlights Report is authored, presented at stakeholder meetings, and posted to the NETWMD website. While the basin highlights report is typically non-technical and intended to provide a high-level overview of issues that may affect water quality in the basin, this year a watershed characterization detailing the results of two Lake O' the Pines special studies is presented. This section of the report is often technical due to discussions of the physicochemical interactions between parameters along with the statistical analysis performed on the collected data. If you have any questions, please contact the NETMWD for further clarification.

OVERVIEW OF 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.

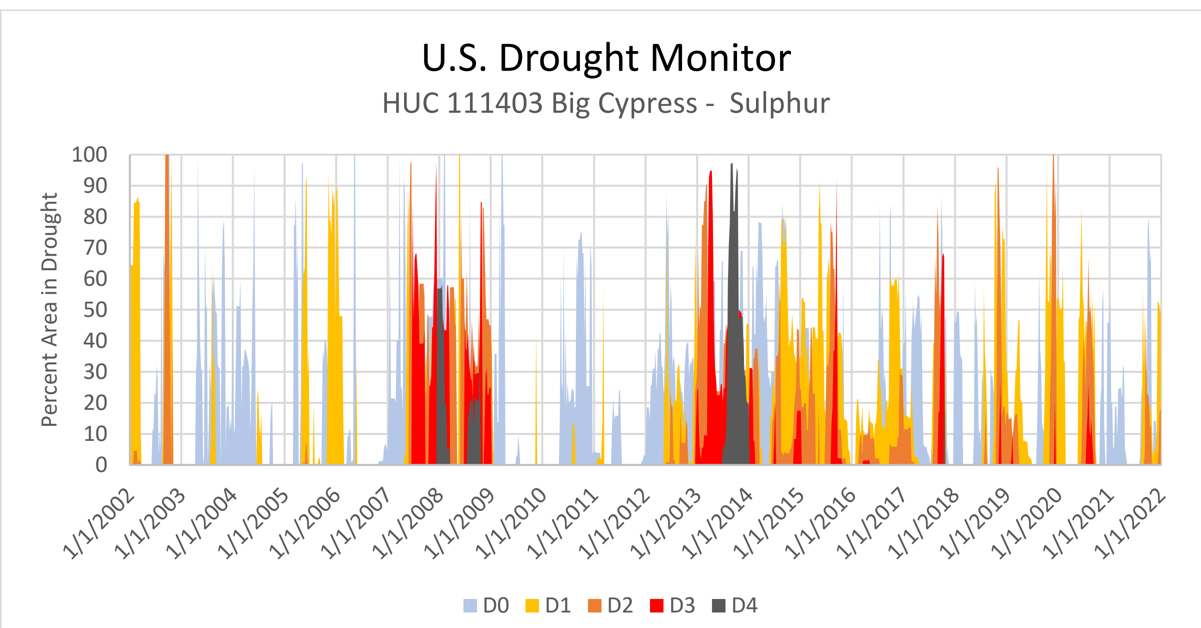

Figure 2: U.S. Drought Monitor, 2002 - 2021

Figure 2 presents the U.S. Drought Monitor data for the basin from 2002 through 2021. The drought monitor is updated weekly and reports the percent of the area in the six stages of drought: D0 – abnormally dry; D1 – moderate drought; D2 – severe drought; D3 – extreme drought; and D4 – exceptional 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-three years, annual precipitation has averaged around 52 inches. However, from 1979 to 1998, the average was 54 inches per year, as compared to 50 inches from 1999 through 2021. 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 was released from Lake Bob Sandlin since its completion.

The 2021 rainfall at Fort Sherman Dam was well-below average at 40.3 inches although over thirteen inches was received in May. In past years, the rain gauge located near the U. S. Army Corps of Engineers (USACE) offices by the Lake O' the Pines dam had shown a general agreement with the Fort Sherman Dam gauge. However, over the past four years, the USACE gauge has measured substantially more rainfall, including over 28 inches more rain in 2021 than at the Fort Sherman Dam gauge, with a total of 68.40 inches. A comparison between the rainfall amounts (in inches) at each reservoir is shown in Figure 3.

Year	Lake Bob Sandlin	Lake O' the Pines	Delta
2015	74.90	72.82	(2.08)
2016	52.37	52.22	(0.15)
2017	48.45	43.57	(4.88)
2018	54.58	67.39	12.81
2019	48.69	62.94	14.25
2020	56.26	75.93	19.67
2021	40.30	68.40	28.10

Figure 3: Rainfall Records in inches for Lake Bob Sandlin and Lake O' the Pines

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. Since there are no instream flow requirements in Big Cypress Creek, water is only released by the Titus County Freshwater Supply District #1 to maintain freeboard of the Fort Sherman Dam.

In 2021, almost 147,000 acre-feet of water was released from Lake Bob Sandlin with most of that water released in the first few months of the year. No water was released after June 30, 2021. Similarly, no water was released after June 16, 2020. Over the past six years, this has been the common release pattern with the exception of 2018, which had releases in both the first and fourth quarters of the year.

Releases (acre-feet)	2021	2020	2019	2018	2017	2016	Average
January	20,536	12,305	43,068	-	1,397	18,737	16,007
February	16,048	57,839	22,953	30,096	9,980	20,108	26,171
March	27,559	47,550	23,866	37,890	8,253	60,767	34,314
April	7,752	35,700	34,494	15,404	38,452	50,707	30,418
May	59,307	36,493	96,159	4,540	2,452	14,765	35,619
June	15,718	7,636	42,377	-	2,907	8,072	12,785
July	-	-	5,991	-	-	496	1,297
August	-	-	-	-	4,438	-	888
September	-	-	-	-	1,227	-	245
October	-	-	-	1,359	-	-	272
November	-	-	-	27,806	-	-	5,561
December	-	-	-	37,832	-	-	7,566
Total	**146,920**	**197,524**	**268,908**	**154,927**	**69,106**	**173,652**	**168,506**

Figure 4: 2016 – 2021 Monthly Releases from Lake Bob Sandlin

From 2000 through 2014, a combined total of 939,956 acre-feet of water was released from the reservoir. Due to the pervasive drought, there were no releases in seven out of those fifteen years which included the years 2005 through 2007 and 2011 through 2014.

As a result of the large amount of rainfall in 2015, a record amount of water was released from the Fort Sherman Dam at over 280,000 acre-feet, followed by 269,000 acre-feet in 2019. Almost 1.3 million acre-feet of water was released in the seven-year period from 2015 through 2021. This amount of water represents nearly 70 percent of the releases from Lake Bob Sandlin over the past twenty years.

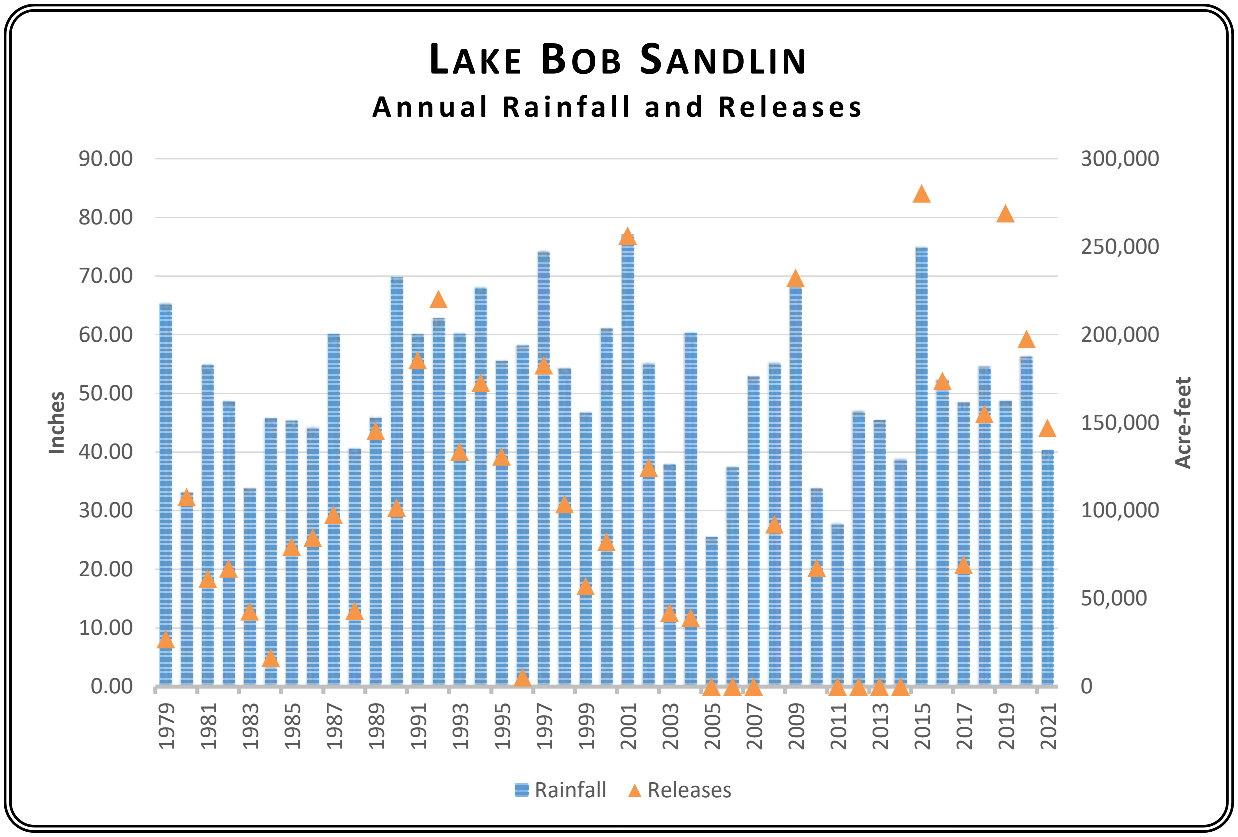

Figure 5: Graph of annual rainfall and releases from Lake Bob Sandlin

The remainder of the 2022 Cypress Creek Basin Highlights Report discusses the following topics:

- 2022 Cypress Creek Basin Monitoring Program
- Lake O' the Pines Special Studies Report
- Aquatic Life Monitoring in Tankersley Creek
- Species of Concern
- Invasive Aquatic Species

The Lake O' the Pines Special Studies Report section features the findings of the pH studies. The Species of Concern section discusses potentially threatened or endangered species in the basin, while the Invasive Aquatic Species section reports on the results of the invasive vegetation surveys performed by the TPWD in 2021 along with their activities to treat and control these non-native species.

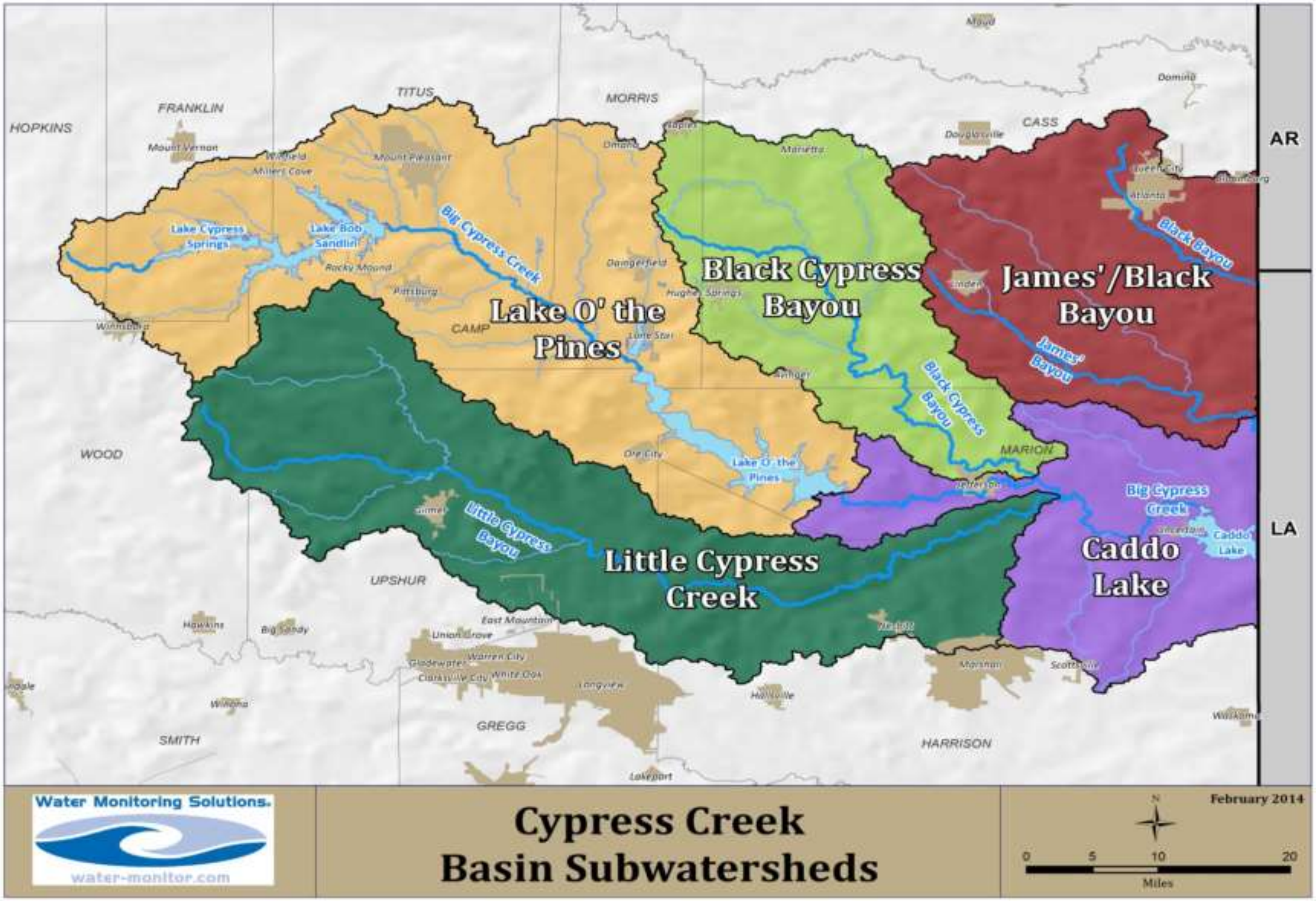

Figure 6: Map of the Cypress Creek Basin watersheds

THE 2022 CYPRESS CREEK BASIN MONITORING PROGRAM

WATER QUALITY MONITORING AND ASSESSMENT

Water quality monitoring and reporting is the heart of the CRP program. NETMWD / Water Monitoring Solutions, Inc. (WMS) and the TCEQ Region 5 – Tyler (R5) routinely collect water quality data. In FY 2022, monitoring is conducted at forty sites located in ten designated segments and in fifteen unclassified segments within the Cypress Creek basin.

Clean Rivers Program partners collect monitoring data following a TCEQ-approved Quality Assurance Project Plan (QAPP). The QAPP references procedures and methods for sample collection and handling. The TCEQ Surface Water Quality Monitoring 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 water quality of the basin.

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

The most recent water quality assessment, the *2020 Texas Integrated Report* (2020 IR) was approved by the TCEQ on March 25, 2020 and by the U.S. Environmental Protection Agency on May 12, 2020. In the 2020 IR, the TCEQ evaluated 36 classified and unclassified water bodies in the Cypress Creek Basin. The results indicated that over half of the water bodies evaluated did not meet surface water quality standards for one or more parameters. The *2020 Texas §303(d) List* identified nine classified and twelve unclassified water bodies that did not meet the water quality criteria. Low concentrations of dissolved oxygen, high levels of bacteria, and mercury in fish tissue were the most common impairments. A table of the segments and parameters included on the *2020 Texas §303(d) List* is shown in Figure 7. Information regarding the water quality impairments and concerns shown in the *2020 Texas Integrated Report* were discussed in detail in the *2020 Cypress Creek Basin Highlights Report*.

The *2020 Texas §303(d) List* for the Cypress Creek Basin includes the following impairments:

Segment ID	Description	Parameter
0401	Caddo Lake (entire)	Mercury in fish tissue
		DO
0401A	Harrison Bayou	DO
0402	Big Cypress Creek below Lake O' the Pines	Mercury in fish tissue
		DO
0402B	Hughes Creek	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*
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	*E. coli*
0410	Black Cypress Bayou	Mercury in fish tissue
		Copper, Lead in water
		DO
0410A	Black Cypress Creek	*E. coli*

Figure 7: Table of Impairments

The Draft *2022 Texas Integrated Report* was released for public comment on January 28, 2022. Changes to the §303(d) List include removing the low dissolved oxygen impairment in Segment 0402B - Hughes Creek while new impairments for low dissolved oxygen in Segment 0409B - South Lilly Creek and for bacteria in Segment 0401A - Harrison Bayou and Segment 0404F - Sparks Branch were added to the list. The 2022 IR will be detailed in the next Cypress Creek Basin Highlights Report.

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 water temperature is too cold, cold-blooded organisms may either die or become weaker and more susceptible to other stresses, such as disease or parasites. Colder water can be caused by reservoir releases. Warmer water can be caused by removing trees from the riparian zone, soil erosion, or use of water to cool manufacturing equipment.

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

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

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

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

Figure 8: 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 the water, and is primarily composed of calcium and magnesium. The hardness of the water is critical due to its effect on the toxicity of certain metals. Higher hardness concentrations in the receiving stream can result in reduced toxicity of heavy metals.

Chloride – Chloride is an essential element for maintaining normal physiological functions in all organisms. Elevated chloride concentrations can disrupt osmotic pressure, water balance, and acid/base balances in aquatic organisms which can adversely affect survival, growth, and/or reproduction. Natural weathering and leaching of sedimentary rocks, soils, and salt deposits can release chloride into the environment. Other sources can be attributed to oil and gas exploration and storage, 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. 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 2022

The Clean Rivers Program is funding quarterly sampling for field and laboratory parameters at eleven stations. In addition, three stations are monitored for field parameters and stream flow each quarter while diel sampling is conducted at three stream stations each quarter. In Fiscal Year (FY) 2022, Aquatic Life Monitoring is scheduled to be performed in Hart Creek and Frazier Creek. 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 will be conducted during the index and critical periods of 2022. The non-critical period sampling will be performed between March 15 and June 30, while the Critical Period extends from July 1 to September 30.

The following pages include a map of the FY 2022 Cypress Creek CRP monitoring stations and the 2022 CRP monitoring schedule. For a full list of stations monitored by both TCEQ Region 5 and the NETMWD/WMS, visit the Coordinated Monitoring Schedule.

Figure 9: Map of 2022 CRP Monitoring Stations

Station Description	Station	Segment	Field	Conv	Bacteria	Flow	24 HR DO	ALU
Segment 0401 Caddo Lake								
CADDO LAKE IN GOOSE PRAIRIE	10288	0401	4	4	4			
CADDO LAKE MID LAKE	10283	0401	4	4	4			
CADDO LAKE TURTLE SHELL	15249	0401	4	4	4			
HARRISON BAYOU AT FM 134	15508	0401A	4	4	4	4		
KITCHEN CREEK AT MARION CR3416	14998	0401B	4					
Segment 0402 Big Cypress below Lake O' the Pines								
BIG CYPRESS CREEK AT SH 43	10295	0402	4	4	4	4		
HUGHES CREEK AT CR 2985	22321	0402B	4					
KELLEY CREEK AT FM250	16934	0402E	4			4		
Segment 0404 Big Cypress below Lake Bob Sandlin								
BIG CYPRESS CREEK NEAR GREASY CK	16458	0404	4	4	4			
TANKERSLEY CREEK AT FM3417	10261	0404B	4	4	4	4		
HART CREEK AT COUNTY ROAD 4550	10266	0404C	2	2	2	2	2	2
PRAIRIE CREEK AT FM 557	15836	0404J	4			4	4	
Segment 0405 Lake Cypress Springs								
BIG CYPRESS CREEK AT CR SW 3170	22151	0405A	4			4	4	
Segment 0407 James Bayou								
JIMS BAYOU AT SH43	14976	0407	4	4	4	4		
FRAZIER CREEK AT US 59	10259	0407B	4	4	4	4		
FRAZIER CREEK AT US 59	10259	0407B	2			2	2	2
Segment 0409 Little Cypress Creek								
LILLY CREEK AT FM 556	20153	0409A	4		4			
SOUTH LILLY CREEK AT FM 2454	17954	0409B	4		4	4		
Segment 0410 Black Cypress Bayou								
BLACK CYPRESS BAYOU AT SH 11	10247	0410	4			4	4	

Figure 10: FY 2022 CRP Monitoring Schedule

LAKE O' THE PINES SPECIAL STUDIES

INTRODUCTION

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.

Figure 11: Downtown Jefferson during the flood of 1945

Releases from the two gates in the control structure vary from a minimum of 5 cubic feet per second (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.

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. While the amount of dissolved oxygen in water fluctuates naturally, human activities 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 completed a revised Implementation Plan to continue their efforts in improving its water quality.

Through the revised Implementation Plan, a group permit for phosphorus was issued to all waste water 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 waste water treatment plants. The TPLA was the first of its kind in the State of Texas.

Permitted Discharger	2016 – 2020 Annual Allocation (pounds of Phosphorus)	2016 – 2020 Actual Discharge (pounds of Phosphorus)	Delta (pounds of Phosphorus)
Daingerfield	2,550	2,903	353
Lone Star	2,250	7,992	5,742
Mt. Pleasant	10,900	14,153	3,253
Omaha	1,300	2,673	1,373
Ore City	5,000	3,225	(1,775)
Pilgrim's Pride	266,000	43,473	(222,527)
Pittsburg/Dry Creek	2,850	718	(2,132)
Pittsburg/Sparks Branch	8,900	4,326	(4,574)
Total	**299,750**	**79,463**	**(220,287)**

Figure 12: TPLA Results in Pounds of Phosphorus, 2016 - 2020

The TPLA allocated Pilgrim's Pride an annual discharge limit of 53,200 pounds of phosphorus. In 2014, the plant discharged almost double that amount at 101,000 pounds. That year, a multimillion-dollar upgrade to the Pilgrim's Pride Wastewater Treatment Plant (WWTP) was initiated which was completed in April 2015. From 2016 through 2020, the WWTP released a combined total of about 43,500 pounds of phosphorus, or only approximately sixteen percent of its permitted allocation of 266,000 pounds. Ore City and both Pittsburg WWTPs have successfully met their phosphorus allocations every year since the permit was implemented. The Cities of Lone Star and Omaha have never met their phosphorus allocation limits. The City of Omaha was one hundred percent over its five-year allotment, while the City of Lone Star exceeded its permit by 255 percent at over 5,700 pounds. Despite the City of Mount Pleasant meeting its permitted allocation in three out of five years, it exceeded its five-year combined phosphorus apportionment by 30 percent.

Although some cities have failed to meet their permitted phosphorus load allocation, the members of the combined permit have discharged 110 tons of phosphorus less than the total allocation into the Lake O' the Pines watershed over the past five years. This reduction was due, in a large part, to the plant upgrades at the Pilgrim's Pride WWTP.

Stakeholders 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.

The 2020 IR showed concerns for nitrate in both assessment units of Segment 0404, Big Cypress Creek below Lake Bob Sandlin, and for total phosphorus in the upper reach of the stream. The 2020 IR had concerns for nitrate and total phosphorus in Segment 0404B - Tankersley Creek and for nitrate in Segment 0404C - Hart Creek. Nitrate concerns were also identified in 0404E – Dry Creek and in 0404F – Sparks Branch. It should be noted that each of these streams are receiving waters for wastewater treatment plants located in Mount Pleasant and Pittsburg.

Special studies in the tributary watersheds of Lake O' the Pines were performed in 2018 through 2020. In 2018 and 2019, a study of Tankersley and Hart Creeks revealed that nitrate concentrations at stations located below the WWTP outfalls were often higher than the TCEQ screening level of 1.95 mg/L. For Tankersley Creek, the mean nitrate concentration at the most downstream station (10261) was 16.6 mg/L, while the downstream station in Hart Creek (10266) was 3.51 mg/L. The study also revealed that none of the samples at the most upstream stations, located above the WWTPs, exceeded the nitrate screening level.

Only one of the total phosphorus samples in Tankersley Creek at station 10261 exceeded the 0.69 mg/L screening level, and none of the Hart Creek samples were high at station 10266. None of the samples at the most upstream station in Hart Creek (station 10272) were reported above the screening level while one sample at the most upstream station in Tankersley Creek (station 10264) was elevated. Disturbed soils from an on-going pipeline construction in the riparian zone above the sample point was the most likely contributor of the excess phosphorus.

In 2019 and 2020, a study of Tankersley Creek and the upper reach of Big Cypress Creek was conducted. Although the primary objective of this study was to obtain sulfate data, nitrate, nitrite, and chloride analyses were also performed. The nitrate results revealed that all but one sample at the most downstream station in Tankersley Creek (10261) exceeded the screening level. The mean of all nitrate samples for station 10261 was more than double that of the 2018 – 2019 study at 34.9 mg/L.

As part of this special study, samples were collected in Big Cypress Creek at US 271 (station 10310). The mean nitrate concentration was 24.3 mg/L. The study revealed that during low flow periods of less than 10 cfs, the nitrate concentration was similar to that obtained at station 10261. Strong inverse correlations between nitrate and stream flow were identified. These correlations demonstrated the importance of releases from Lake Bob Sandlin in reducing the concentration of nutrients in Big Cypress Creek.

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

- AU 0403_01 Lower 5,000 acres near the dam
- AU 0403_02 Middle 5,000 acres
- AU 0403_03 Middle 5,000 acres below State Highway 155
- AU 0403_04 Upper 3,700 acres above State Highway 155

AU 0403_02 was the first identified as impaired for high pH in the *2016 Texas §303(d) List*. The *2016 Texas Integrated Report* also included a concern for high pH in AU 0403_01. The *2020 Texas §303(d) List* identified the three lower assessment units as impaired for high pH. The high pH impairment was due to more than one-quarter of the pH samples exceeding the 8.5 s.u. pH criterion. Data collected during the assessment period also revealed high chlorophyll and dissolved oxygen values. Further, the *2020 Texas Integrated Report* defined Lake O' the Pines as an eutrophic reservoir and ranked it in the top thirty percent out of 130 Texas resevoirs for elevated chlorophyll.

In eutrophic reservoirs, algae (phytoplankton) consume the 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.

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 lower assessment unit (AU 0403_01). Since chlorophyll 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.

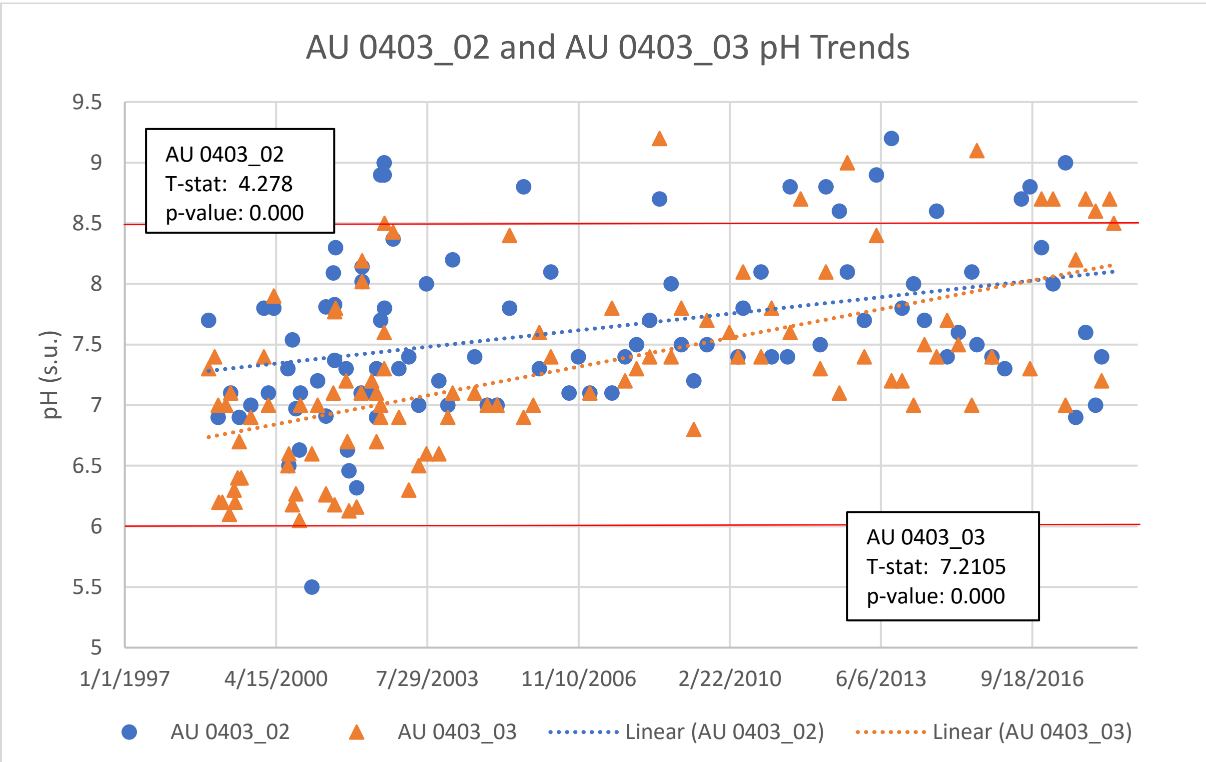

Figure 13: Increasing pH Trends in the Middle Assessment Units

The report also revealed that high pH readings had been rare prior to 2010 throughout the reservoir. Historically, only one pH value was reported above the 8.5 s.u criterion from 1973 through 2009 in AU 0403_01. From 2010 through 2018, a high pH reading had been recorded six times and all were collected during the warm weather months. All seven of the high pH readings corresponded with super-saturated dissolved oxygen levels. In AU 0403_02, the middle 5,000 acres, records from 1998 through 2010 showed three samples with elevated pH. From 2011 through March 2018, a high pH was observed nine times. As with the lower AU, all of the high pH readings were obtained during in the warm weather months, and all of the high pH values corresponded with dissolved oxygen readings above saturation.

Similar to the lower portions of the reservoir, AU 0403_03 had only one high pH reported from 1987 through 2010. From 2011 to June 2018, an elevated pH was reported eight times. As with the other assessment units, the high pH value was associated with a high dissolved oxygen reading and primarily collected during the warm weather months. Unlike the other assessment units, only two high pH values were recorded since 1997 in the headwaters of AU 0403_04. The peak value of 8.7 s.u. was observed in September 2012 with a 118.4 dissolved oxygen saturation.

Finally, the report demonstrated that all high pH measurements collected since 2010 corresponded with super-saturated dissolved oxygen. A strong statistical correlation between all pH and dissolved oxygen percent saturation was reported.

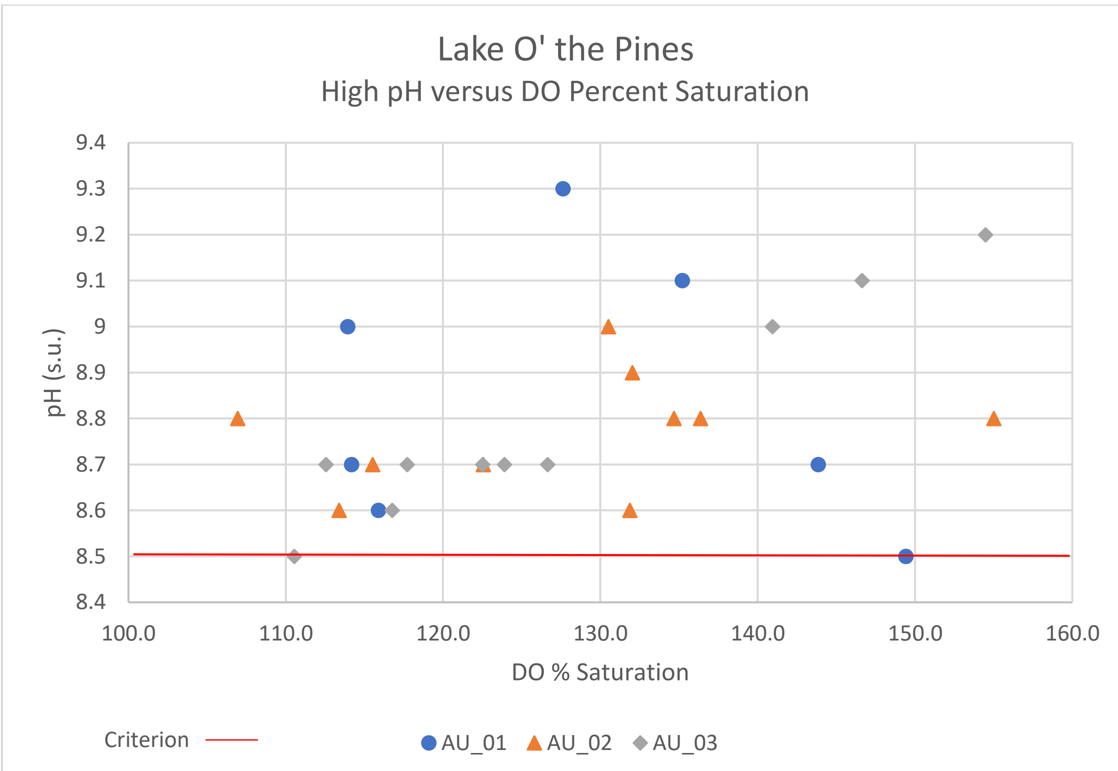

Figure 14: High pH versus DO Percent Saturation

An increasing trend for chlorophyll was identified for AU 0403_01 and AU 0403_02 in the *2009 Cypress Creek Basin Summary Report.* This increasing trend continued in AU 0403_01 in the 2014 analysis. The chlorophyll trends did not persist into the 2019 report; however, pH was increasing at a statistically significant rate in both of the middle assessment units.

The combination of elevated chlorophyll and super-saturated dissolved oxygen supported the assumption that the high pH readings were a direct result of phytoplankton productivity since all of the data used in the 2018 assessment 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 support 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. A Diel Special Study incorporated targeted diel monitoring in the lower assessement units.

Figure 15: Continuous Water Quality Monitoring Stations; US 259 (left) and NETMWD Intake (right)

Study Design

Stations used for the special studies were readily accessible and did not require permission from the U.S. Army Corps of Engineers to install buoys or alter boat markers in the reservoir. As a result, the stations selected were not necessarily representative of each assessment unit. Most stations were located near the shore, rather than in the central portion of the reservoir where routine monitoring is conducted. Since these stations were not representative of the assessment unit, data collected through these special studies will not be used for assessment purposes.

The Continuous Water Quality Monitoring Special Study was conducted from November 2019 through August 2021. Both continuous water quality instruments measure DO, pH, chlorophyll, and other parameters at fifteen-minute intervals. Data generated by these continuous monitors are used by NETMWD for internal purposes. Since chlorophyll is also measured, data obtained from the monitors were used to make general assertions regarding primary productivity in addition to providing diel DO and pH ranges.

The two existing NETMWD continuous water quality monitoring stations in Lake O' the Pines were used for this study. The monitors are located at US 259 and at the NETMWD Intake. It should be noted that the continuous monitor at US 259 is actually located in Segment 0404_01 of Big Cypress Creek, not in Segment 0403_04 of Lake O' the Pines. With the exception of extended drought periods, this station functions more lacustrine than riverine so it was chosen to represent the upper assessment unit of the reservoir. The NETWMD intake is located in AU 0403_03, and the continuous monitor installed at the intake represented that assessment unit.

Since data were also needed in the lower portion of the reservoir, a diel study was designed to measure daily DO and pH ranges. The study targeted the summer months since most of the high pH values reported in Lake O' the Pines were obtained during these months. For this study, an instrument was deployed at each station and programmed to record DO and pH at fifteen-minute storage intervals for a minimum of twenty-four hours. The diel studies were scheduled to be performed in the months of May through August 2020 and 2021. Diel monitoring was performed at the City of Longview intake (station 22172) and at station 22173 located in a swimming area near the dam. Station 22172 represented AU 0403_02 while station 22173 represented AU 0403_01.

The objectives of these Special Studies were to provide real-time water quality data for stakeholders; obtain data used to address the pH impairment and algae concerns in the reservoir; identify other potential water quality issues such as low DO and algal blooms; and to test the relationships between pH, DO, and chlorophyll in order to better understand the daily range of pH throughout the reservoir.

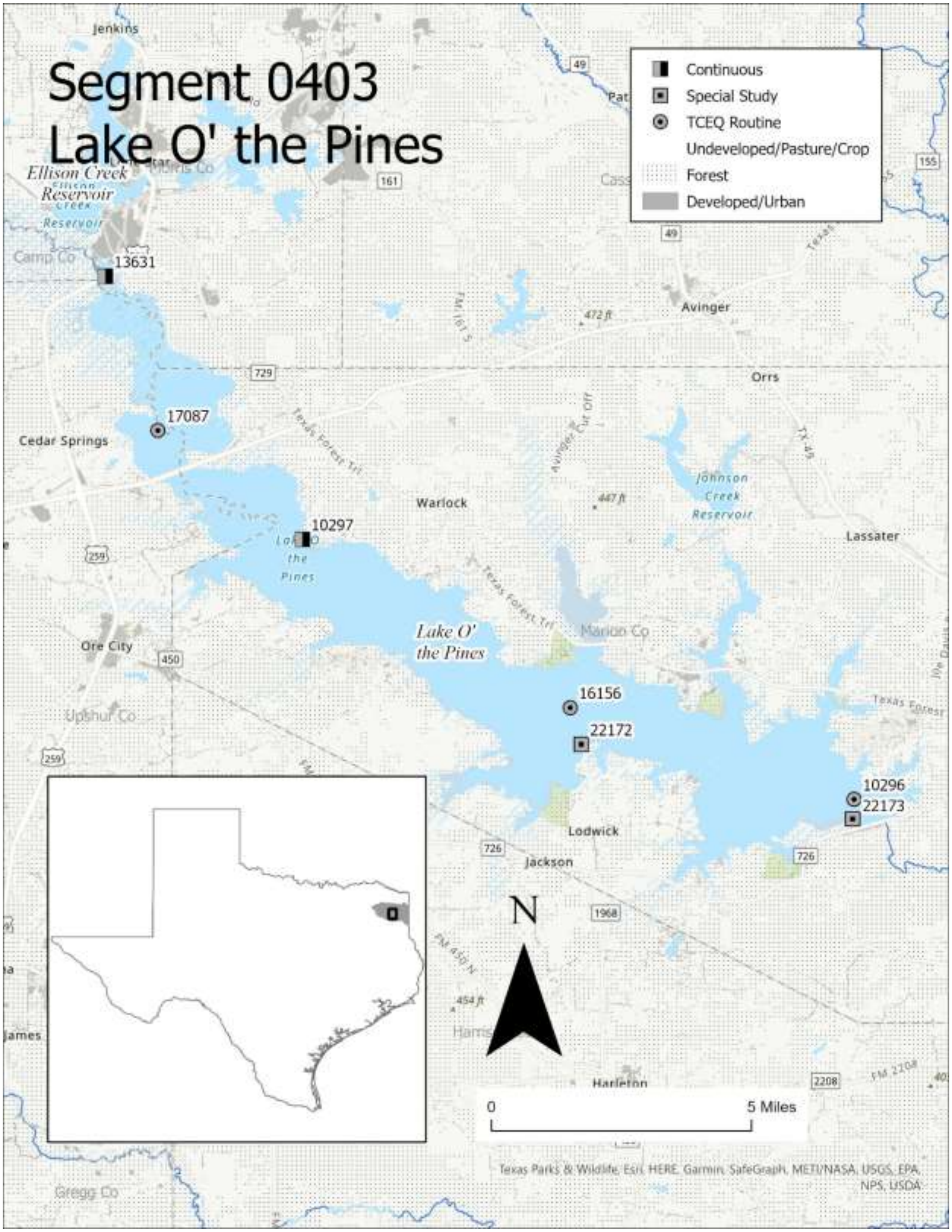

Figure 16: Lake O' the Pines Special Study Site Map

Results

Lake O' the Pines has two conservation pool levels, one for summer and one for the rest of the year. The Summer Recreational Pool, from May 1 to September 15, is 230.0 feet while the conservation pool is 228.5 feet during the rest of the year. The lake level never fell below 228.0 feet during the study period. One of the challenges for analyzing and comparing the results from the continuous monitors was the inability to maintain the instrument at a fixed depth below the surface. Ideally, the measurements should be made in the mixed surface layer at approximately 0.5 meters below the surface. At the beginning of the study and throughout much of the study period, Lake O' the Pines was above its conservation pool. (*Figure 17*).

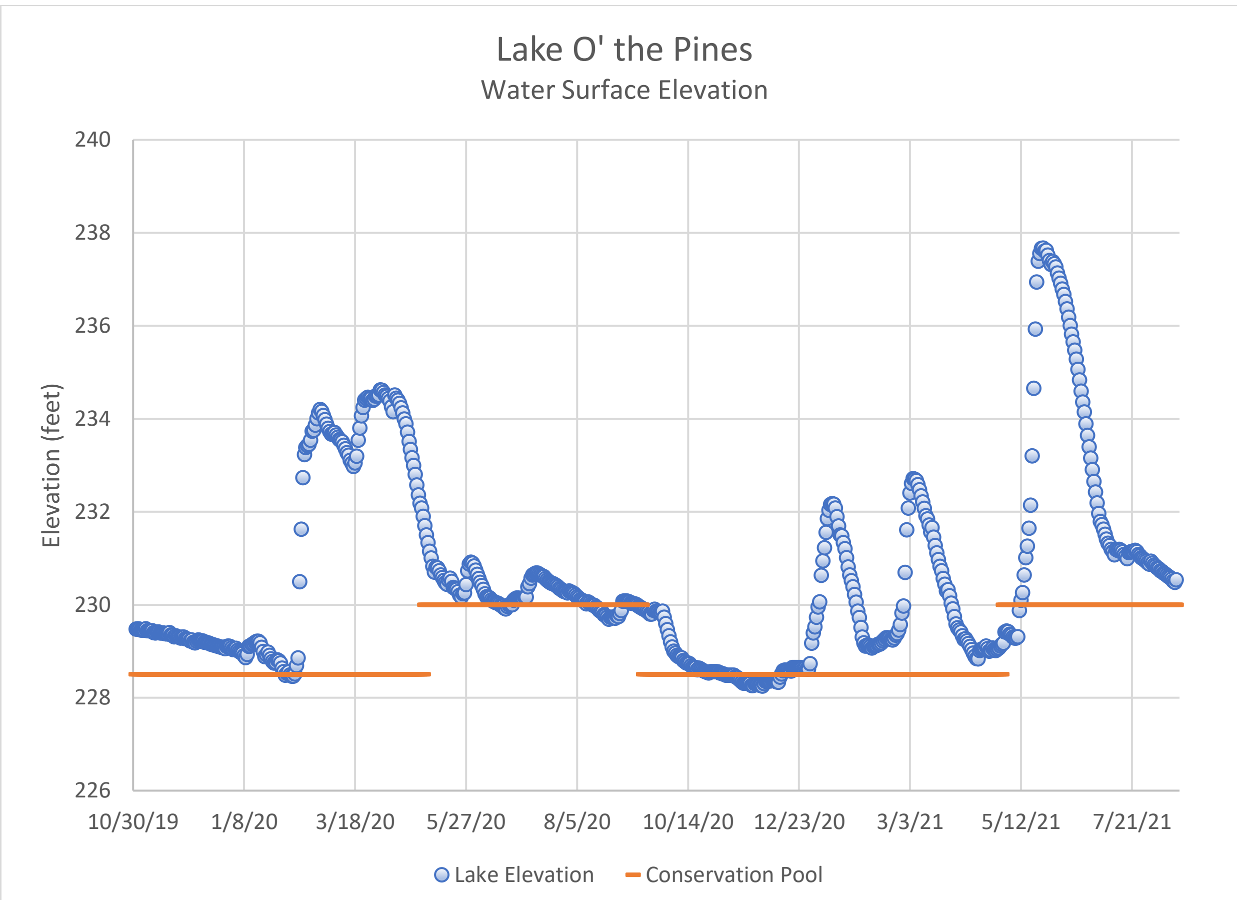

Figure 17: Lake O' the Pines Elevation

Since the instruments were mounted in a fixed position inside the deployment apparatus, the instrument depth ranged from around 0.5 to 3.5 meters with an overall average depth of over 1.5 meters at both stations. Moreover, the reservoir level increased dramatically in February 2020 and May 2021 due to flooding and releases from Lake Bob Sandlin. Lake O' the Pines remained well-above the conservation pool through April 2020 before dropping throughout the summer. Flooding in May 2021 caused the reservoir to rise eight feet over conservation pool and resulted in the closing of boat ramps and swim areas for several weeks. The reservoir remained above conservation pool level through August 2021.

A weather station, located near the dam, recorded precipitation, wind speed, and wind direction at fifteen-minute intervals. Approximately 13 inches of rain was measured at the station between June 1 and August 26, 2020 while over 22 inches fell in May and June 2021. Wind was generally calm throughout the study period with an average speed of 4.1 and 4.5 miles per hour in the summers of 2020 and 2021, respectively. Wind was generally in a southeasterly direction for both years. A wind speed of 10 miles per hour or higher was recorded in fewer than 3.5 percent of the measurements made at the weather station.

Both continuous water quality sondes were installed on November 20, 2019. Both sondes measured specific conductance, temperature, dissolved oxygen, pH, turbidity, chlorophyll, and blue-green algae and were programmed to internally record these parameters every fifteen minutes. Between November 20, 2019 and August 16, 2021, almost 650,000 data points at the US 259 station and over 576,000 readings at the NETMWD intake were recorded. Power failure and routine maintenance accounted for data loss.

The satellite transmitter at the NETMWD intake failed early on in the study. The transmitter could not be repaired so no data were transmitted to the website. As a result, no real-time data were available to the NETMWD water plant operators and stakeholders. In addition, the vendor changed hosting services, web address, and access credentials midway through the study. These issues limited the usability of the real-time data for the stakeholders.

The instruments were serviced and calibrated generally every six to eight weeks during the study period. Site visits were more frequent in the warmer/biologically productive months and less frequent in the cooler times of the year. The central wiping mechanism on the instruments proved to be effective at keeping the sensors free from biological fouling, and as a result, fouling did not appear to significantly impact the readings. Instruments from both stations passed post-deployment calibration tests during each service visit. High flows deposited sediments on the US 259 sonde which increased the amount of time needed to clean the instrument. Sedimentation was not an issue at the NETMWD intake.

The US 259 continuous water quality monitor recorded 58,944 pH readings between November 20, 2019 and August 16, 2021. The median pH during this time period was neutral at 6.8 s.u. The minimum pH was 6.0 s.u. and maximum was 9.1 s.u. Only 68 (0.11 percent) of the pH readings were reported above the 8.5 s.u. criterion. All high pH values were measured between June 15 and October 10, 2020. Sixty-five of those high pH values were recorded during three time periods: June 18 – 21, July 27 - 30, and October 8 – 10 (*Figure 18*). No high pH readings were recorded after October 10, 2020.

Figure 18: Water Quality Sonde After Eight-Week Deployment at NETMWD Intake

The highest pH values were obtained in the warm weather months of 2020 with a peak of 8.9 s.u., collected in both June and July. The pH range, or the difference between the maximum and minimum pH (6.5 s.u.), was also largest during these two months at 2.4 s.u. Recall that the pH scale is a logarithmic, base-ten scale meaning that each unit is ten times greater than the one below it. Considering the range of 2.4 s.u., the maximum value of 8.9 s.u. was approximately 400 times higher than the minimum pH of 6.5 s.u.

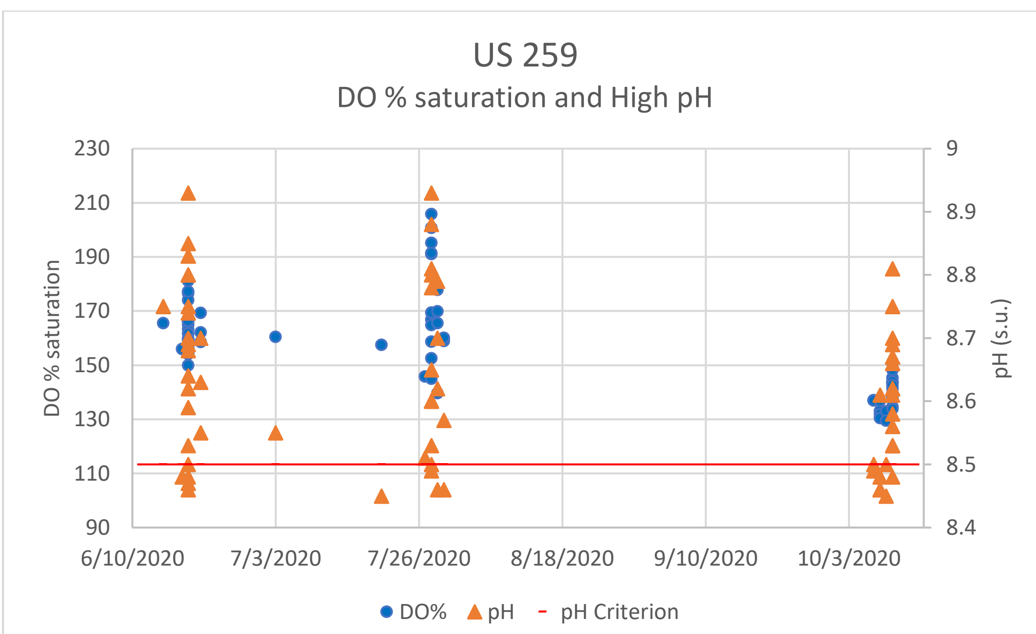

Figure 19: US 259: DO percent saturation and High pH

The mean chlorophyll concentration for the study period at the US 259 station was 7.2 µg/L, and the median was 5.5 µg/L. Less than five percent of all chlorophyll readings exceeded the 26.7 µg/L screening level. The maximum result of 79.6 µg/L was recorded on July 29, 2020. Chlorophyll values exceeding the screening level were primarily observed during the warm months with eighty percent of the high values collected in June through August 2020. Flooding in May 2021 likely affected the summer pH and chlorophyll results due to high flows and the inability to maintain the sonde depth near the surface of the water column.

The highest dissolved oxygen percent saturation and chlorophyll values were also obtained during these months. A strong correlation between pH and DO percent saturation was identified with a coefficient of 0.66. However, only weak correlations between DO percent saturation and chlorophyll, and pH and chlorophyll, were calculated. Both comparisons had a correlation coefficient of less than 0.4. A possible reason for the weak relationships is due to the station being located in a transition zone between riverine and lacustrine and confounded by the measurement depth ranging from 0.5 to 3.8 meters.

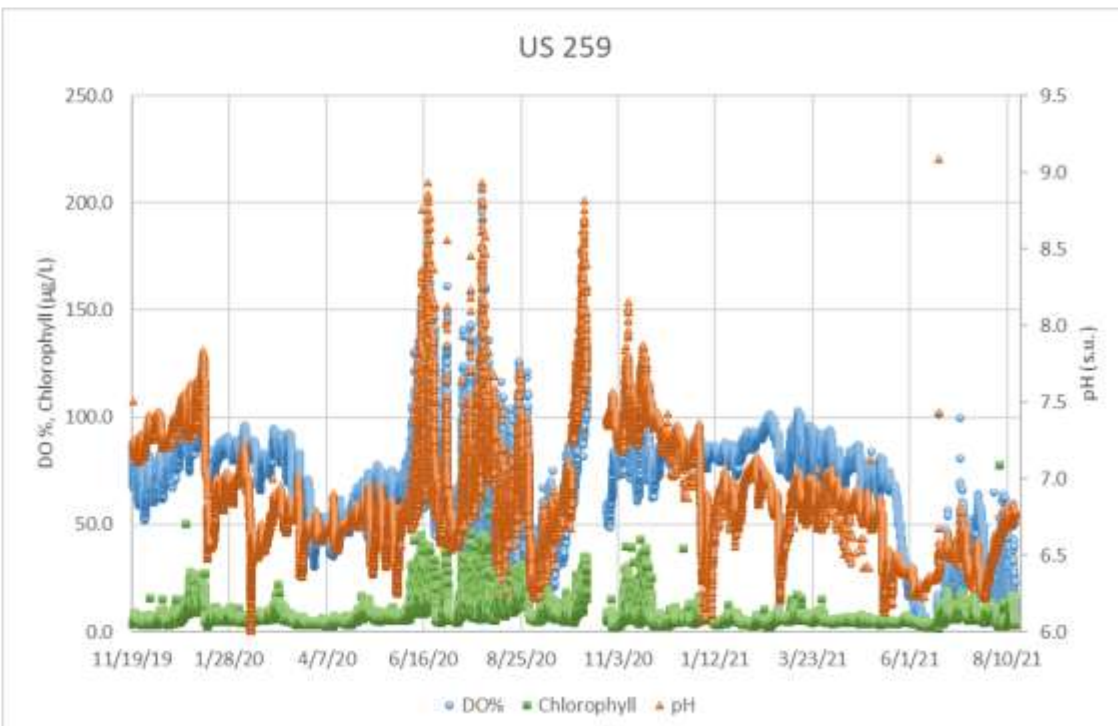

Figure 20: US 259: DO percent saturation, chlorophyll, and pH

The NETMWD intake continuous water quality monitor recorded 52,390 pH readings between November 20, 2019 and August 16, 2021. The mean and median pH of all readings during this time period was neutral at 7.2 s.u. Similar to the US 259 site, the minimum pH was 5.9 s.u. and maximum of 9.3 s.u. Exactly 1.22 percent of the readings were reported above the 8.5 s.u. criterion during this period.

While all high pH values at US 259 were obtained in the months of June through October, nearly 14 percent of the high pH results for the NETMWD intake were collected in November, December, and January. Similar to US 259, many of the high pH readings were clustered in groups of a few days (*Figure 21*).

The warm weather months had the highest pH values and the greatest range between minimum and maximum pH. The highest pH value obtained during the study period, 9.3 s.u., was collected in June 2020. The minimum pH that month was 6.3 s.u. for a range of 3.0 s.u. July 2020 had the greatest range at 3.1 s.u., meaning that the peak pH was 1,100 times higher than the minimum.

For all pH readings above the 8.5 s.u. criterion, a corresponding super-saturated dissolved oxygen value was reported. About sixteen percent of all DO values recorded in the study period were above 100 percent saturation. Super-saturated DO occurred throughout the year, but the highest DO percent saturation values reported at the NETMWD intake were obtained during the warm weather months of 2020. Nearly every reading reported at or above 125 percent saturation was obtained between May and August 2020 with a peak value of 166.4 DO percent saturation in June 2020.

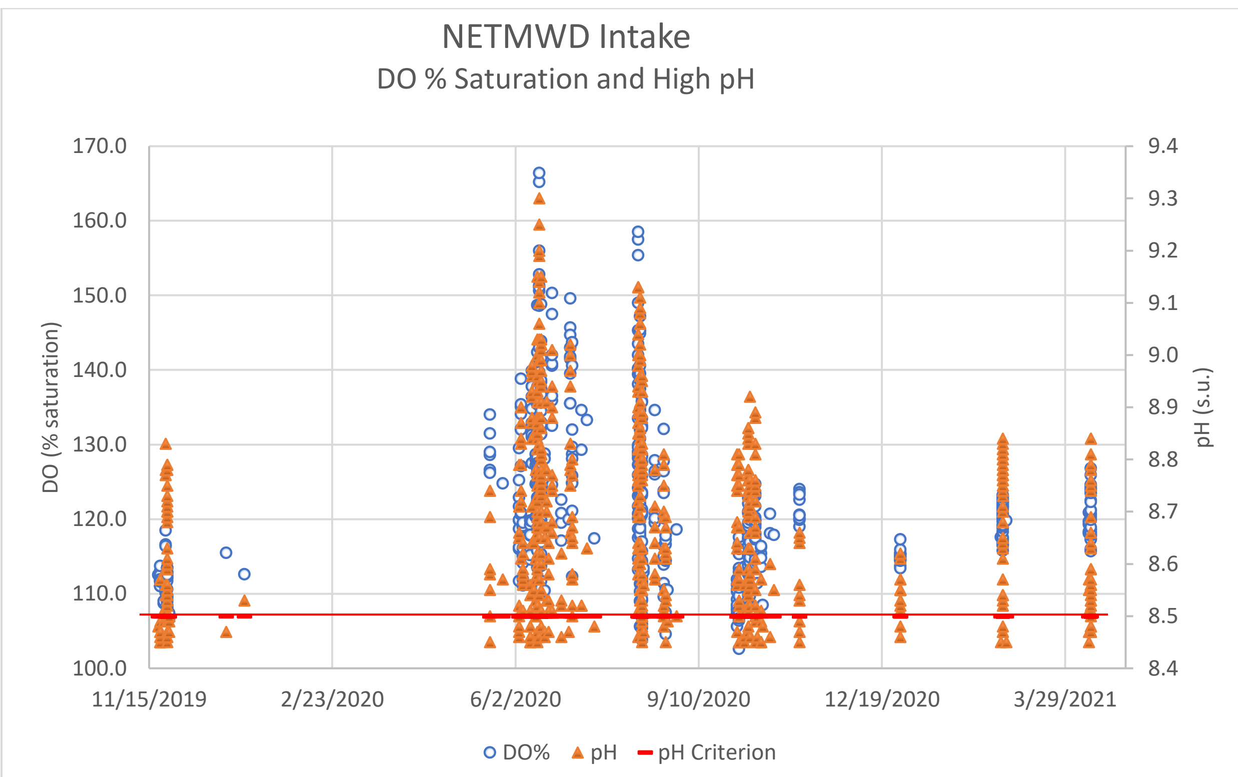

Figure 21: NETMWD Intake: DO percent saturation and High pH

The mean chlorophyll concentration of 18.4 µg/L at the NETMWD intake was below the 26.7 µg/L screening level. Almost 15 percent of the readings were measured at or above this screening level. Unlike the US 259 site, the winter and spring months had the highest chlorophyll concentrations. With the exception of February 2020, from December 2019 through March 2020, the monthly average for chlorophyll result was at or above the screening level. This was also the case in February 2021. Out of the 7,491 readings that were at or above 26.7 µg/L, almost 7,000 were obtained between the months of November 2019 and April 2020 and from December 2020 through April 2021. The highest reading of 83.4 µg/L occurred in March 2021, followed by several values reported above 60 µg/L in January 2020 and March 2021.

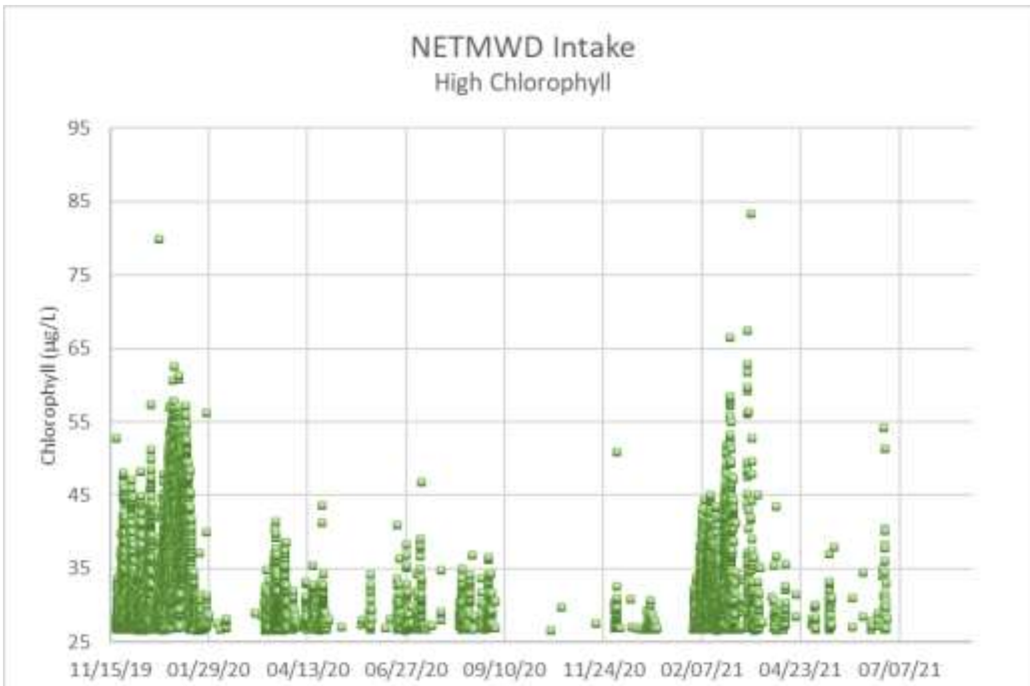

Figure 22: Chlorophyll readings reported over the screening level at the NETMWD Intake

Regression analyses performed on these data showed statically significant relationships between chlorophyll, pH, and dissolved oxygen. T-tests and the Analysis of Variance agreed with these findings. However, the relationships may be a due to using such a large number of observations from the continuous water quality sondes. Figure 23 shows the general agreement between these three parameters throughout the study period.

A statistically significant relationship between DO percent saturation and pH was discovered using all data obtained in the study period. DO percent saturation and pH strongly correlated with a coefficient of 0.79. A correlation between pH and chlorophyll was also identified with a coefficient of 0.5. DO percent saturation and chlorophyll were weakly correlated at 0.38.

For the months of January through April 2020, pH had a statistically significant correlation with chlorophyll at 0.71 while DO percent saturation correlated with chlorophyll with a coefficient of 0.55. These parameters also correlated in August 2020 at 0.52 and 0.62, respectively. In 2021, pH and chlorophyll strongly correlated in January at 0.84 while DO and chlorophyll correlated at 0.78. Similar relationships were identified in May with pH and chlorophyll (0.66) and DO and chlorophyll (0.74). These relationships may have been even higher had the sonde been fixed in the mixed surface layer.

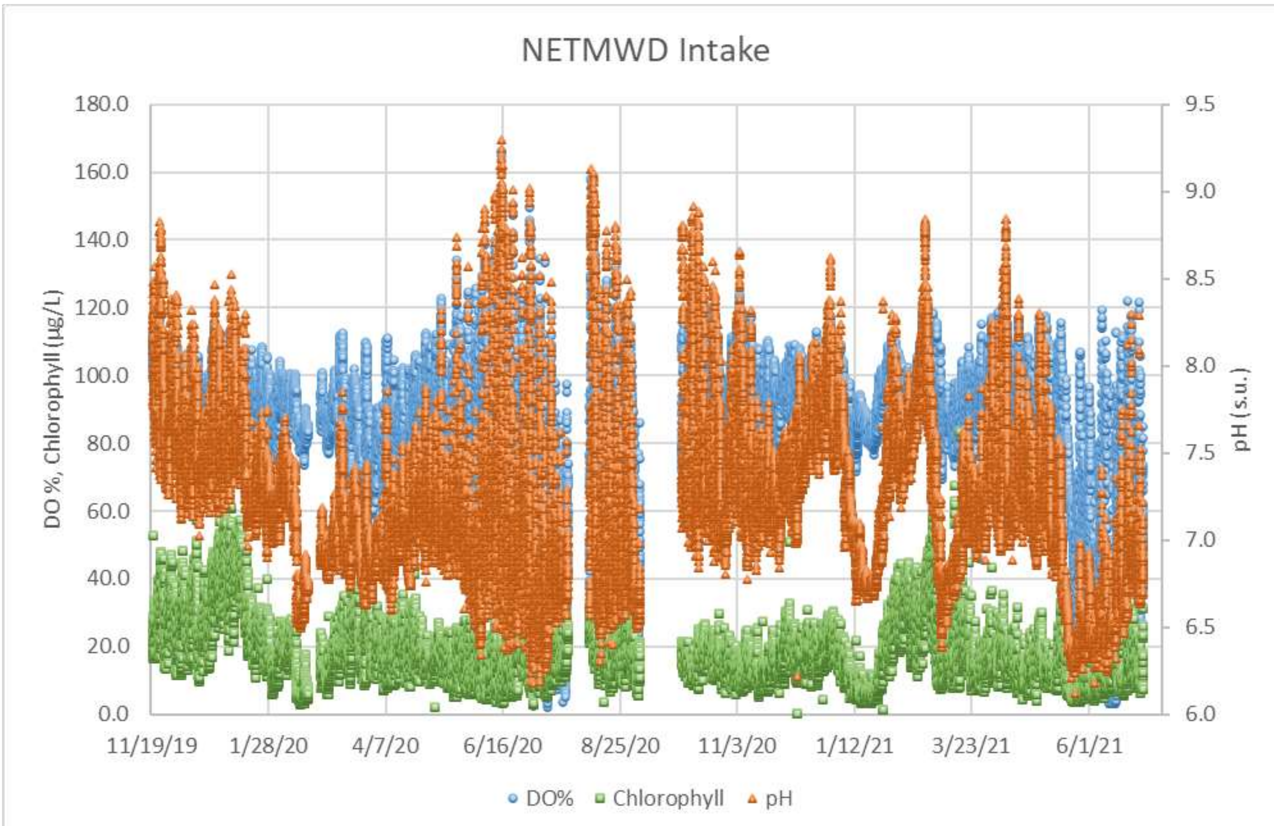

Figure 23: NETMWD Intake: DO percent saturation, pH, and Chlorophyll

DIEL SPECIAL STUDY

For the Diel Special Study, water quality sondes were calibrated and programmed to record data at fifteen-minute intervals and were deployed in the upper half-meter of the water column for a minimum of 24 hours at the City of Longview Intake (station 22172) and at the Dam station (22173). Sondes were deployed four times in 2020 and six times in 2021. All but the August 25, 2020 deployment recorded data for 46 to 49 hours. The August 25, 2020 study was suspended after twenty-four hours because of forecasted high winds and inclement weather from the remnants of Hurricane Laura.

Due to heavy rainfall in May 2020, the diel studies scheduled for that month were postponed until June. The sondes were deployed in June, July, and in early and late August. For 2021, sondes were deployed in early May, early and late June, early and late July, and mid-August. Heavy rainfall in May 2021 caused the lake level to rise over eight feet resulting in park and boat ramp closures.

Figure 24: Boat lane marker near station 22172: City of Longview Intake on May 5, 2021 and June 9, 2021

There were no results reported for the dam station in late June 2020 and early July 2021 due to the deployment apparatus becoming dislodged from its mooring. Divers were able to find and recover the instrument in August of both years. Since both instruments failed the post-deployment checks, the data were not valid for analysis or reporting.

Over 1,800 pH readings were recorded from the ten deployments at the Longview intake, while 1,450 pH values were reported from the eight diel studies at the Dam station. In general, pH results were similar at both the City of Longview intake and at the Dam stations. While pH tended to be much lower at the NETWMWD intake during the diel studies, there was a general agreement in the ranges of the daily pH cycles (*Figure 25*). Overall, approximately one-third of all diel pH readings were reported above the 8.5 s.u. criterion. There were no high pH results reported at either station from the August 25, 2020 study while about five percent were elevated during the June 21, 2021 study. The highest pH measurements were obtained during the June 2020 and the July 2021 deployments while the lowest were measured in August 2020 and June 2021.

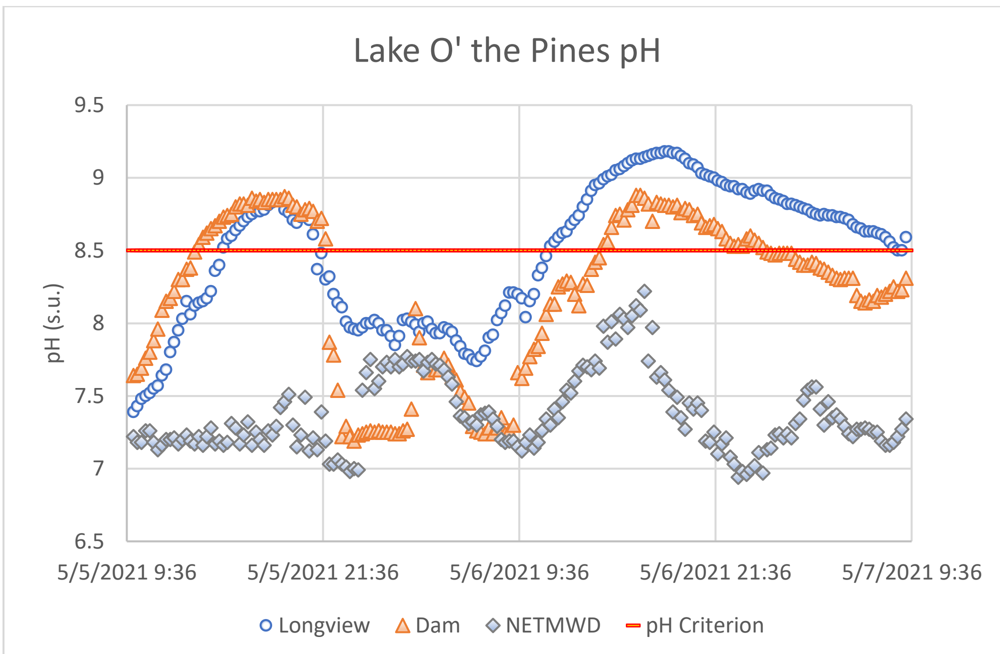

Figure 25: Lake O' the Pines pH, May 2021

For the Longview intake station, the maximum pH of 9.4 s.u. was obtained from both July 2021 deployments while the minimum of 6.7 s.u. was collected during the August 2020 diel. Similarly, the maximum pH at the Dam station was 9.5 s.u. in July 2021, and the minimum of 6.9 s.u. was obtained during both August 2020 and June 2021 studies.

The July 26, 2021 deployments had the greatest number of high pH measurements, highest median pH, and highest maximum values at both stations. Out of 193 observations over 94 percent of the readings exceeded the 8.5 s.u. criterion at the Longview station while 84.5 percent of the pH values exceeded the criterion at the Dam station (*Figure 26*). For the Longview intake, the median pH was 9.1 s.u. and maximum was 9.4 s.u. while the median and maximum pH at the Dam station were 9.0 s.u. and 9.5 s.u., respectively (*Figure 27*).

High pH	Longview	Dam
01-Jun-20	40.9%	61.7%
29-Jun-20	0.5%	-
05-Aug-20	10.4%	3.1%
25-Aug-20	0.0%	0.0%
05-May-21	41.5%	39.0%
09-Jun-21	0.5%	21.6%
21-Jun-21	5.1%	5.0%
06-Jul-21	69.8%	-
26-Jul-21	**94.4%**	**84.5%**
16-Aug-21	93.0%	33.2%

Figure 26: Percent of Samples with High pH

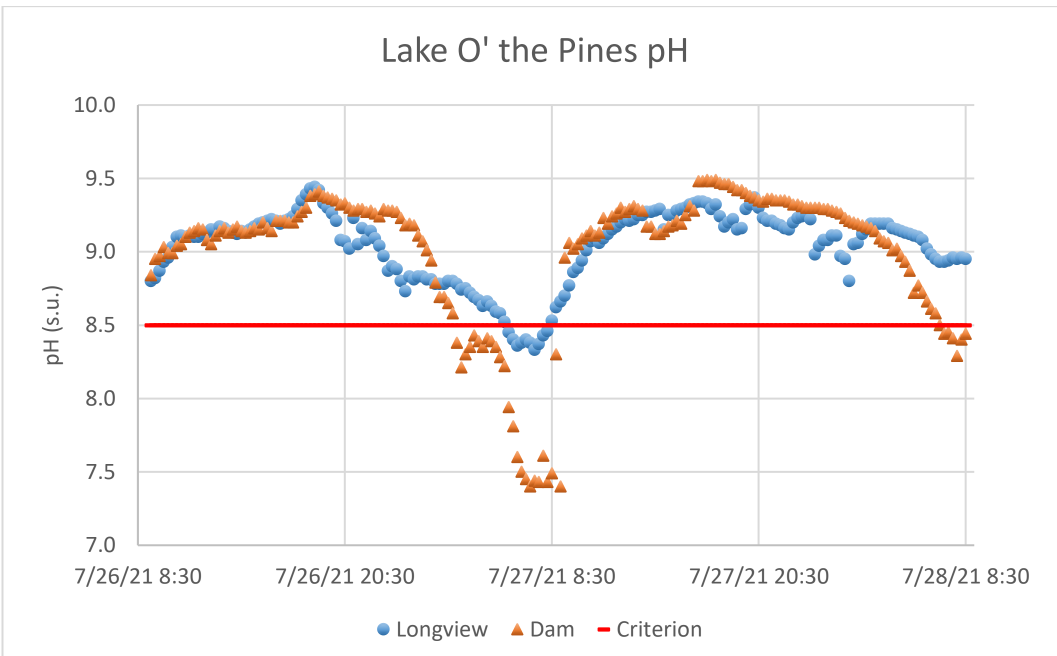

Figure 27: Diel pH Results, July 2021

The August 2021 deployments had the greatest range, or difference between the maximum and minimum pH (*Figure 28*). The greatest range occurred at the Longview intake during the August 5, 2020 and August 16, 2021 diel studies at 2.1 s.u. The pH range was 2.4 s.u. for the August 16, 2021 diel at the Dam. Due to a power failure, there were no pH data for the NETMWD intake during the July or August 2021 diels.

pH Range	Longview	Dam	NETMWD
01-Jun-20	1.6	1.4	1.2
29-Jun-20	1.0	-	1.7
05-Aug-20	**2.1**	1.7	0.7
25-Aug-20	0.7	0.7	1.8
05-May-21	1.9	1.7	1.3
09-Jun-21	1.6	1.7	1.1
21-Jun-21	1.9	1.7	1.3
06-Jul-21	1.9	-	-
26-Jul-21	1.1	2.1	-
16-Aug-21	**2.1**	**2.4**	-
Mean	1.6	1.7	1.3

Figure 28: Diel pH Range

Similar to the historical grab sampling data from Lake O' the Pines, all of the pH values recorded above the criterion were obtained when dissolved oxygen was super-saturated. Dissolved oxygen percent saturation, on average, exhibited an extensive range between minimum and maximum values obtained during each of the diel events (*Figure 29*). For the Longview station, DO saturation had an average range of 51.9 percent while the Dam station ranged 65.0 percent. The smallest range was 21.7 percent at the Longview intake during the June 29, 2020 study while the greatest range was 125.8 percent in August 2021 at the Dam station. These ranges in DO percent follow a similar trend with the pH ranges.

DO % Range	Longview	Dam
01-Jun-20	36.9	46.5
29-Jun-20	21.7	-
05-Aug-20	**92.6**	67.7
25-Aug-20	44.2	57.1
05-May-21	35.6	37.7
09-Jun-21	30.6	50.2
21-Jun-21	64.6	54.0
06-Jul-21	56.2	-
26-Jul-21	53.6	80.7
16-Aug-21	83.2	**125.8**

Figure 29: Diel DO Percent Saturation Range

Sixty percent of all DO readings collected from both stations during the diel studies were reported over 100 percent saturation (*Figure 30*). All of the July 26, 2021 samples at the Longview intake were above saturation with a maximum of 161.0 percent, minimum of 107.4

percent, and mean of 133.2 percent. Similarly, 94 percent of the DO readings at the Dam on these dates were reported above saturation with maximum of 163.3 percent and mean of 132.5 percent.

DO %	Longview	Dam
01-Jun-20	71.5%	86.1%
29-Jun-20	19.2%	-
05-Aug-20	18.2%	14.0%
25-Aug-20	0.0%	0.0%
05-May-21	96.9%	79.8%
09-Jun-21	96.3%	86.3%
21-Jun-21	22.7%	47.5%
06-Jul-21	78.1%	-
26-Jul-21	**100.0%**	**93.8%**
16-Aug-21	54.6%	44.9%

Figure 30: Percent of DO Readings Reported Above Saturation

As found with the continuous monitors, pH and DO percent saturation were well-correlated. All of the high pH values at the Longview and Dam stations occurred while DO was super-saturated (*Figures 31 and 33*).

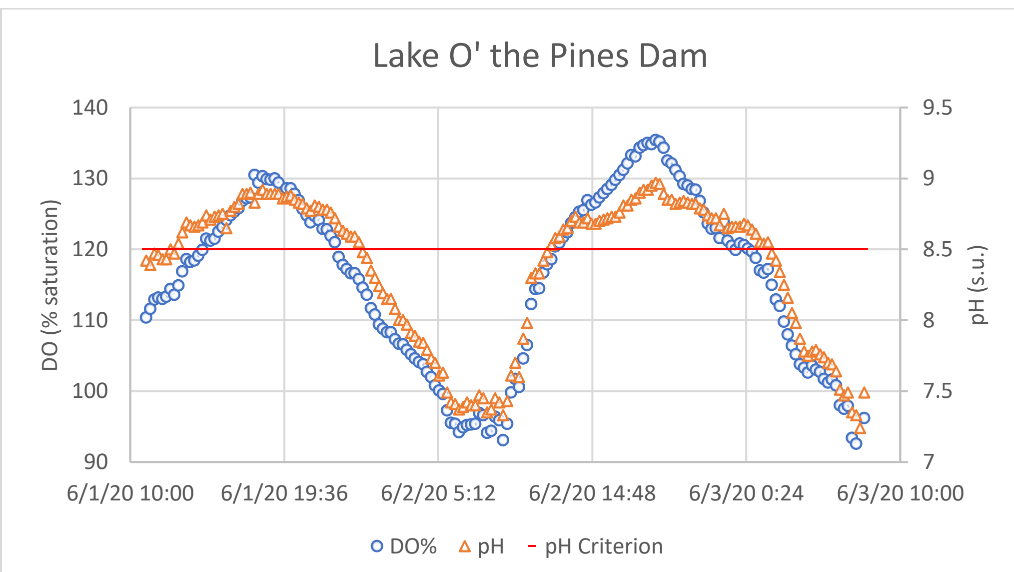

Figure 31: Lake O' the Pines Dam Station: DO percent saturation and pH

Figure 32: Station 22173: Lake O' the Pines Swimming Area near Dam on June 9, 2021 and August 16, 2021

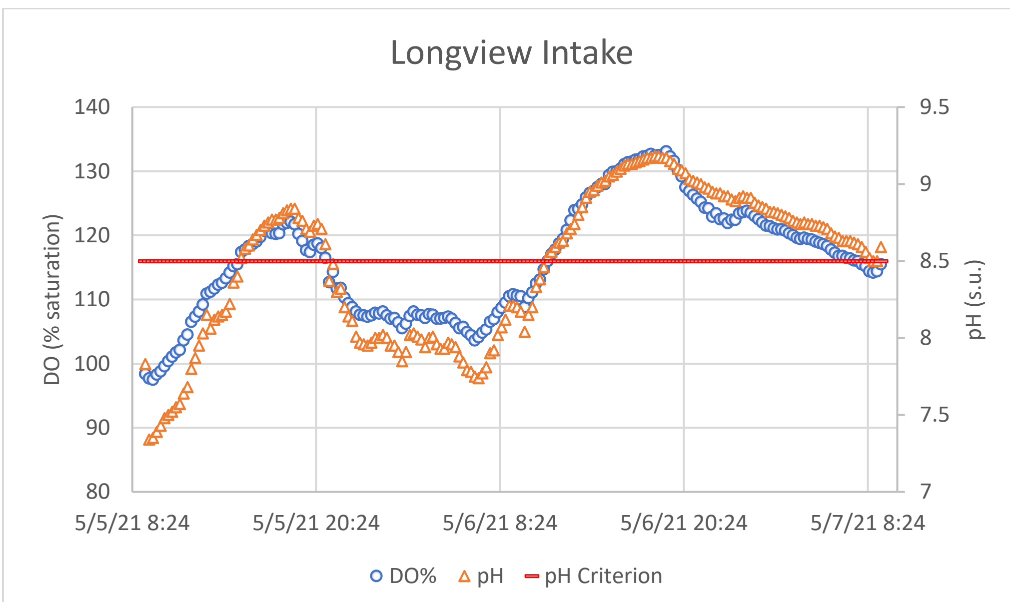

Figure 33: Lake O' the Pines: Longview Intake DO percent saturation and pH

Correlation analysis revealed that dissolved oxygen and pH strongly correlated at both diel stations and with the NETMWD intake continuous monitor *(Figure 34)*. Recall that a perfect correlation is 1.0 and anything greater than 0.6 is considered a significant correlation. All correlation coefficients ranged from 0.85 to 0.99 indicating that pH and dissolved oxygen were strongly related throughout the study period.

The correlation coefficients between DO percent saturation and pH for the diel studies at the City of Longview intake had a mean correlation of 0.96 and ranged from 0.90 to 0.98. The mean correlation at the Dam was 0.95 with a minimum of 0.92 and maximum of 0.99 while the NETMWD station had a correlation of 0.93 and ranged from 0.85 to 0.97. These results suggest that pH and DO percent saturation were very closely related.

DO% - pH Correlation	Longview	Dam	NETMWD
01-Jun-20	0.97	0.97	0.96
29-Jun-20	0.97	-	0.94
05-Aug-20	0.95	0.92	**0.97**
25-Aug-20	0.97	0.97	0.93
05-May-21	**0.98**	**0.99**	0.93
09-Jun-21	0.95	0.96	0.91
21-Jun-21	0.90	0.93	0.85
06-Jul-21	0.96	-	-
26-Jul-21	0.94	0.92	-
16-Aug-21	**0.98**	0.96	-

Figure 34: Correlation coefficients between DO percent saturation and pH

The TCEQ Region 5 office was scheduled to sample Lake O' the Pines on a quarterly basis in each of the four assessment units in FY 2020 and 2021. Data were reported to SWQMIS for eight events in each of the assessment units except for AU 0403_03. There were only five samples reported and no data were available for quarters 1 through 3 of FY 2020. On June 15, 2021, the surface pH reading exceeded the criterion in all assessment units. The maximum value was 9.1 s.u. in assessment units 0403_02 and 0403_03. The pH was 8.8 s.u. in AU 0403_01 and 8.9 s.u. in AU 0403_04. All other pH measurements were below the criterion, except for a measurement of 8.7 s.u. reported in AU 0403_02 on September 25, 2019. In all cases of elevated pH, dissolved oxygen was reported over 130 percent saturation.

Chlorophyll results exceeded the screening level in over half of all samples collected by TCEQ in the reservoir. Chlorophyll was reported above the screening level in all assessment units on September 24, 2020 with a peak value of 62.3 µg/L in AU 0403_04. The mean chlorophyll concentration for all samples collected in FY 2020 and 2021 was 37.3 µg/L. The mean value for each assessment unit was about 36 µg/L, except in AU 0403_03 which had a mean of 40.6 µg/L.

TCEQ samples collected in AU 0403_03 and AU 0403_04 were compared with the values recorded by the continuous water quality monitors around the time of sampling. Unsurprisingly, the greatest variation between the TCEQ data and the continuous monitors were between station 17087 (AU 0403_04) and the US 259 bridge monitor (AU 0404_01). While pH values had less than five percent difference, dissolved oxygen was reported almost nineteen percent higher by the TCEQ. Laboratory analysis of chlorophyll revealed that the continuous monitor was underreporting chlorophyll by over fifty percent. These results indicate that the continuous monitoring data was not representative of the upper assessment unit of the reservoir. The disparity in the results was likely due to the depth of the continuous monitoring sonde and it being located in a transitional zone of the reservoir rather than a lacustrine station.

There was a much better agreement between the NETMWD intake continuous monitor and the TCEQ results at station 10296 (AU 0403_03). On average, dissolved oxygen values were within ten percent of one another while pH readings were within 0.2 s.u. Laboratory chlorophyll results averaged 12.5 µg/L higher than those reported by the continuous monitor. The variation in chlorophyll data are possibly due to not being able to maintain the sonde depth. These results suggest that the NETMWD intake monitor provided a good comparison data set for the assessment unit.

Only two diel events in each assessment unit could be compared with TCEQ data. Samples collected on June 11, 2020 and June 15, 2021 were compared with the diel results from June 1, 2020 and June 26, 2021. Despite being collected several days apart, the diel data had relatively good agreement with the TCEQ grab data. A difference of about 1 mg/L dissolved oxygen and 0.3 s.u. pH was discovered upon comparing diel data at the Longview intake with station 16156 (AU 0403_02). The results obtained at the Dam location and station 10296 (AU 0403_01) had much better agreement with a difference of 0.1 mg/L DO and 0.15 s.u. pH.

CONCLUSIONS

The biggest challenge faced in the continuous water quality monitoring special study was the changing depth of the reservoir causing the sonde to not be maintained at a specific depth below the surface. This issue impacted the results of the study. Overall, routine maintenance and calibration data showed that the wiper mechanism was effective at keeping the sensor faces free of biological growth. Post deployment checks revealed that the instrument readings were reliable and had little drift. High flows deposited sediments on the US 259 sonde which increased the amount of time needed to clean the instrument. Sedimentation was not an issue at the NETMWD intake.

Due to the failure of the satellite transmitter at the NETMWD intake early on in the study, data could not be transmitted to the website. As a result, no real-time data were available to the NETMWD water plant operators and stakeholders. In addition, the vendor changed hosting services, web address, and access credentials midway through the study. These issues limited the usability of the real-time data for the stakeholders.

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 while the NETMWD intake was above the criterion in 1.22 percent of the readings.

The vast majority of 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.

For the Diel Special Study, high pH was most commonly obtained at the City of Longview intake, 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 during the August 25, 2020 deployment.

The greatest diel pH range for both the City of Longview intake and Dam stations occurred during the August 21, 2021 study. The Longview intake range was 2.1 s.u. while the Dam station was 2.4 s.u. The August 5, 2020 deployment at the City of Longview intake also had a range of 2.1 s.u., while the Dam station had a range of 2.1 s.u. during the July 26, 2021 study.

The results from these studies indicate that there is a close relationship between DO percent saturation and pH throughout the reservoir. Most high pH results were collected at a super-saturated dissolved oxygen saturation. 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.

Excessive algal growth is likely a significant cause of the elevated pH in Lake O' the Pines. Chlorophyll was relatively high at the NETWMWD intake continuous monitoring station and exceeded the 26.7 µg/L screening level in fifteen percent of the readings. One of the notable findings from this station was that chlorophyll exceeded the screening level most often during the winter months and also had strong correlations with both DO percent saturation and pH during this season.

Regression analyses showed statically significant relationships between chlorophyll, pH, and dissolved oxygen. The Analysis of Variance and T-tests also revealed that the relationships between these parameters were statistically significant. However, these relationships may be due to using such a large number of observations from the continuous monitoring stations.

The data collected by the TCEQ Region 5 office in FY 2020 and 2021 corroborated these findings. Although pH exceeded the criteria twice in AU 0403_02 and only once in the other assessment units, these values were reported in the warm weather months along with super-saturated dissolved oxygen readings. The results of chlorophyll analysis showed that the concentration exceeded the screening level in over half of the samples.

With the exception of the US 259 continuous monitor, the TCEQ data had relatively good agreement with the NETMWD intake continuous monitor and with the diel stations. On average, the NETMWD intake and AU 0403_03 results were comparable. Despite being collected a few days prior to the diel events, the DO and pH values reported by the TCEQ in June 2020 and 2021 were quite similar to those obtained at the Longview intake and Dam stations.

The results of these special studies indicate 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 dissolved oxygen was super-saturated; the high pH readings primarily occurred during warm weather months; and pH correlated closely with dissolved oxygen saturation. These conditions will likely continue into the future due to nutrient enrichment in the contributing watershed to the reservoir. However, the Total

Phosphorus Load Allocation has tremendously reduced the amount of phosphorus entering the watershed since its implementation in 2015. A similar study of Lake O' the Pines should be performed in the future to evaluate whether the TPLA has resulted in decreased primary productivity in the reservoir.

Figure 35: City of Longview Intake

TANKERSLEY CREEK AQUATIC LIFE MONITORING

Aquatic Life Monitoring (ALM) was performed at station 10261: Tankersley Creek at Farm to Market Road (FM) 3417, located south of Mount Pleasant, in the index and critical periods of 2020 and 2021. The station is approximately 5 km downstream of the Pilgrim's Pride WWTP. ALM consists of collecting fish using electrofishing and seining techniques, collecting benthic macroinvertebrates using dip, sweep, and kick-net techniques, measuring habitat conditions at five to six transects over the reach length, and performing stream flow and diel water quality measurements. Organisms are identified, enumerated, and evaluated using species diversity, functional feeding groups, biotic index, as well as other scoring metrics. Unless requiring a microscope for identification, all fish were returned to the stream after enumeration and voucher photos were taken. Similarly, an assessment of the habitat is performed using the results of the field measurements.

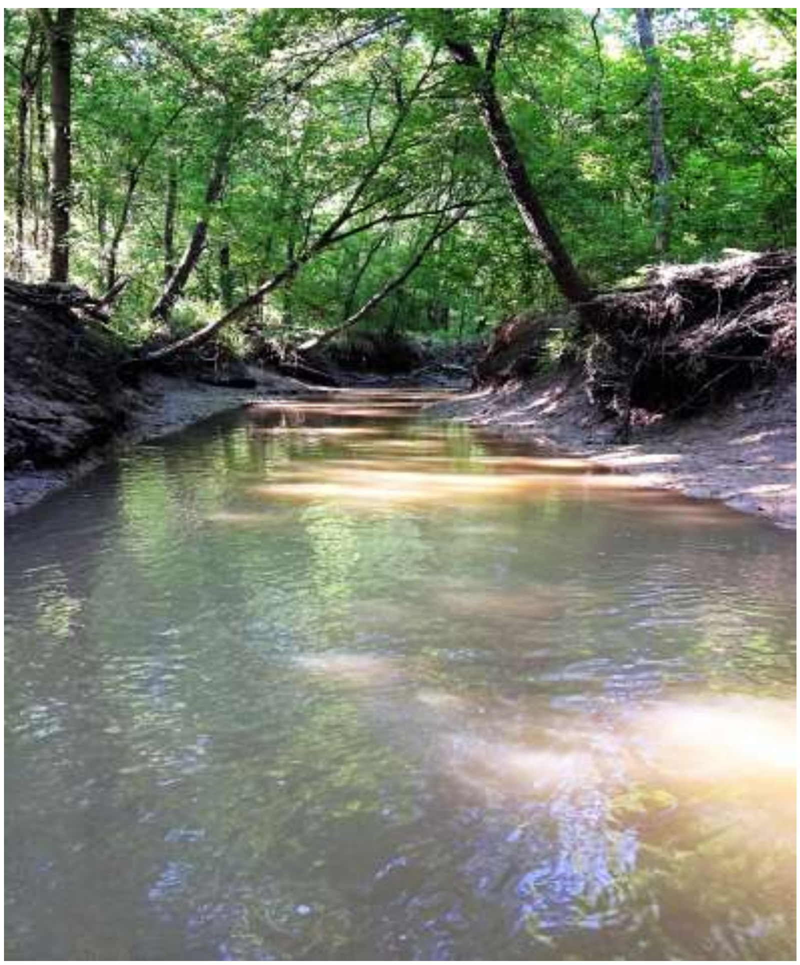

Figure 36: Station 10261 Tankersley Creek at FM 3417

Biological monitoring revealed that the fish populations in Tankersley Creek were diverse and abundant. A total of 920 individuals representing twenty-four taxa were collected across the four sampling events. On average, 230 individuals across sixteen taxa were collected during each event. Two relatively uncommon taxa were collected during the August 2020 ALM: spotted sucker (*Minytrema melanops*), and harlequin darter (*Etheostoma histrio*). Only nine other harlequin darters have been collected in the Cypress Creek Basin according to a review of the TCEQ database. Spotted suckers were more commonly collected; however, only two other individuals had been reported in Tankersley Creek.

Figure 37: Spotted sucker (Minytrema melanops) top; Harlequin darter (Etheostoma histrio) bottom

Station 10261	Habitat	Benthos	Fish
6/10/2020	17	26	45
8/21/2020	18	21	49
6/17/2021	19.5	26	55
7/23/2021	18.5	27	51
Mean	18.3	25	50
ALM Score	**Intermediate**	**Intermediate**	**High**

Figure 38: ALM scores for Tankersley Creek

The results of the scoring metrics for Tankersley Creek showed that the fish populations were in the High category, while both the benthos and habitat fell into the Intermediate classification. Note that the fish metrics are based upon regionalized scoring metrics while the benthos and habitat assessment used state-wide metrics. The state-wide metrics tend to have bias against streams commonly encountered in East Texas.

Other fish species of interest are the red shiner (*Cyprinella lutrensis*), bullhead minnow (*Pimephales vigilax*), and blacktail shiner (*Cyprinella venusta*). These species have been documented as host fish for the glochidia of the potentially Threatened and Endangered Louisiana pigtoe mussel (*Pleurobema riddellii*). A discussion of the research being performed on potentially Threatened and Endangered species in the Cypress Creek Basin is found in the Species of Concern section of this report.

Figure 39: Bullhead minnow, Pimephales vigilax (top) and Blacktail shiner, Cyprinella venusta (bottom)

The presence and abundance of these fish species can be used to prioritize areas for future *P. riddellii* sampling efforts, thereby, using monitoring funds more cost-effectively. For stations where the host fish were not collected or not abundant, then *P. ridellii* is less likely to be found in that watershed. Whereas a stream with a high abundance of these species, the watershed has a key component necessary for reproduction of the mussel. In this ALM study of Tankersley Creek, blacktail shiners and bullhead minnows were collected during all four ALM events with a total of 505 individuals from these species. Since the host fish species for *P. riddellii* were present in relative abundance in Tankersley Creek, this stream may support the Louisiana pigtoe and should be considered for future mussels sampling.

A review of the TCEQ database showed that these host species have been collected in several streams within the Cypress Creek Basin, although mostly in low abundance. However, this sampling effort in Tankersley Creek suggests that the current fishing protocols and latest electrofishing technologies may yield better sampling efficiencies than those of previous decades. Four sampling events were conducted at station 10261 in 1997, 1998, and 2003. A combined total of 18 individuals from the host species were collected. The June 2021 effort alone yielded two host species with a total of 209 individuals (*C. venustra*, 161; *P. vigilax*, 48). These results suggest that stations last sampled in the late 1990’s and early 2000’s should be sampled to provide a better representation of the overall health of the biotic community within the Cypress Creek Basin.

The TPWD River Studies is currently studying the lower portions of Big Cypress Creek, Little Cypress Creek, and Black Cypress Creek. A review of data available at the Mussels of Texas website revealed that there were no mussels data for Frazier Creek, no mussels data in Big Cypress Creek between SH 11 and Sand Crossing (near the headwaters of Lake O’ the Pines), and a single collection from Hart Creek in 2000. Due to the lack of data in the upper portion of the watershed along with TPWD’s work in the lower portion, focused field efforts in the upper reaches and tributaries of Big Cypress Creek are of great value to the NETMWD for the prioritization of areas for future mussels surveys.

The NETMWD identified six priority watersheds that are suspected to support *P. riddellii*. Five of these streams are located in Segment 0404 and are tributaries to Big Cypress Creek. The most recent biological data from these streams were obtained in 2003. In September 2021, the TCEQ CRP awarded the NETMWD with funding to support ALM studies in each of these watersheds. Sampling will be conducted in the index and critical periods of 2022 and 2023 in these priority streams:

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

Figure 40: Aquatic Life Monitoring watersheds in FY 2022 - 2023

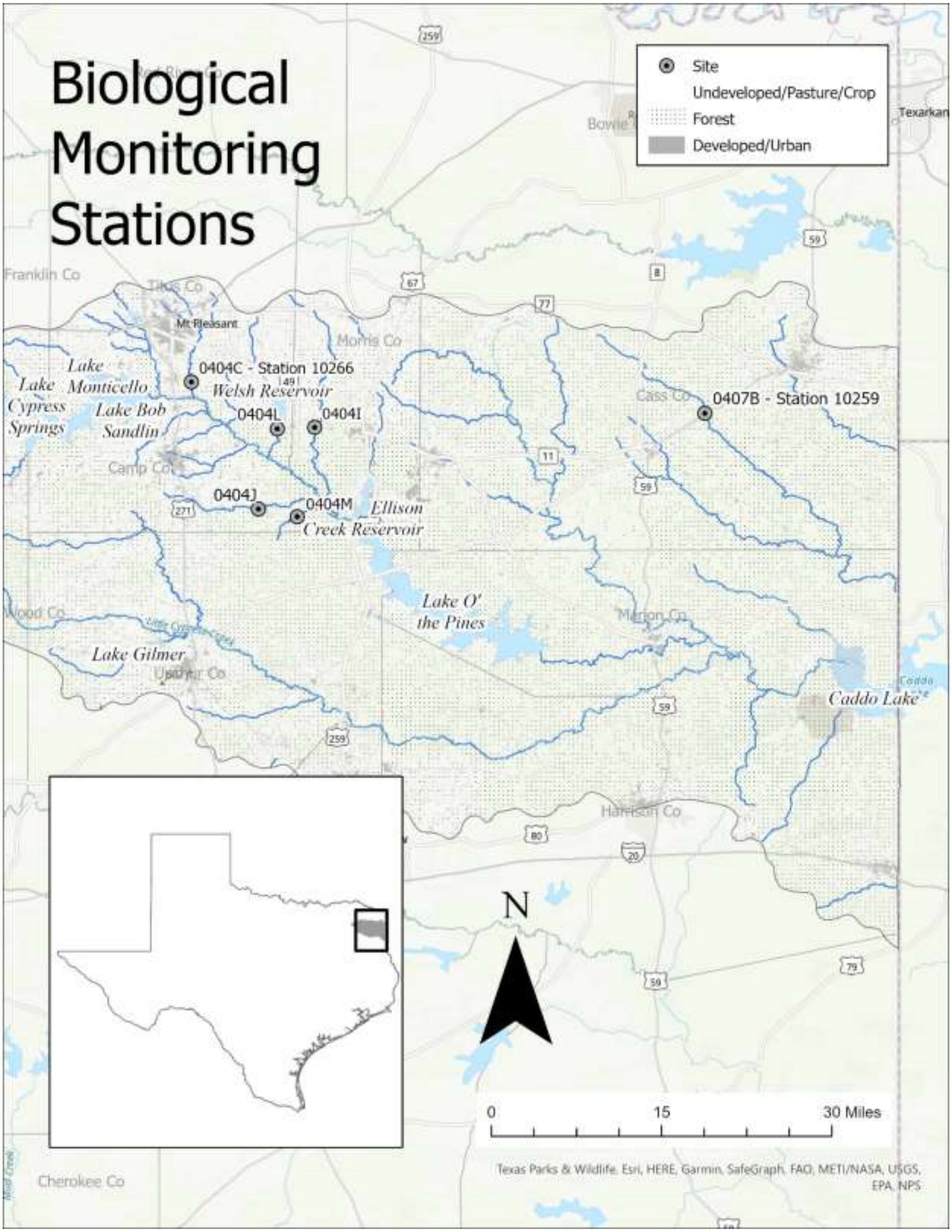

Figure 41: Map of 2022 - 2023 Biological Monitoring Stations

SPECIES OF CONCERN

- **Louisiana Pigtoe**
- **Alligator Snapping Turtle**
- **Western Chicken Turtle**
- **Kisatchie Painted Crawfish**

LOUISIANA PIGTOE

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 recently documented.

The decline of freshwater mussel populations has become an important focus 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 in the ongoing U.S. Fish and Wildlife (USFWS) Species Status Assessment, 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.

The USFWS has recently 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 is difficult as there is a limited amount of sampling data available in the literature in this area of the state.

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 larvae (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.), 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 Red Shiner (*Cyprinella lutrensis*), Bullhead Minnow (*Pimephales vigilax*), and Blacktail Shiner (*Cyprinella venustra*) 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 in order to use mussels sampling funds efficiently.

A review of the TCEQ database showed that these potential fish host species have been collected in several streams within the Cypress Creek Basin, although in very low abundance. However, as discussed in the previous section, the sampling effort in Tankersley Creek indicated that the present techniques and electrofishing technology may yield better sampling efficiencies than that of past decades. The Tankersley Creek results indicate that the fish host species for the Louisiana pigtoe are in relative abundance at this station.

Figure 42: Louisiana pigtoe (Pleurobema riddellii) photo by US Fish & Wildlife Service

More information about state-threatened freshwater mussels and ongoing studies for species of concern is available at the Texas Comptroller of Public Accounts Natural Resources website.

NORTHEAST TEXAS AQUATIC TURTLE SURVEYS

By Mandi Gordon, Environmental Institute of Houston at the University of Houston – Clear Lake

East Texas is home to numerous aquatic turtle species, including some currently under review for inclusion on the Endangered Species Act (ESA). Specifically, the Western Chicken Turtle (*Deirochelys reticularia miaria*) has been petitioned for listing with a significant 90-day finding. The Species Status Assessment (SSA) is due for public review in 2024. Currently, the western chicken turtle is endangered in Missouri and is a species of greatest conservation need in Louisiana and Oklahoma but holds no protection in Texas. Conversely, in late 2021, a SSA for the Alligator Snapping Turtle (*Macrochelys temminckii*) was released by the U.S. Fish and Wildlife Service with a final recommendation to list the species as "Threatened" under the ESA due to lack of information. The Alligator Snapping Turtle is currently recognized as a threatened species in Texas and is protected in multiple states.

The Environmental Institute of Houston at the University of Houston–Clear Lake (EIH-UHCL) is currently developing partnerships with private landowners and stakeholders in East Texas to conduct surveys for the Western Chicken Turtle and Alligator Snapping Turtle throughout their historic range. These surveys are funded by the Texas Comptroller of Public Accounts Natural Resources Program and are aimed at providing the U.S. Fish and Wildlife Service with the most current and relevant data necessary for pending SSA and ESA listing decisions.

Western Chicken Turtles are ephemeral wetland habitat dwellers associated with watersheds throughout east Texas. This cryptic species exhibits a seasonal activity pattern, with most activity occurring in the spring and early summer months. Due to their cryptic nature and narrow window of opportunity for observation, surveys for the Western Chicken Turtle are aimed at testing a suite of traditional and novel sampling techniques for detection of the species. These include trapping surveys, visual surveys, environmental DNA (eDNA) sampling, small unmanned aerial systems (sUAS) surveys, and canid scent surveys using trained detector dogs. In the first two years of our ongoing study (2020 and 2021), EIH-UHCL has sampled 54 sites throughout east Texas from March through July. Multiple sites have yielded positive detections of Western Chicken turtles via eDNA, canid scent surveys, and visual surveys. The project will be expanding sampling efforts in northeast Texas, including areas within the northeast Texas river basins in 2022. If you or someone you know are aware of Western Chicken Turtles present on your (or their) property, EIH-UHCL would love to hear about it! Additionally, we have developed an Online Reporting Tool for compilation of reports from citizen scientists. The reporting tool will be active until early 2023 and can be accessed via the following link: https://arcg.is/11yWyn. If you have observed a Western Chicken Turtle, please report your sighting via this tool today!

Alligator Snapping Turtles are the largest freshwater turtle in North America, with some records of individuals weighing over 200 lbs. Due to the impending ESA listing decision, research pertaining to population structure and distribution is critical for future conservation of the species. Trapping surveys began in Spring 2021 and will be conducted seasonally through the end of 2022. These surveys are aimed at providing baseline population data in areas where surveys are not currently being conducted. The goal of EIH-UHCL's Alligator Snapping Turtle program is to "fill the gaps" in population distribution data via genetic analyses and routine trapping efforts. If you know of an area where Alligator Snapping Turtles are prevalent and are willing to allow EIH-UHCL access to your property, please contact EIH-UHCL for more information. We currently need more leads on potential Alligator Snapping Turtle survey sites within the Cypress, Sulphur, and Red river basins.

Academic and private stakeholder partnerships are integral in the collection of holistic and pertinent data for the conservation of these and other species in Texas. For questions related to these ongoing surveys, please contact Mandi Gordon (gordon@uhcl.edu; 281-283-3794). More information about EIH-UHCL can be found online at eih.uhcl.edu, including information about our ongoing Western Chicken Turtle and Alligator Snapping Turtle surveys.

Figure 43: Left: a 65 lbs. female alligator snapping turtle near Houston, TX. Upper right: A male western chicken turtle basking near Port Arthur, TX. Bottom right: QR code for direct connection to western chicken turtle online reporting tool.

KISATCHI 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, while 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.

Figure 44: Kisatchie painted crayfish (*Faxonius maletae) Photo by Steve Shively, USDA Forest Service*

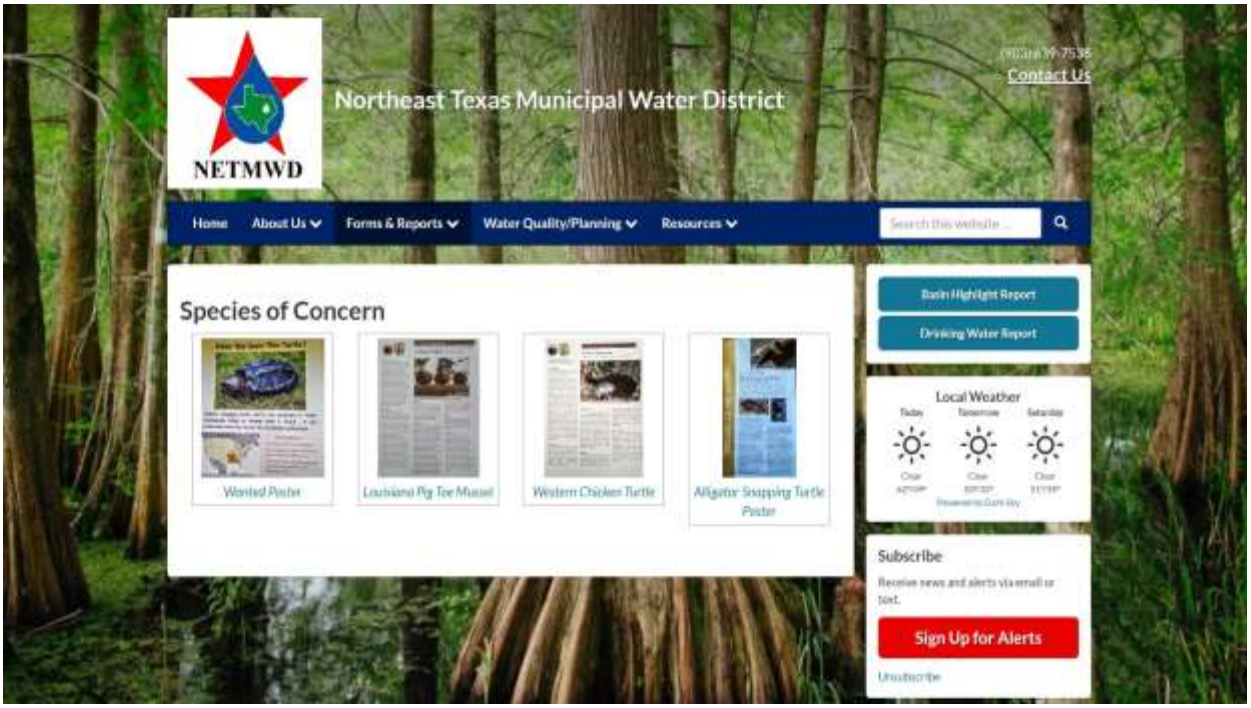

Figure 45: Species of Concern Screenshot from the NETMWD website

Information regarding these species of concern is also available at the NETMWD website and at the USFWS websites. If you see an individual that you suspect is one of these species, please take a photo and contact the NETMWD at 903-639-7538. Please include the date, time, and location of the sighting.

Figure 46: Western chicken turtle detected by Laura Speight's dog, Raine (left); western chicken turtle observed near the author's home (right)

ALLIGATOR SNAPPING TURTLE (*MACROCHELYS TEMMINCKII*) REPATRIATION PROJECT

By Connor S. Adams, MS, and Christopher M. Schalk, PhD, Stephen F. Austin State University

As part of a larger study involving the repatriation of illegally poached alligator snapping turtles back into native Texas waters, we performed two separate turtle surveys along Big Cypress Creek and associated creeks or oxbows in southeastern Camp County. Survey efforts for the first survey, conducted April 29 - May 2, 2021 were focused on trapping two small oxbow lakes adjacent to Big Cypress Creek. This survey yielded thirty captures of two turtle species (i.e., false map turtle [*Graptemys pseudogeographica*] and red-eared slider), but failed to detect alligator snapping turtles. For the second survey, conducted May 25 - May 28, 2021, we focused our efforts within Prairie Creek and Big Cypress Creek where we observed higher quality habitat for alligator snapping turtles than in the previous survey. We documented twenty captures represented by five species including the alligator snapping turtle, spiny softshell, common snapping turtle, red-eared slider, and eastern mud turtle (*Kinosternon subrubrum*). The alligator snapping turtle and the spiny softshell had not been previously recorded in Camp County. Photo vouchers of these specimens were taken and distribution notes were published in *Herpetological Review*.

Figure 47: One of two alligator snapping turtles captured during surveys

Taking these above-mentioned surveys and genetic analyses of illegally collected individuals into account, this area was chosen as an appropriate release site for repatriation efforts. In June 2021, eight turtles (1 male, 2 females, 5 subadults) were released into the Big Cypress Creek system in southeastern Camp County. From the initial release in June, we have radio-tracked these individuals obtaining weekly fixes to investigate their habitat use and survival. Of the initial 8 turtles released, 5 turtles have been located consistently post-release. Initial movements within the first two months of release were long and sporadic; however, turtles have now settled into smaller areas along a 6.5 km stretch of Big Cypress Creek and have substantially reduced distances moved between checks. We will continue to perform weekly checks over the next year to continue our investigation.

Fish Community Study

We have begun to conduct seasonal fish surveys within the Big Cypress Creek system as part of a collaborative study with Dr. Carmen Montana at Stephen F. Austin State University to understand spatial connectivity of waterways and the organization of fish communities. We conducted surveys on September 17 – 18, 2021 at five sampling sites in or associated with Big Cypress Creek in southeastern Camp County. Surveys were performed by electrofishing and seining along transects. We recorded general environmental data, the number of fish species and their abundance, and any other taxa we observed at each sampling location. Overall, we recorded 439 individuals of 35 fish species. This included the spotted sucker (*Minytrema melanops*) and the ironcolor shiner (*Notropis chalybaeus*) which are both species of greatest conservation need. Additionally, we documented the presence of the Kisatchie painted crayfish which has been petitioned for endangered species listing. Photo vouchers were obtained for this species. We will continue to conduct surveys of the fish communities within the Big Cypress Creek system in 2022.

Figure 48: Researchers seining Prairie creek upstream of its confluence with Big Cypress Creek (left); Kisatchie painted crayfish observed while conducting fish surveys (right)

INVASIVE AQUATIC SPECIES

INVASIVE AQUATIC SPECIES UPDATE

By: Tim Bister, Texas Parks and Wildlife Department

Invasive aquatic vegetation remains a threat to reservoirs in the Cypress Creek Basin, and the TPWD is actively managing these species. Although the region experienced much lower than average temperatures during the February 2021 winter storm reduced some level of plant coverage, no invasive aquatic plant species were eradicated from the reservoirs in the Cypress Creek Basin. The following is a summary of invasive aquatic plant coverage and management of the public reservoirs in the basin in 2021:

Lake Cypress Springs has remained relatively free of invasives. In 2021, TPWD estimated that there was one acre of alligatorweed while Hydrilla has not been detected in many years.

Lake Bob Sandlin also had a low amount of invasive vegetation in 2021. Only one acre of alligatorweed was present. Less than one acre of water hyacinth was discovered in Monticello Cove which was treated with herbicide by TPWD. Hydrilla has been present in the past but has not been detected in recent surveys.

Lake O' the Pines had two acres of alligatorweed and less than one acre of water hyacinth in 2021. Hydrilla coverage of 517 acres in 2021 was similar to the amount estimated in 2020 at 535 acres. The largest threat to Lake O' the Pines is giant salvinia. Coverage of giant salvinia was estimated at 39 acres during TPWD's routine annual survey in August/September 2021. However, this is likely an underestimate because of the complexity of habitat and the difficulty in access all areas in the upper end of the reservoir during the annual survey. The U. S. Army Corps of Engineers continues to contract herbicide treatments to control giant salvinia. Contractors treated 1,054 acres of giant salvinia with herbicide from September 2020 through December 2021.

Gilmer Reservoir had less than one acre of alligatorweed and 136 acres of hydrilla during the 2021 survey, but hydrilla growth had rebounded by the fall. Giant salvinia was discovered at the boat ramp on December 14, 2021 and was removed. The area will be treated by TPWD. There have been numerous giant salvinia infestations in past years that were successfully eradicated.

Lake Welsh contained 87 acres of hydrilla and 6 acres of alligatorweed. Alligatorweed flea beetles were released in spring 2021 to help control the growth of alligatorweed.

Lone Star Lake had an estimated 21 acres of hydrilla and eight acres of alligatorweed in the 2021 survey. Giant salvinia and water hyacinth are still present in the reservoir and are being managed with applications of herbicide.

New Mount Pleasant City Lake (Town Lake) had approximately twelve acres of giant salvinia in November 2020. TPWD has been conducting herbicide applications and believe the infestation has been eliminated

Caddo Lake was surveyed during September 2021. Despite the winter storm reducing large expanses of giant salvinia in Caddo Lake, there were enough areas underneath cypress trees or other cover to protect some plants. The insulating effect of snow cover may have also helped some plants survive the unusually low temperatures. TPWD documented the presence of hydrilla (497 acres), water hyacinth (111 acres), alligatorweed (8 acres), Indian hygrophila (228 acres), crested floating heart (278 acres), Eurasian watermilfoil (8 acres), and giant salvinia (865 acres). Herbicide treatments were conducted on 3,559 acres of giant salvinia in 2021 compared to 7,862 acres in 2020. Giant salvinia weevils were also used as part of an integrated management approach. During 2021, the Caddo Biocontrol Alliance released 78,935 weevils and TPWD released 23,800.

Figure 49: Damage caused by the February 2021 winter storm at a marina on Caddo Lake

INVASIVE CARP (BIGHEAD AND SILVER CARP)

Invasive carp (Bighead and Silver Carp) are a threat to native Texas ecosystems. These fish grow to large sizes and feed on zooplankton. They can outcompete native species that also feed on zooplankton and are a highly prolific species whose population numbers can expand rapidly.

Silver Carp are known to jump out of the water when startled, which poses a danger to boaters that may be hit by these large jumping fish. To learn more about these invasive species, TPWD has been working with Oklahoma Department of Wildlife Conservation, Arkansas Game and Fish Commission, U. S. Fish and Wildlife Service, and researchers from Auburn University and Texas Tech University to assess invasive carp populations in the Red River system, which includes the Sulphur River and other Texas tributaries of the Red River. Invasive carp have been in the Red River since 1998.

Bighead carp were documented in the Sulphur River below Lake Wright Patman as early as 2011. Because the river is free-flowing from the Lake Wright Patman dam downstream to the Red River, invasive carp have the ability to freely swim upstream.

The first Bighead Carp was reported in Big Cypress Bayou below the Lake O' the Pines spillway during fall 2010. It is suspected that Bighead Carp were able to swim upstream from the Red River and Twelve Mile Bayou into Caddo Lake during the winter 2009/2010 flood event. In 2011, several more specimens were removed from the system when USACE dewatered the spillway. To date, no additional invasive carp have been documented in Big Cypress Bayou or Caddo Lake.

Figure 50: Lynn Wright (TPWD) holding bighead carp collected in the Sulphur River on 7-10-2012

Figure 51: Bighead carp removed from the Lake O' the Pines spillway during dewatering in May 2011.

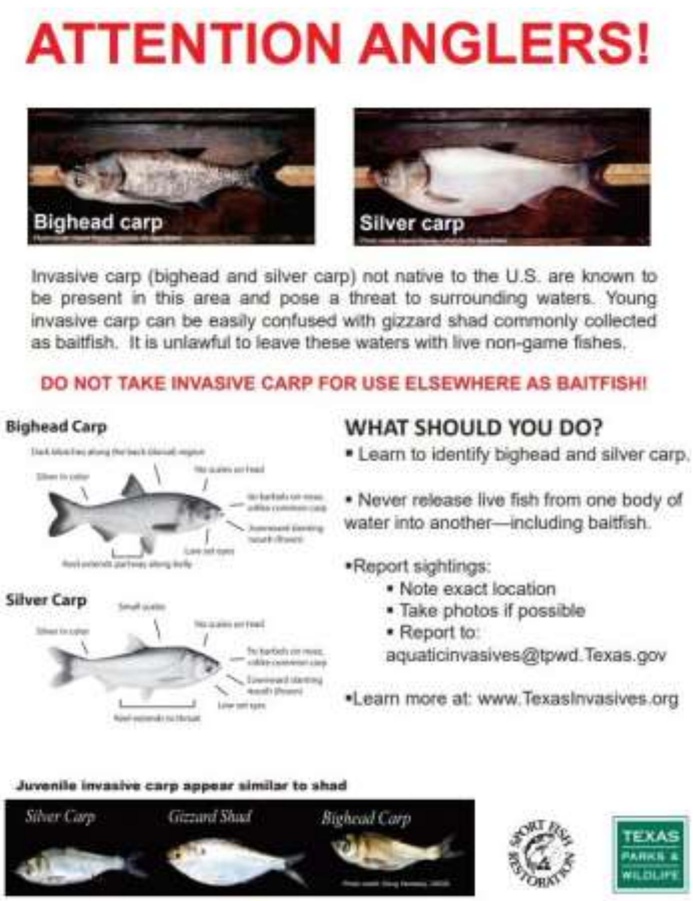

Figure 52: Invasive carp warning sign

Young invasive carp species can be easily confused with gizzard shad, which are commonly collected as baitfish. To help prevent the spread of invasive carp, it is unlawful to transport live, non-game fishes from the Red River below Lake Texoma downstream to the Arkansas border, Big Cypress Bayou downstream of Ferrell's Bridge Dam on Lake O' the Pines (including the Texas waters of Caddo Lake), and the Sulphur River downstream of the Lake Wright Patman dam. Nongame fishes collected from these waters may be used as live bait only in the water bodies where they were collected.

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