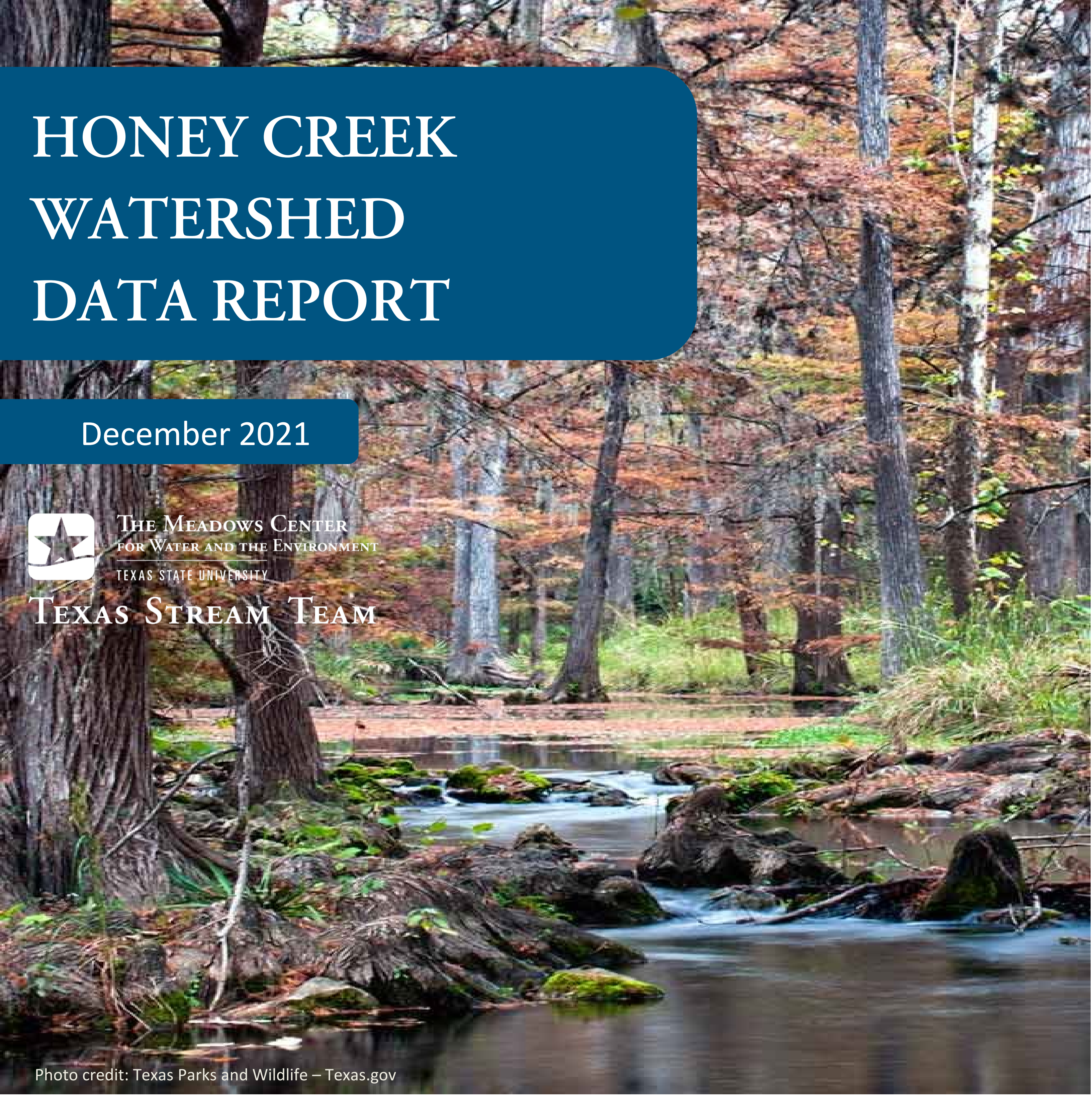
HONEY CREEK WATERSHED DATA REPORT

December 2021



The Meadows Center for Water and the Environment
Texas State University
Texas Stream Team

Photo credit: Texas Parks and Wildlife – Texas.gov

EPA United States Environmental Protection Agency

Texas Commission on Environmental Quality

Texas State University
The rising STAR of Texas

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The Texas Stream Team encourages life-long learning about the environment and people's relationship to the environment through its multidisciplinary citizen science programs. We also provide hands-on opportunities for Texas State University students and inspire future careers and studies in natural resource related fields. Preparation of this report fulfills a contract deliverable for the granting entity, but it also serves as a valuable educational experience for the students that assisted in preparing the report. The Texas Stream Team staff values the student contributions and recognizes each individual for their role. The following staff and student workers assisted in the preparation of this report and are acknowledged for their contributions:

Sandra S. Arismendez, Senior Watershed Scientist and Research Coordinator
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INTRODUCTION

Texas Stream Team

Texas Stream Team is a volunteer-based citizen science water quality monitoring program. Citizen scientist water quality monitoring occurs at predetermined monitoring sites, at approximately the same time of day each month. Information collected by Texas Stream Team citizen scientists is covered by a Texas Commission on Environmental Quality (TCEQ)-approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. The citizen scientist data may be used to identify surface water quality trends, target additional data collection needs, identify potential pollution events and sources of pollution, and to test the effectiveness of water quality management measures. Texas Stream Team citizen scientist data are not used by the state to assess whether water bodies are meeting the designated surface water quality standards. The data collected by Texas Stream Team provide valuable records, often collected in portions of a water body that professionals are not able to monitor frequently or monitor at all.

For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer citizen science monitoring, please refer to the following sources:

- Texas Stream Team Core Water Quality Citizen Scientist Manual
- Texas Stream Team Advanced Water Quality Citizen Scientist Manual
- Texas Stream Team Program Volunteer Water Quality Monitoring Program Quality Assurance Project Plan
- TCEQ Surface Water Quality Monitoring Procedures

The purpose of this report is to provide a summary of the data collected by Texas Stream Team citizen scientists. The data presented in this report should be considered in conjunction with other relevant water quality reports for a holistic view of water quality in the Brushy Creek watershed. Such sources may include, but are not limited to, the following:

- Texas Surface Water Quality Standards
- Texas Water Quality Inventory and 303(d) List (Integrated Report)
- Texas Clean Rivers Program partner reports, such as Basin Summary and Highlight Reports
- TCEQ Total Maximum Daily Load reports
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including watershed protection plans

To get involved with Texas Stream Team or for questions regarding this watershed data report contact us at TxStreamTeam@txstate.edu or at (512) 245-1346. Visit our website for more information on our programs at www.TexasStreamTeam.org.

WATERSHED DESCRIPTION

Location and Climate

Honey Creek, a spring-fed, perennial tributary of the Guadalupe River, is contained within western Comal County and derives its name from Honey Creek Cave, the water source to Honey Creek (Clark, et al., 2014). Honey Creek Cave is a subsurface trellis cave system and is the longest known cave in Texas with mapped passages extending over 20 miles (Elliott, 2012). Honey Creek proper is part of the Honey Creek State Natural Area which is managed by the Texas Parks and Wildlife Department. This area remains relatively undeveloped with only a few historic roads and buildings accessible only by guided tours (Clark, et al., 2014). The Honey Creek State Natural Area spans some 2,284 contiguous acres (3.6 mi^2) and falls within the Guadalupe River-Canyon Lake Watershed (283 mi^2), located within the larger Guadalupe River Basin (Figure 1).

The TCEQ classifies freshwater stream segments in the Guadalupe River watershed. The Guadalupe River Above Canyon Lake (Segment ID 1806) is a classified freshwater stream. Honey Creek is a tributary to the Guadalupe River with an assessment unit identification (AUID 1806_08) that extends from the confluence of Honey Creek in Comal County upstream to the confluence of Big Joshua Creek in Kendall County.

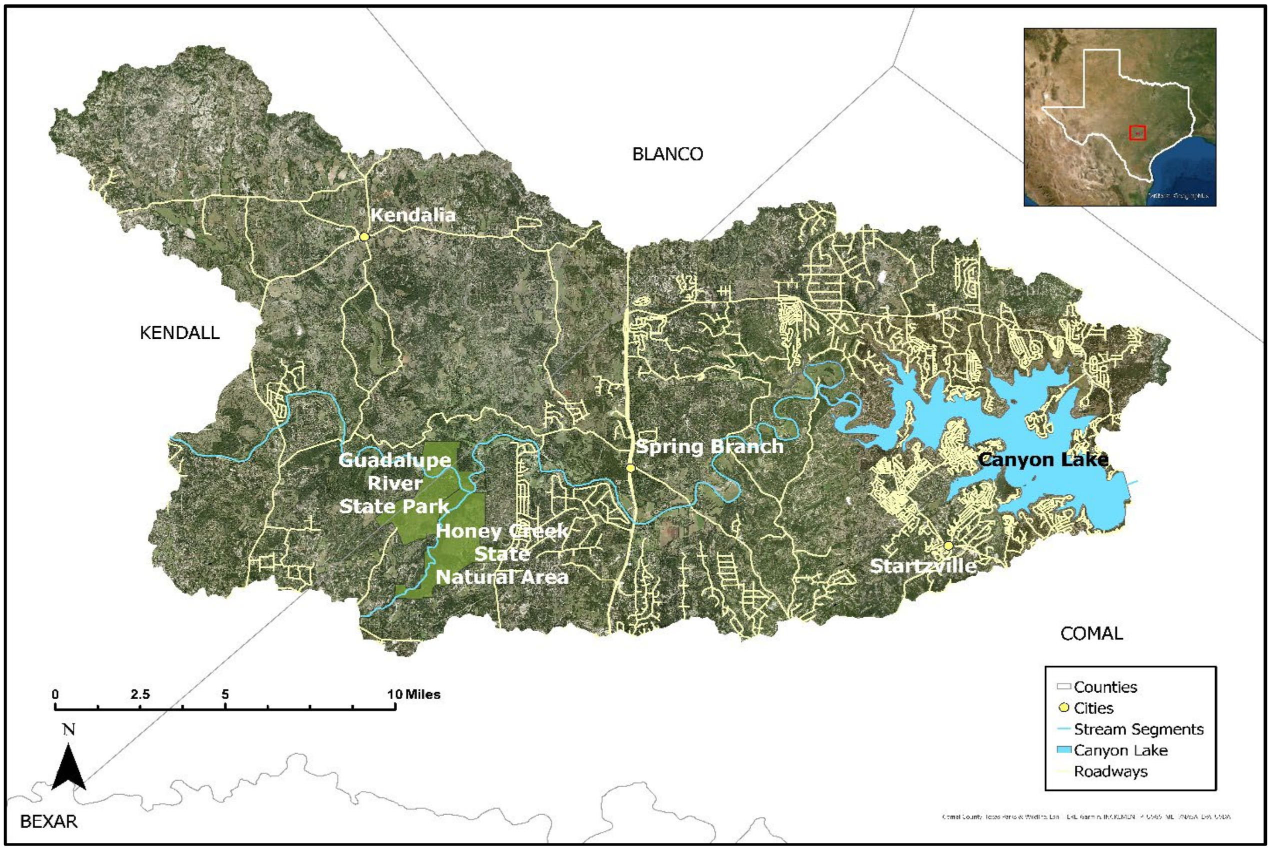

Figure 1. Honey Creek within the Guadalupe River-Canyon Lake Watershed.

National Oceanic and Atmospheric Administration (NOAA) climate data from a weather station in nearby Canyon Dam, Texas, was acquired from the National Data Center (NOAA, 2020). Precipitation at Canyon Dam averaged 38 inches annually and occurred year-round (Figure 2). Long-term monthly average precipitation has a bimodal distribution with peaks occurring in May and October. Average rainfall during these months was 4.5 and 4.9 inches each month, respectively. The least amount of rainfall (1.98 inches) occurred in February, which coincided with the third coldest time of the year (12.3°C). The warmest and coldest months of the year occurred in August (29.1°C) and January (10.2°C), respectively.

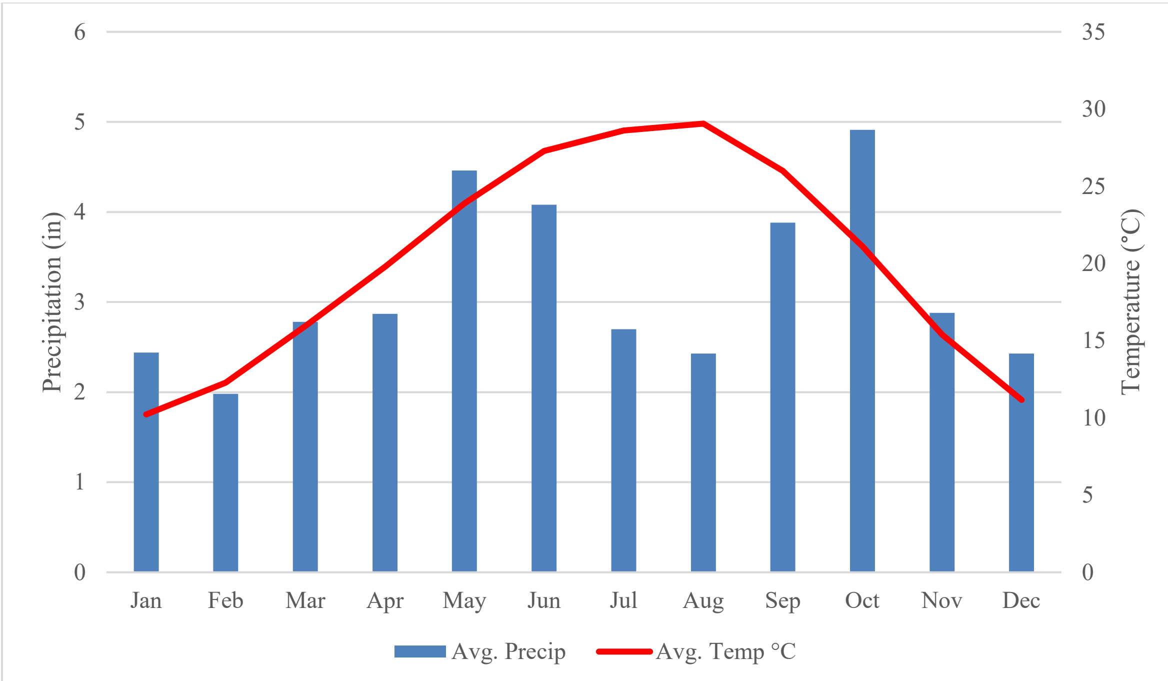

Figure 2. Long-term (1991-2020) monthly average precipitation (in) and air temperature (°C) from Canyon Dam, Texas (NOAA Climate Data, 2020).

Physical Description

Honey Creek lies above the Edwards Aquifer within the Guadalupe River-Canyon Lake Watershed and within the larger Guadalupe River Basin. This area is underlain geologically by the Early Cretaceous Trinity Group which consists of limestone, sand, clay, gravel, and conglomerate (Clark, et al., 2014). The approximately 2-mile-long permanent stream and its surrounding area has been designated a State Natural Area due to its pristine flora and fauna that is representative of the Edwards Plateau Ecoregion. The region is characterized by hills of rocky terrain, clear streams, and native vegetation that consists of oak-hickory or oak-juniper woodlands, mesquite-mixed brush savannah, and grasslands (TPW, 2009).

Land Use

Land cover types were identified and calculated for the Guadalupe River-Canyon Lake Watershed that contains Honey Creek (Figure 3) (NLCD, 2016). The watershed predominantly consists of forest (40%), shrub (39%), and developed (10%) land use types, with all other land use types, (i.e., grassland, open water, planted/cultivated, barren land, woody wetlands, and herbaceous wetlands) consisting of about 11% total combined (Table 1).

History

In the late 1800's Honey Creek was owned by German immigrants who had built their homestead in the Honey Creek area and gradually increased their land holdings until they owned most of what is now Honey Creek State Natural Area (Friends of Guadalupe River/Honey Creek, 2018). In the mid 1980's Texas Parks and Wildlife Department purchased the land and designated it a State Natural Area to preserve its pristine nature. Today, visitors can experience the preserved flora and fauna at Honey Creek State Natural Area via guided tours.

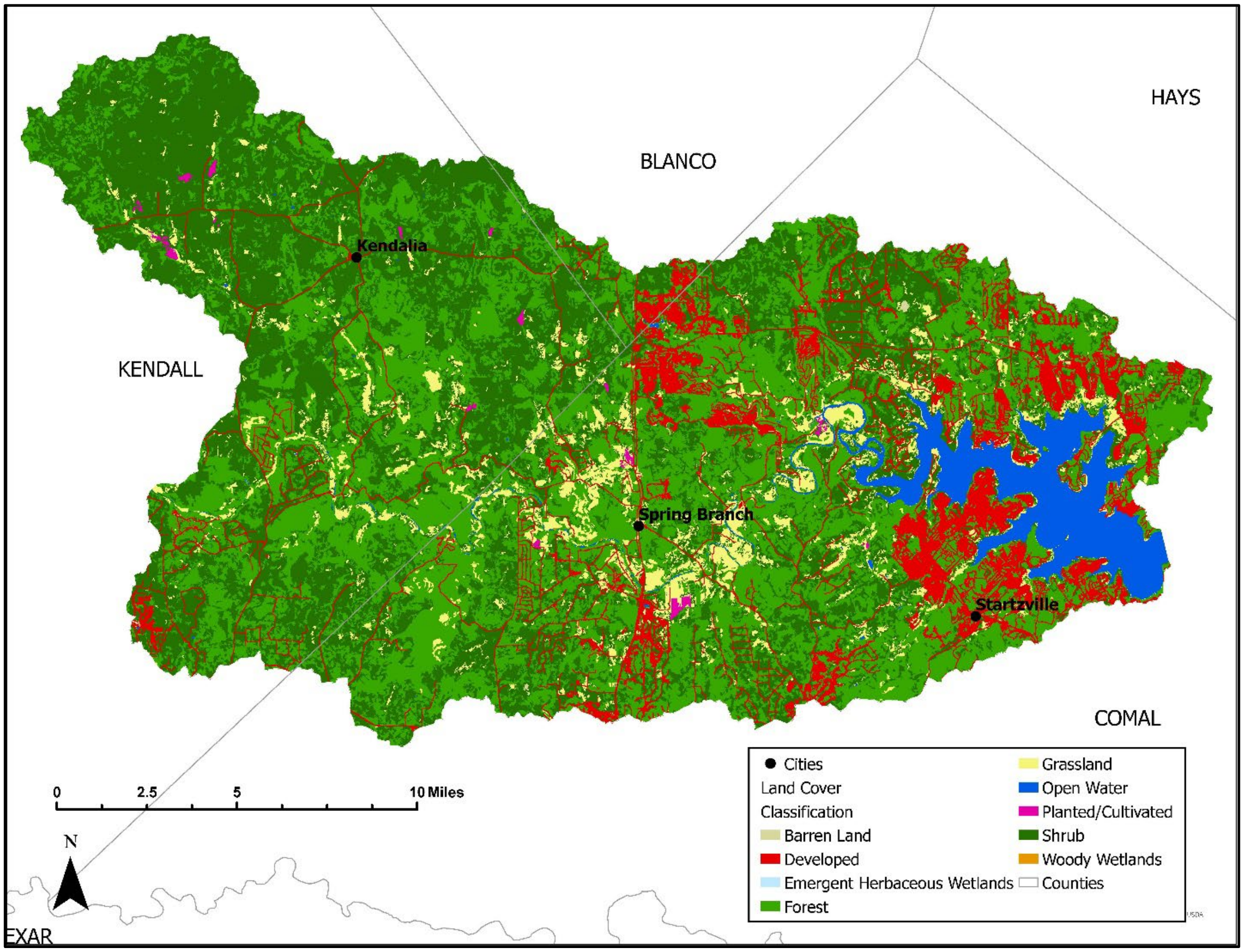

Figure 3. Land cover for the Guadalupe River-Canyon Lake Watershed (NLCD, 2016).

Table 1. Land cover for the Guadalupe River-Canyon Lake Watershed (NLCD, 2016).

Land Use	Total Acreage	Percentage
Forest	73,198.48	40%
Shrub	69,886.80	39%
Developed	18,686.70	10%
Grassland	10,441.42	5.8%
Open Water	8,408.07	4.6%
Planted/Cultivated	411.87	0.2%
Barren Land	213.50	0.1%
Woody Wetlands	35.58	0.02%

Herbaceous Wetlands	2.45	0.001%
TOTAL	181,284.87	100%

Endangered Species and Conservation Needs

The common names of 30 species listed as threatened or endangered (under the authority of Texas state law and/or under the US Endangered Species Act) within the Honey Creek area are included in Appendix I at the end of this report. A summary of the number of species per taxonomic group listed as state or federally endangered, threatened, G1 or G2 (critically imperiled or imperiled), species of greatest conservation need, and/or endemic are provided in Table 2.

Table 2. State and Federally Listed Species in Honey Creek within the Guadalupe River-Canyon Lake Watershed (TPWD, 2020).

Texas Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals for the quality of streams, rivers, lakes, and bays throughout the state. The standards are developed to maintain the quality of surface waters in Texas to support public health and protect aquatic life, consistent with the sustainable economic development of the state. Water quality standards identify appropriate uses for the state's surface waters, including aquatic life, recreation, and sources of public water supply (drinking water). The criteria for evaluating support of those uses in the Guadalupe River above Canyon Lake segment (1806) and Honey Creek assessment unit (AUID 1806_08) included in this report are provided in Table 3.

Taxon	**Endangered (Federal or State)**	**Threatened (Federal or State)**	**G1 or G2 (Critically imperiled or imperiled)**	**Species of Greatest Conservation Need (NPWD) (S1 or S2)**	**Endemic Total Count**	**Total Count**
Amphibians	1	3	3	4	5	16
Birds	4	6	2	7	0	19
Fish	1	3	2	4	4	14
Mammals	0	2	1	5	1	9
Reptiles	0	3	0	5	3	11
Crustaceans	1	0	7	7	9	24
Insects	2	0	12	12	9	35
Arachnids	0	0	3	3	4	10
Mollusks	0	3	10	11	9	33
Plants	0	1	7	10	25	32
Total Count	**9**	**21**	**47**	**68**	**69**	**203**

The Texas Surface Water Quality Standards also contain narrative criteria (verbal descriptions) that apply to all waters of the state and are used to evaluate support of applicable uses. Narrative criteria include general descriptions, such as the existence of excessive aquatic plant growth, foaming of surface waters, taste- and odor-producing substances, sediment build-up, and toxic materials. Narrative criteria are evaluated by using screening levels, if they are available, as well as other information, including water quality studies, existence of fish kills or contaminant spills, photographic evidence, and local knowledge. Screening levels serve as a reference point to indicate when water quality parameters may be approaching levels of concern.

Table 3. State water quality criteria in the Guadalupe River and Honey Creek within the Guadalupe River-Canyon Lake Watershed (TCEQ, 2018).

Segment	Total Dissolved Solids (TDS) (mg/L)	Dissolved Oxygen (mg/L)	pH Range (s.u.)	*E. coli* Bacteria (#/100 mL)	Temperature (°C)
1806 – Guadalupe River above Canyon Lake (Exceptional Aquatic Life Use)	400	*Mean: 6.0 Min.: 4.0	6.5-9.0	Primary Contact Recreation: 126 geometric mean, 399 single sample	32.2
AUID 1806_08 – From the confluence of Honey Creek in Comal County upstream to the confluence of Big Joshua Creek in Kendall County	400	*Mean: 6.0 Min.: 4.0	6.5-9.0	Primary Contact Recreation: 126 geometric mean, 399 single sample	32.2

*The dissolved oxygen mean is applied as a minimum average over a 24-hour period. The 24-hour minimum is not to extend beyond eight hours per 24-hour day.

Water Quality Impairments

The 2020 Texas Water Quality Inventory and 303(d) List (Integrated Report) assessed the Guadalupe River above Canyon Lake (Segment 1806) and found bacteria water quality impairments for the primary contact recreation use in assessment unit 1806_08 from the confluence of Honey Creek in Comal County upstream to the confluence of Big Joshua Creek in Kendall County. A Total Maximum Daily Load (TMDL) was prepared in the Guadalupe River Watershed to address the bacteria impairment in two small assessment areas within the city of Kerrville. In 2014, a TMDL addendum to the state's Water Quality Management Plan added two additional tributaries, Quinlan Creek and Town Creek, listed for bacteria impairments. However, no TMDLs or Watershed Protection Plans have been initiated for the bacteria impairment in assessment unit 1806_08 in the lower portion of the watershed.

WATER QUALITY PARAMETERS

Water Temperature

Water temperature influences the physiological processes of aquatic organisms, and each species has an optimum temperature for survival. High water temperatures increase oxygen-demand for aquatic communities and can become stressful for fish and aquatic insects. Water temperature variations are most detrimental when they occur rapidly, leaving the aquatic community no time to adjust. Additionally, the ability of water to hold oxygen in solution (solubility) decreases as temperature increases. This effect is exacerbated in coastal water bodies influenced by tidal, saline waters.

Warm water temperatures occur naturally with seasonal variation, as water temperatures tend to increase during summer and decrease in winter in the Northern Hemisphere. Daily (diurnal) water temperature changes occur during normal heating and cooling patterns. Man-made sources of warm water include power plant effluent after it has been used for cooling or hydroelectric plants that discharge warmer water. Citizen scientist monitoring may not identify fluctuating patterns due to diurnal changes or events such as power plant releases because of the sampling frequency. While citizen scientist data may not show diurnal temperature fluctuations, they could demonstrate the fluctuations over seasons and years when collected consistently at predetermined monitoring sites and monthly frequencies.

Specific Conductance and Salinity

Salinity is a measure of the saltiness or the dissolved inorganic salt concentration in water. Salinity is often measured in ocean, estuarine or tidally-influenced waters, but in Texas there are some inland streams that have a high salt content due to the local geology and require salinity measurements. Some common ions measured as salinity include sodium, chloride, magnesium, sulfate, calcium, and potassium. Seawater typically has a salt content of 35 parts per thousand (ppt or ‰). Like other water quality parameters, salinity affects the homeostasis or the balance of water and solutes within both plants and animals. Too much or too little salt can affect plant and animal cell survival and growth, therefore salinity is an important measurement.

Specific conductance is a measure of the ability of a body of water to conduct electricity. It is measured in microsiemens per centimeter (µS/cm). A body of water is more conductive if it has more total dissolved solids (TDS) such as nutrients and salts, which indicates poor water quality if they are overly abundant. High concentrations of nutrients can lower the level of dissolved oxygen (DO), leading to eutrophication. High concentrations of salt can inhibit water absorption and limit root growth for vegetation, leading to an abundance of more drought tolerant plants, and can cause dehydration of fish and amphibians. Sources of TDS can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants. Specific conductance values are converted to TDS using a conversion factor of 0.65 and are reported as mg/L.

Dissolved Oxygen (DO)

Oxygen is necessary for the survival of organisms like fish and aquatic insects. The amount of oxygen needed for survival and reproduction of aquatic communities varies according to species composition and adaptations to watershed characteristics like stream gradient, habitat, and available streamflow.

The DO concentrations can be influenced by other water quality parameters such as nutrients and temperature. High concentrations of nutrients can lead to excessive surface vegetation and algae growth, which may starve subsurface vegetation of sunlight and, therefore, reduce the amount of oxygen they produce via photosynthesis. This process is known as eutrophication. Low DO can also result from high groundwater inflows (which have low DO due to minimal aeration), high temperatures, or water releases from deeper portions of dams where DO stratification occurs. Supersaturation typically occurs underneath waterfalls or dams with water flowing over the top where aeration is abundant.

pH

The pH scale measures the concentration of hydrogen ions on a range of zero to 14 and is reported in standard units (s.u.). The pH of water can provide information regarding acidity or alkalinity. The range is logarithmic; therefore, every one-unit change is representative of a 10-fold increase or decrease in acidity or alkalinity. Acidic sources, indicated by a low pH level, can include acid rain and runoff from acid-laden soils. Acid rain is mostly caused by coal powered plants with minimal contributions from the burning of other fossil fuels and other natural processes, such as volcanic emissions. Soil-acidity can be caused by excessive rainfall leaching alkaline materials out of soils, acidic parent material, crop decomposition creating hydrogen ions, or high-yielding fields that have drained the soil of all alkalinity. Sources of high pH (alkaline) include geologic composition, as in the case of limestone increasing alkalinity and the dissolving of carbon dioxide in water. Carbon dioxide is water soluble, and as it dissolves it forms carbonic acid. A suitable pH range for healthy organisms is between 6.5 and 9.0 s.u.

Water Transparency and Total Depth

Two instruments can be used by Texas Stream Team Citizen scientist to measure water transparency, a Secchi disc or a transparency tube. Both instruments are used to measure water transparency or to determine the clarity of the water, a condition known as turbidity. The Secchi disc is lowered into the water until it is no longer visible, then raised until it becomes visible, and the average of the two depth measurements is recorded. A transparency tube is filled with sample water and water is released using the release valve until the black and white pattern at the bottom of the tube can be seen. The tube is marked with two-millimeter increments and is used to measure water transparency. Transparency measurements less than the total depth of the monitoring site are indicative of turbid water. Readings that are equal to total depth indicate clear water. Highly turbid waters pose a risk to wildlife by clogging the gills of fish, reducing visibility, and carrying contaminants. Reduced visibility can harm predatory fish or birds that depend on good visibility to find their prey. Turbid waters allow very little light to penetrate deep into the water, which, in turn, decreases the density of phytoplankton, algae, and other aquatic plants. This reduces the DO in the water due to reduced photosynthesis. Contaminants are most commonly transported in sediment rather than in the water. Turbid waters can result from sediment washing away from construction sites, erosion of farms, or mining operations.

E. coli and Enterococci Bacteria

E. coli bacteria originate in the digestive tract of endothermic organisms. The United States Environmental Protection Agency has determined *E. coli* to be the best indicator of the degree of pathogens in a freshwater system. A pathogen is a biological agent that causes disease.

Enterococci bacteria are a subgroup of fecal streptococci bacteria (mainly *Streptococcus faecalis* and *Streptococcus faecium*) that are present in the intestinal tracts and feces of warm-blooded animals. It is used by TCEQ as an indicator of the potential presence of pathogens in tidally-influenced saltwater along the Texas Gulf coast.

Honey Creek is designated a primary contact recreation 1 (PCR1) use. This means that recreation activities on Honey Creek are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, handfishing as defined by Texas Parks and Wildlife Code, §66.115, and the following whitewater activities: kayaking, canoeing, and rafting).

The standard for a bacteria impairment is based on the geometric mean (geomean) of the bacteria measurements collected. A geometric mean is a type of average that incorporates the high variability found in parameters such as *E. coli* and enterococci which can vary from zero to tens of thousands of colony forming units per 100 milliliters (CFU/100 mL). The standard for contact recreational use of a water body is 126 CFU/100 mL for *E. coli* in freshwater or 35 CFU/100 mL for enterococci in saltwater. A water body is considered impaired if the geometric mean is higher than the corresponding water quality standard.

Texas Stream Team does not monitor water quality for enterococci in coastal waters, instead citizen scientists can get certified in *E. coli* bacteria monitoring, the indicator used by TCEQ for freshwater streams.

Orthophosphate

Orthophosphate is the phosphate molecule all by itself. Phosphorus almost always exists in the natural environment as phosphate, which continually cycles through the ecosystem as a nutrient necessary for the growth of most organisms. Testing for orthophosphate detects the amount of phosphate in the water itself, excluding the phosphate bound up in plant and animal tissue. There are other methods to retrieve the phosphate from the material to which it is bound, but they are too complicated and expensive to be conducted by citizen scientists. Testing for orthophosphate provides an idea of the degree of phosphate in a water body. It can be used for problem identification, which can be followed up with more detailed professional monitoring, if necessary. Phosphorus inputs into a water body may be caused by the weathering of soils and rocks, discharge from wastewater treatment plants, excessive fertilizer use, failing septic systems, livestock and pet waste, disturbed land areas, drained wetlands, water treatment, and some commercial cleaning products. The effect excess orthophosphate has on a water body is known as eutrophication and is described above under the Dissolved Oxygen heading.

Nitrate-Nitrogen

Nitrogen is present in terrestrial or aquatic environments as nitrate-nitrogen, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with TCEQ and other partners. Just like phosphorus, nitrogen is a nutrient necessary for the growth of most organisms. Nitrogen inputs into a water body may be from livestock and pet waste, excessive fertilizer use, failing septic systems, and industrial discharges that contain corrosion inhibitors. The effect excess nitrogen has on a water body is known as eutrophication and is described previously in the "Dissolved Oxygen" section. Nitrate-nitrogen dissolves more readily than orthophosphate, which tend to be attached to sediment, and, therefore, can serve as a better indicator of possible sewage or manure pollution during dry weather.

DATA COLLECTION, MANAGEMENT AND ANALYSIS

Data Collection

The field sampling procedures implemented by trained citizen scientists are documented in the Texas Stream Team Core Water Quality Citizen Scientist Manual and the Texas Stream Team Advanced Water Quality Citizen Scientist Manual. The sampling protocols in both manuals adhere closely to the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012). Additionally, all data collection adheres to Texas Stream Team's approved QAPP.

Procedures documented in Texas Stream Team Water Quality Citizen Scientist Manuals or the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012) outline the necessary steps to prevent contamination of samples, including direct collection into sample containers, when possible. Field quality control samples are collected and analyzed to detect whether contamination has occurred and to ensure data accuracy and precision.

Field sampling activities are documented on field data sheets. The following items are recorded for each field sampling event: station ID, location, sampling time, date, depth, sample collector's name/signature, meter calibration information, and reagent expiration dates.

For *E. coli* sampling events, station ID, location, sampling time, date, depth, sample collector's name/signature, incubation temperature, incubation duration, *E. coli* colony counts, dilution aliquot, field duplicates and blank, and media expiration dates are recorded.

Values for measured parameters are recorded. If expired reagents or media are used for the sampling event, it is noted, and data are flagged and communicated to Texas Stream Team staff. Sampling is not permitted with expired reagents or bacteria media; the corresponding values will be flagged in the database and excluded from data reports. Detailed observational data recorded include water appearance, weather, field observations (biological activity and stream uses), algae cover, unusual odors, days since last significant rainfall, and flow severity. Comments related to field measurements, number of participants, total time spent sampling, and total round-trip distance traveled to the sampling site are also recorded for grant reporting and administrative purposes.

Data Management

The citizen scientists collect field data and report the measurement results to Texas Stream Team, either by submitting a hard copy of the form or by entering the data directly into the online Waterways Dataviewer. All data are reviewed to ensure they are representative of the samples analyzed and locations where measurements were made, and the data and associated quality control data conform to specified monitoring procedures and project specifications as stated in the approved QAPP.

Data review and verification is performed using a data management checklist and self-assessments, as appropriate to the project task, followed by automated database functions that will validate data as the information is entered into the database. The data are verified and evaluated against project specifications and are checked for errors, especially errors in transcription, calculations, and data input. Potential errors are identified by examination of documentation and by manual and computer-assisted examination of corollary or unreasonable data. Issues that can be corrected are corrected and documented. Once entered, the data can be accessible through the online Texas Stream Team Datamap.

Data Analysis

Data were compiled, analyzed, summarized, and compared to state water quality standards and screening criteria to provide readers with a reference point for parameters that may be of concern. The statewide, biennial assessment performed by TCEQ involves more stringent monitoring methods and oversight than those used by citizen scientists and staff in this report. The citizen scientist water quality monitoring data are not currently used in the TCEQ assessments mentioned above but are intended to inform stakeholders about general characteristics and assist professionals in identifying areas of potential concern to plan future monitoring efforts.

All data collected by citizen scientists from the watershed were exported from the Texas Stream Team database and grouped by site. Once compiled, data were sorted, summary statistics were generated and reviewed, and results were graphed in JMP Pro 14.0.0 (SAS Institute Inc., 2018) using standard methods. Best professional judgement was used to verify outliers. Statistically significant trends were analyzed further. Outlier box plots were prepared to provide a compact view of the distribution of the data for each parameter and site(s). The horizontal line within the box represents the median sample value, while the ends of the box represent the 25th and 75th quantiles or the interquartile range. The lines extending from each end of the box, or whiskers, are computed using the 25th/75th quartiles ± 1.5 x (interquartile range). Outliers are plotted as points outside the box plot.

DATA RESULTS

Water quality data from three Texas Stream Team monitoring sites on or near the Guadalupe River or its tributary Honey Creek were acquired for analysis (Figure 4). Trained Texas Stream Team citizen scientists conducted between 84 and 95 sampling events at each site, for a total of 264 monitoring events (Table 4). The period of record for the sampling events ranged from February 2008 to September 2021, with all sites experiencing temporal intermittent sampling.

Table 4. Honey Creek and Guadalupe River Texas Stream Team monitoring sites.

Site ID	Description	Number of Samples (n)	Period of Record
80524	Guadalupe River @ FM 3351	85	07/28/2009 – 9/21/2021
80516	Guadalupe River State Park swimming area	84	02/24/2009 – 9/9/2021
15399	Honey Creek @ unimproved road crossing	95	2/9/2008 – 7/5/2012 9/29/2016 – 9/9/2021

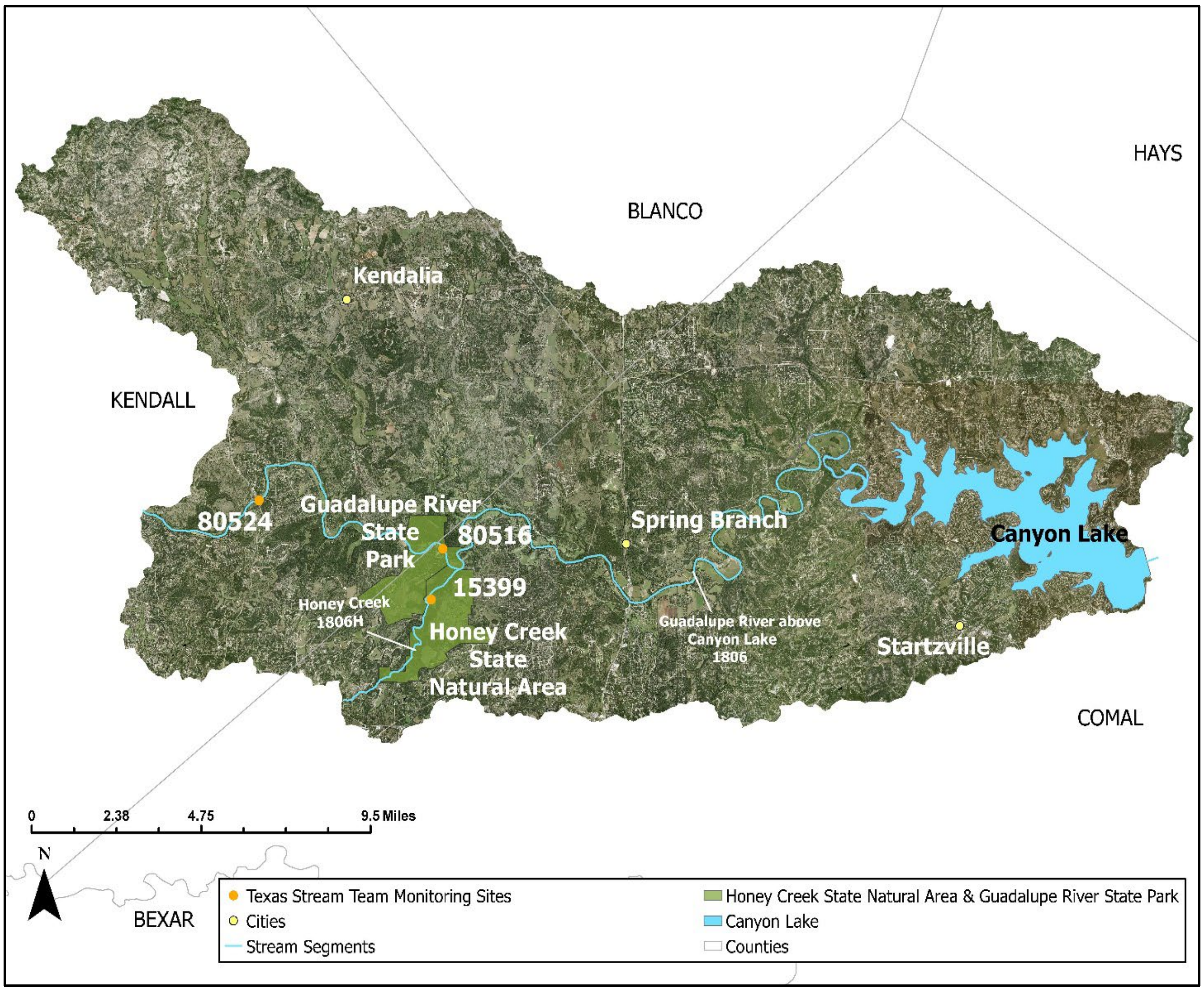

Figure 4. Texas Stream Team monitoring sites at Honey Creek and the Guadalupe River within the Guadalupe River-Canyon Lake Watershed.

Site Analysis

The period of record for data analyzed for this report intermittently spanned from February 2008 to September 2021. Data from 264 monitoring events conducted at three sites were acquired from the Waterways Dataviewer (Table 4). Water quality monitoring data for the three sites on the Guadalupe River and Honey Creek were analyzed and summarized including the number of samples, mean, standard deviation, and range of values (Table 5). Citizen scientists monitored the three sites for Standard Core and *E. coli* Bacteria water quality monitoring parameters. The total number of sampling events for the Texas Stream Team Standard Core and *E. coli* Bacteria water quality monitoring parameters (air and water temperature, conductivity, TDS, DO, pH, Secchi disc transparency, total depth, and *E. coli*) remained somewhat consistent for the duration of the period of record.

Table 5. Texas Stream Team data summary in the Guadalupe River and Honey Creek (Feb 2008-Sep 2021). Mean±SD (range)

Parameter	**Guadalupe River @ FM 3351 ID 80524 n=85**	**Guadalupe River State Park Swimming Area ID 80516 n=84**	**Honey Creek @ Unimproved Road Crossing ID 15399 n=95**
Air Temp. (°C)	17.6±7.5 (24.0)	24.5±5.7 (24.1)	23.7±5.3 (24.0)
Water Temp. (°C)	19.2±6.7 (21.8)	21.8±5.7 (22)	20.8±2.0 (11.3)
Specific Conductance (µS/cm)	508±34 (200)	508±41 (230)	600±20 (100)
***TDS (mg/L)**	330±22 (130)	330±27 (150)	390±13 (65)
Dissolved Oxygen (mg/L)	6.7±1.5 (6.1)	7.7±1.1 (4.7)	7.4±1.3 (6.7)
pH (s.u.)	7.6±0.3 (1.2)	7.7±0.2 (1.1)	7.2±0.3 (2.1)
Secchi Tube Transp. (m)	1.2±0.0 (0)	0.9±0.3 (1.0)	1.2±0.1 (0.3)
Secchi Disc Transp. (m)	0.5±0.3 (1.3)	1.6±2.3 (4.6)	1.0±0.8 (0.5)
Total Depth (m)	0.5±0.3 (1.3)	0.6±0.3 (1.4)	0.8±0.4 (1.9)
****E. coli* (CFU/100ml)**	83.4 (630)	59.2 (2500)	37.9 (280)

*TDS was calculated from specific conductance (TDS = specific conductance * 0.65)

**Geometric means were calculated for *E. coli*.

Air and Water Temperature

Average air temperature for all sites ranged from 17.6 to 24.5 °C (Table 5). The lowest mean air temperature (17.6 °C) was observed at the Guadalupe River at FM 3351 (Site 80524). The highest mean air temperature (24.5 °C) was observed at the Guadalupe River State Park swimming area (Site 80516). The distribution of air temperatures for each site for the entire period of record are displayed from upstream to downstream in Figure 5.

Water temperatures at all sites were below the water quality standard (WQS) of 32.2 °C (Figure 5). Average water temperature for all three sites ranged from 19.2 °C at the Guadalupe River at FM 3351 (Site 80524) to 21.8 °C at the Guadalupe River State Park swimming area (Site 80516) (Table 5). The distribution of water temperatures for each site from upstream to downstream are displayed in Figure 5.

Specific Conductance and Total Dissolved Solids

Specific conductance measurements were converted to TDS for all sites (Table 5). Average TDS values at all sites were below the water quality standard (400 mg/L) and ranged from 330 to 390 mg/L (Table 5). The distribution of TDS measurements for each site are displayed in Figure 6 with the lowest median TDS measurements reported at both the Guadalupe River sites (80524 and 80516) and the highest median TDS reported at Honey Creek (Site 15399). The median values at all sites were below the WQS, however some values at Honey Creek exceeded the WQS.

Dissolved Oxygen

Average DO values at all three sites (80524, 80516, and 15399) were above the 6.0 mg/L water quality standard (Table 5). The range of average DO values for all sites spanned from 7.7 to 6.7 mg/L. The distribution of DO measurements for each site are displayed in Figure 7. Some individual DO values fell below the water quality standard (6.0 mg/L) at all sites during the period of record evaluated, but all were at or above the minimum water quality standard (4.0 mg/L) during the same period.

pH

The pH values at all sites were within the water quality standard of 6.5 to 9.0 s.u. (Figure 8). Average pH for all sites ranged from 7.2 to 7.7 s.u. (Table 5).

Transparency and Total Depth

Secchi tubes and discs were used for measuring transparency at the three sites monitored and included in this report (Figure 9). The average Secchi tube transparency values reported at two sites (80524 and 15399) where this parameter was measured was 1.2 m or the maximum reportable value using a 120 cm tube and 0.9 m at the Guadalupe River State Park site 80516. The average range of Secchi disc transparency values reported was from 0.5 to 1.6 m (Table 5). The largest measurement, or most transparent site, was the Guadalupe River State Park Swimming area (Site 80516) and the smallest measurement or least transparent site was the Guadalupe River @ FM 3351 (Site 80524) (Table 5).

Total depth was measured at the three sites monitored (Table 5). The deepest site was at Honey Creek (15399), while the shallowest site was the Guadalupe River at FM 3351 site (80524).

E. coli

E. coli bacteria was measured and reported at all three sites included in this report (Table 5). The *E. coli* geometric means were calculated for the entire period of record and were below the WQS (126 cfu/100 mL) at all three sites (Table 5). The lowest geometric mean was observed at Honey Creek (37.9 cfu/100 mL), while the highest geometric mean was observed at Guadalupe River at FM 3351 (83.4 cfu/100 mL). Although the geometric means were below the water quality standard at all sites, there were individual values that exceeded the standard throughout the period of record of this study at the two Guadalupe River sites (Figure 10).

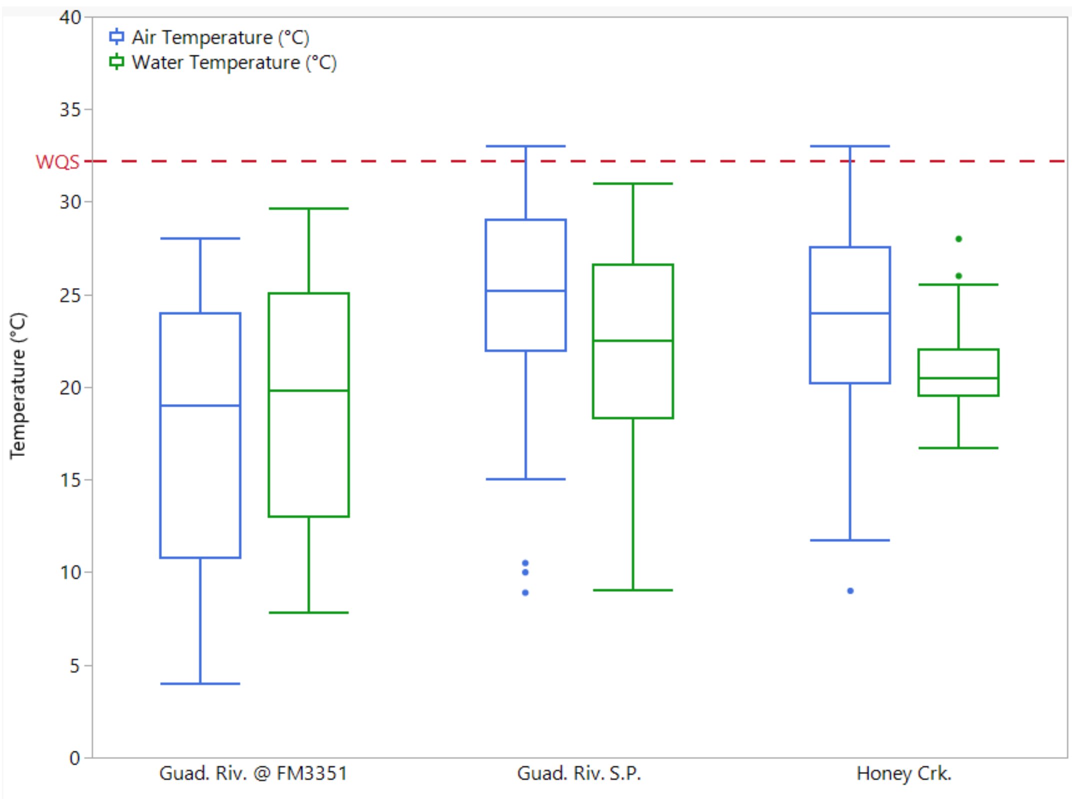

Figure 5. Air and water temperature for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (Feb 2008 - Sep 2021).

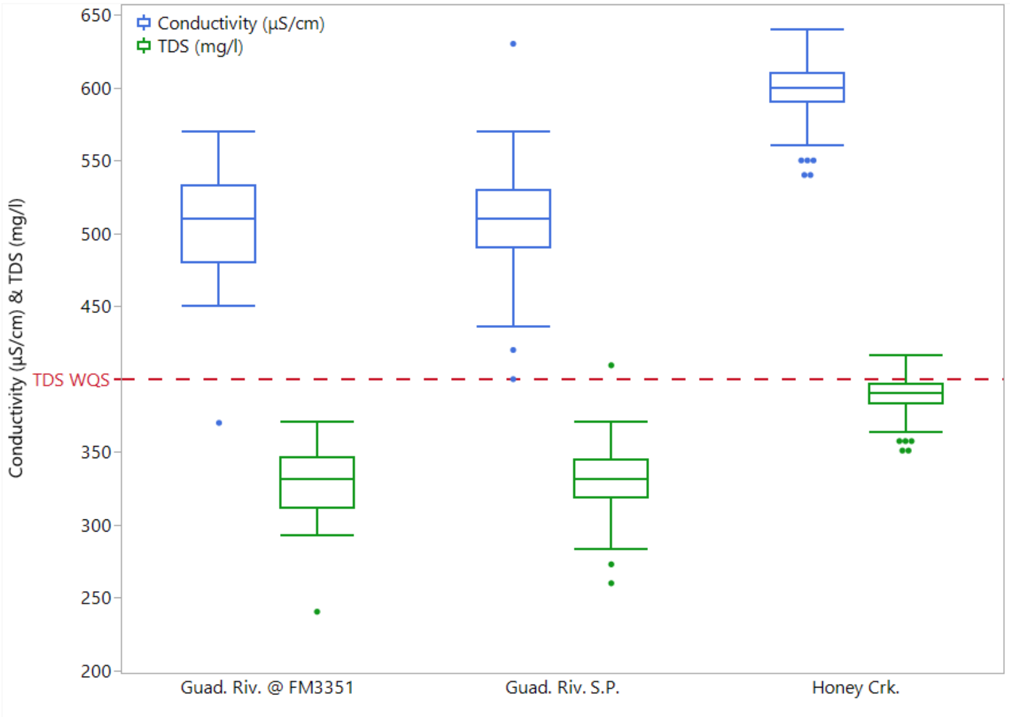

Figure 6. Conductivity (µS/cm) and total dissolved solids (TDS) (mg/L) for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (Feb 2008 - Sep 2021).

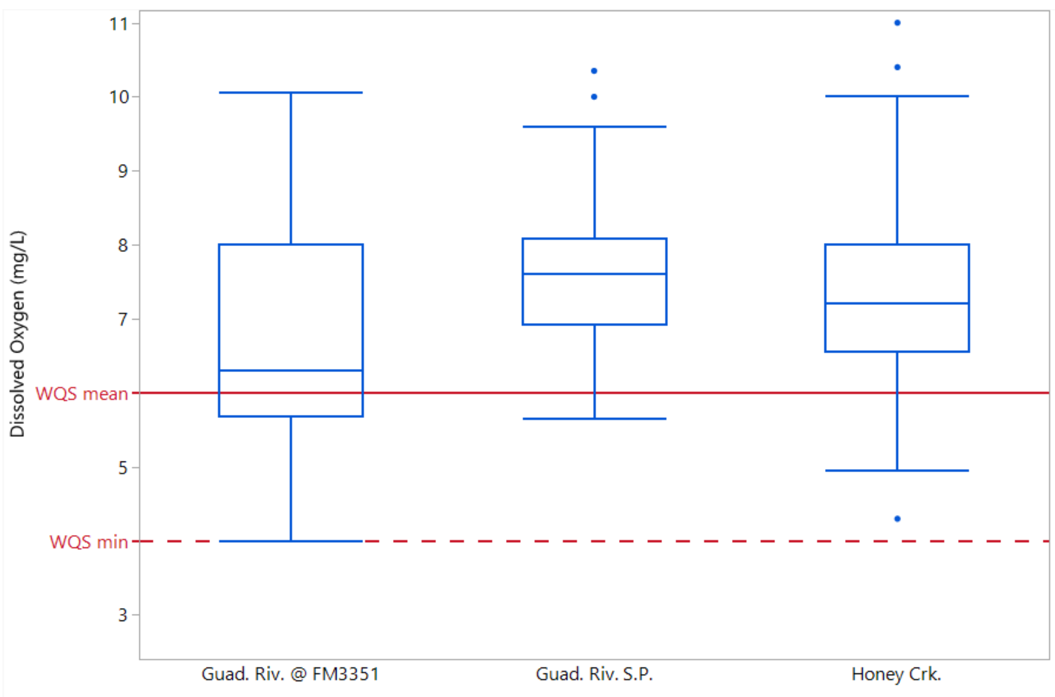

Figure 7. Dissolved oxygen (mg/L) for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (Feb 2008 - Sep 2021).

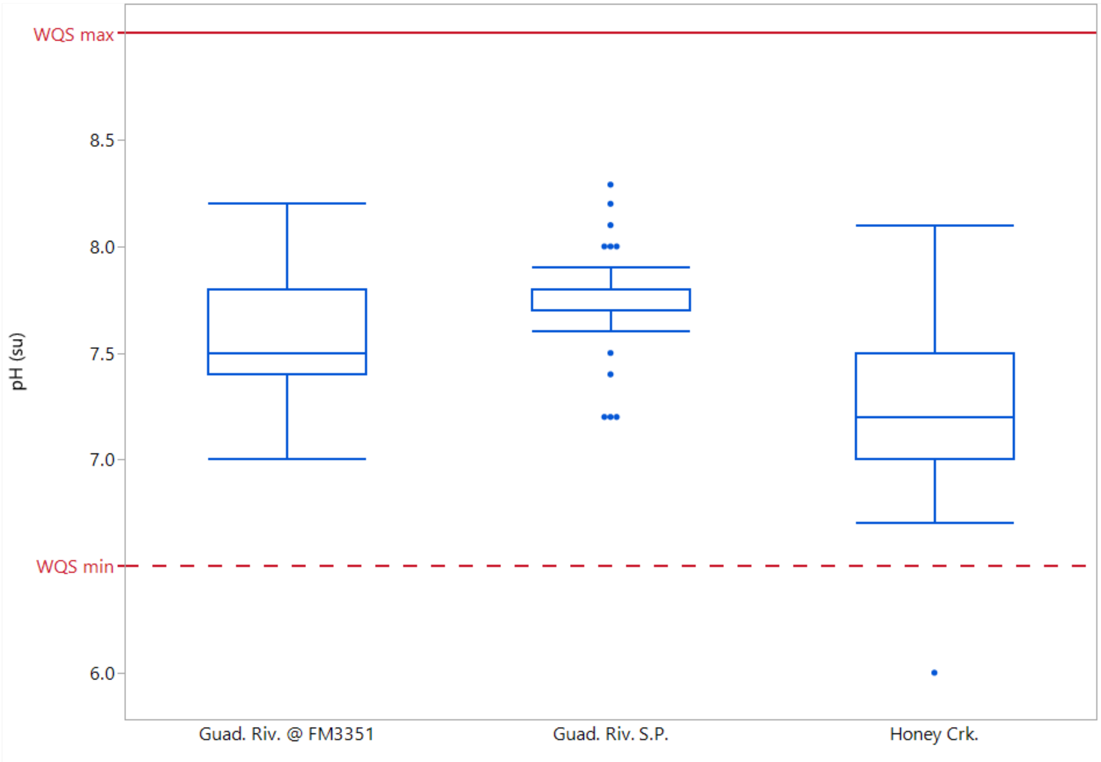

Figure 8. pH (s.u.) for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (Feb 2008 - Sep 2021).

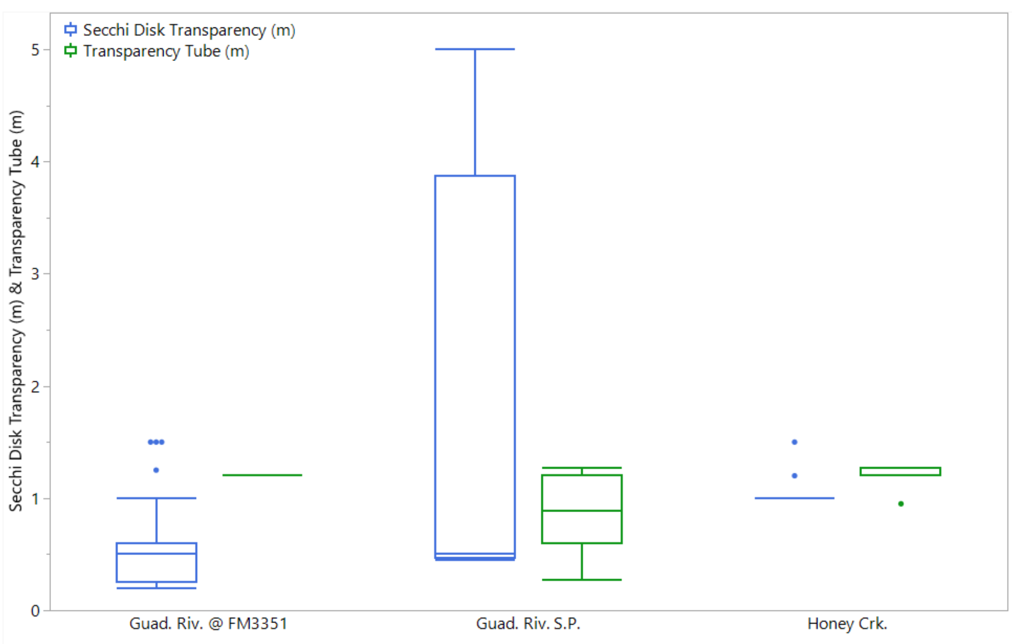

Figure 9. Secchi disc and transparency tube measurements for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (Feb 2008- Sep 2021).

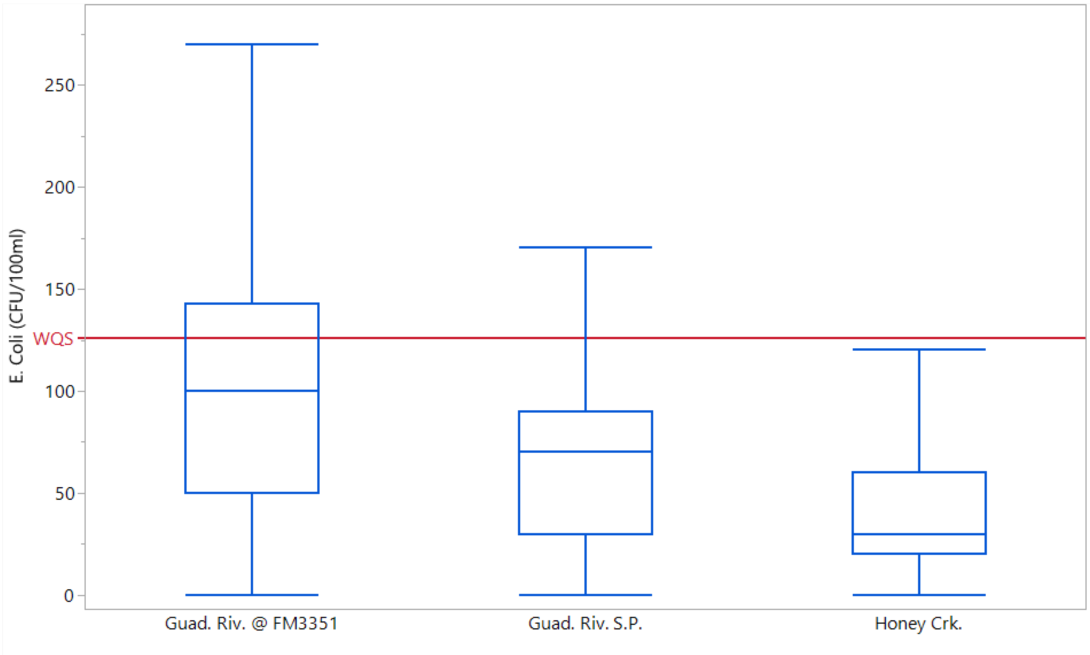

Figure 10. *E. coli* bacteria (CFU/100 mL) for Texas Stream Team sites in the Guadalupe River - Canyon Lake Watershed (February 2008 - September 2021).

WATERSHED SUMMARY

Texas Stream Team citizen scientists monitored Standard Core and *E. coli* Bacteria water quality parameters at three sites in the Guadalupe River – Canyon Lake Watershed from February 2008 to September 2021. Two sites were located on the Guadalupe River, while one site was located on Honey Creek. Parameters monitored included water and air temperature, specific conductance, total dissolved solids, dissolved oxygen, pH, transparency, total depth, and *E. coli* bacteria. Monitoring for the Advanced Texas Stream Team parameters nitrate-nitrogen and orthophosphate did not take place in the study area during the period of record. Data from the three monitoring sites were analyzed and summarized in this report.

Water quality standards and criteria for water temperature, TDS, DO, pH, and *E. coli* bacteria were met at all sites in the Guadalupe River – Canyon Lake Watershed. Although the WQS for TDS was met at all sites, some values at Honey Creek exceeded the standard. This is likely due to the proximity to spring water flowing into Honey Creek. Spring water is naturally higher in TDS than surface water due to the dissolution of minerals in groundwater aquifers. Additionally, all three sites had discreet DO measurements below the WQS at some point during the period of record, but the average DO values at all sites were above the WQS. The pH values at all three sites were within the range of the water quality standard (6.5 to 9.0 s.u.).

Although the Guadalupe River assessment unit within the study area is on the 2020 303(d) list of impaired waters for not meeting the *E. coli* bacteria standard for the contact recreation use, the geometric means for *E. coli* presented in this report met the WQS. All measurements at the Honey Creek site were below the bacteria WQS, but both sites on the Guadalupe River had discreet measurements that exceeded the bacteria WQS.

The Texas Stream Team citizen scientists monitoring Standard Core and *E. coli* Bacteria water quality parameters in the Guadalupe River – Canyon Lake Watershed are encouraged to continue monitoring and consider pursuing the Advanced water quality monitoring trainings and certifications. Continuation of the ongoing monitoring is crucial due to the results presented here and the potential for increased urbanization in this region of Texas. There is a need for water quality monitoring to continue for the development of long-term water quality data sets. The information gathered thus far has been useful to describe current water quality conditions. Continuation of this monitoring will allow future trend analysis to capture changes in water quality over time as the area grows. Texas Stream Team will continue to support current citizen scientists as needed by providing technical support, creating new monitoring sites, and re-activating existing sites, and we look forward to training new citizen scientists to expand and grow the water quality monitoring efforts in this area and beyond. For more information about Texas Stream Team and upcoming trainings contact us at TxStreamTeam@txstate.edu or visit the calendar of events on our website at www.TexasStreamTeam.org.

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Appendix A:

Table 1: Endangered species located within the Honey Creek Watershed

Species Type	Common Name	Federal/State Listing
Amphibians	Texas Blind Salamander	Federally Listed as Endangered, State Listed as Endangered
Birds	Whooping Crane	Federally Listed as Endangered, State Listed as Endangered
	Eskimo Curlew	Federally Listed as Endangered, State Listed as Endangered
	Golden-cheeked Warbler	Federally Listed as Endangered, State Listed as Endangered
	Interior Least Tern	State Listed as Endangered
Fish	Fountain Darter	Federally Listed as Endangered, State Listed as Endangered
Crustaceans	Peck's Cave Amphipod	Federally Listed as Endangered, State Listed as Endangered
Insects	Comal Springs Dryopid Beetle	Federally Listed as Endangered, State Listed as Endangered
	Comal Springs Riffle Beetle	Federally Listed as Endangered, State Listed as Endangered

Table 2: Threatened species located within the Honey Creek Watershed

Species Type	**Common Name**	**Federal/State Listing**
Amphibians	San Marcos Salamander	Federally Listed as Threatened, State Listed as Threatened
	Texas Salamander	State Listed as Threatened
	Cascade Caverns Salamander	State Listed as Threatened
Birds	Reddish Egret	State Listed as Threatened
	White-faced Ibis	State Listed as Threatened
	Wood Stork	State Listed as Threatened
	Zone-tailed Hawk	State Listed as Threatened
	Piping Plover	Federally Listed as Threatened, State Listed as Threatened
	Tropical Parula	State Listed as Threatened
Fish	Plateau Shiner	State Listed as Threatened
	Headwater Catfish	State Listed as Threatened
	Guadalupe Darter	State Listed as Threatened
Mammals	Black Bear	State Listed as Threatened
	White-nosed Coati	State Listed as Threatened
Reptiles	Cagle's Map Turtle	State Listed as Threatened
	Texas Tortoise	State Listed as Threatened
	Texas Horned Lizard	State Listed as Threatened
Mollusks	Guadalupe Fatmucket	State Listed as Threatened
	Guadalupe Orb	State Listed as Threatened
	False Spike	State Listed as Threatened
Plants	Bracted Twistflower	Federal Candidate for Listing