Geronimo Creek Watershed Data Report

October 2016

The preparation of this report was prepared in cooperation with, and financed through, grants from the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency.

Table of Contents

Introduction

Texas Stream Team is a volunteer-based citizen water quality monitoring program. Citizen scientists collect surface water quality data that may be used in the decision-making process to promote and protect a healthy and safe environment for people and aquatic inhabitants. Citizen scientist water quality monitoring occurs at predetermined monitoring sites, at roughly the same time of day each month. Citizen scientist water quality monitoring data provides a valuable resource of information by supplementing professional data collection efforts where resources are limited. The data may be used by professionals to identify 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. Texas Stream Team citizen scientists use different methods than the professional water quality monitoring community. These methods are not utilized by Texas Stream Team due to higher equipment costs, training requirements, and stringent laboratory procedures that are required of the professional community. As a result, Texas Stream Team data do not have the same accuracy or precision as professional data, and are not directly comparable. However, the data collected by Texas Stream Team provides valuable records, often collected in portions of a water body that professionals are not able to monitor frequently, or monitor at all. This long-term data set is available, and may be considered by the surface water quality professional community to facilitate management and protection of Texas water resources. For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer monitoring, please refer to the following sources:

- Texas Stream Volunteer Water Quality Monitoring Manual
- Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring Procedures

The information that Texas Stream Team citizen scientists collect is covered under a TCEQ approved Quality Assurance Project Plan (QAPP) to ensure that a standard set of methods are used. All data used in watershed data reports are screened by the Texas Stream Team for completeness, precision, and accuracy, in addition to being scrutinized for data quality objectives and with data validation techniques.

The purpose of this report is to provide analysis of 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 in order to provide a holistic view of water quality in this water body. Such sources include, but are not limited to, the following potential resources:

- Texas Surface Water Quality Standards
- Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)
- Texas Clean Rivers Program partner reports, such as Basin Summary Reports 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

Questions regarding this watershed data report should be directed to the Texas Stream Team at (512) 245-1346.

Watershed Location and Physical Description

Location and Climate

Geronimo Creek as well as its tributary Alligator Creek are located within Comal and Guadalupe Counties. The approximately 70-square-mile (44,800 acres) watershed lies within the larger Guadalupe River Basin. The headwaters of Alligator Creek are located in southeastern Comal County, just above IH-35. Alligator Creek flows southeast towards Seguin until approximately halfway in the watershed at which point it flows into Geronimo Creek. The majority of Alligator Creek is intermittent with pools during much of the year, until slightly above its confluence with Geronimo Creek, where it begins to receive spring flow. Geronimo Creek begins approximately 1 mile east of the community of Clear Springs in northwestern Guadalupe County and runs southeast for 17 miles into its confluence with the Guadalupe River, which is located 3 miles southeast of Seguin. The majority of the Alligator Creek watershed is located within the extra-territorial jurisdiction (ETJ) of New Braunfels, while the majority of the Geronimo Creek watershed is located almost completely within the ETJ of Seguin. Geronimo Creek is a perennial river, with Alligator Creek, Baer Creek, an unnamed tributary, and numerous springs along its length contributing to its flow. (Geronimo and Alligator Creeks Watershed Protection Plan 2012)

Physical Description

While the headwaters of Alligator Creek are located in the Edwards Plateau/Blackland Prairies transition ecoregion zone, the bulk of Alligator Creek and the entirety of Geronimo Creek flow through the Blackland Prairie ecoregion. (Geronimo and Alligator Creeks Watershed Protection Plan 2012) The Edwards Plateau ecoregion is a region dominated by Ashe Juniper, Oaks, and Honey Mesquite with riparian corridors dominated by Bald Cypress, Pecan, Hackberry and Sycamores, located in a rugged, semi-arid region of central Texas. The Texas Blackland Prairies ecoregion was historically dominated by tallgrass species on uplands and by deciduous woodlands along riparian corridors (USDA, 1984). Geronimo Creek is representative of a minimally altered stream system within the Blackland Prairie. The ecoregion has extensive fish communities that include species such as the Central Stoneroller, Orangethroat Darter, Texas Logperch, Texas Shiner, Largemouth and Spotted Bass, Channel Catfish and multiple species of Sunfish. It also is home to many benthic macrinvertebrates such as mayflies, dragonflies, aquatic beetle species, and dobsonflies. Both Comal and Guadalupe Counties have several federal and state listed endangered or threated species (Texas Parks & Wildlife 2016):

Amphibians	Cascade Caverns Salamander	Mammals	Black Bear
	Comal Blind Salamander		Jaguarundi
Birds	American Peregrine Falcon		Red Wolf
	Bald Eagle	Mollusks	False Spike Mussel
	Black-Capped Vireo		Golden Orb
	Interior Least Tern		Texas Pimpleback
	Golden-Cheeked Warbler		Texas Fatmucket
	Peregrine Falcon	Reptiles	Cagle's Map Turtle
	Whooping Crane		Texas Horned Lizard
	Wood Stork		Texas Tortoise
	Zone-tailed Hawk		Timber Rattlesnake
Crustaceans	Peck's Cave Amphipod	Plants	Bracted Twistflower
Fishes	Fountain Darter		
Insects	Comal Springs Dryphoid Beetle		
	Comal Springs Riffle Beetle		

In addition, both counties have several Species of Greatest Conservation Need (SGCN). These species are in decline or are rare and are in need of attention in order to recover and prevent them from becoming listed species (Texas Parks & Wildlife 2016):

Amphibians	Comal Springs Salamander	Plants (*cont.*)	Gravel Brickellbush
	Edwards Plateau Spring Salamander		Green Beebalm
Birds	Mountain Plover		Heller's Marbleseed
	Sprague's Pipit		Hill Country Wild-Mercury
	Western Burrowing Owl		Low Spurge
Crustaceans	Ezell's Cave Amphipod		Narrowleaf Brickllbush
	Long-legged Cave Amphipod		Net-Leaf Bundleflower
Fishes	Guadalupe Bass		Osage Plains False Foxglove
Insects	A Mayfly		Parks' Jointweed
	Comal Springs Diving Beetle		Plateau Loosestrife
	Comal Springs Diving Beetle		Plateau Milkvine
	Edwards Aquifer Diving Beetle		Sandhill Woollywhite
Mammals	Cave Myotis Bat		Scarlet Leather-Flower
	Plains Spotted Skunk		South Texas Spikesedge
Mollusks	Horseshoe Liptooth Snail		Sycamore-Leaf Snowbell
Reptiles	Spot-tailed Earless Lizard		Texas Almond
	Texas Garter Snake		Texas Amorpha
Plants	Big Red Sage		Texas Barberry
	Buckley Tridens		Texas Fescue
	Comal Snakewood		Texas Seymeria
	Darkstem Noseburn		Tree Dodder
	Elmendorf's Onion		Wright's Trichocoronis
	Glass Mountains Coral-Root		

Soils located in the upper end of Alligator Creek's watershed tend to be shallow, clayey soils with rocky outcrops (Edwards Plateau zone), transitioning into deeper clay soils located on gently rolling hills farther downstream (Blackland Prairies zone) towards the confluence with Geronimo Creek. However, it should be noted that soils across both ecological regions are highly variable. Flows in Alligator Creek are intermittent, chiefly occurring only during, as well as immediately after, rainfall events. About midway through the watershed before Alligator Creek joins with Geronimo Creek, spring flows begin to provide a more consistent supply of water. Geronimo Creek is also an intermittent stream at its headwaters above the confluence with Alligator Creek, but receives significant spring flows downstream from this point. The Geronimo Creek's watershed, which includes Alligator Creek, lies within a humid subtropical climate zone, which is characterized by hot summers. The average annual rainfall for the area is just below 31 inches. The wettest year on record was 1949 which had a total annual rainfall of 49.47 inches. However, in 2008 the total annual rainfall for Guadalupe County was slightly more than 10 inches. (Geronimo and Alligator Creeks Watershed Protection Plan 2012)

Land Use

Both the upper and lower ends of the watershed are mostly made up of urbanized areas. This urbanization is because the upper area is that of New Braunfels while the lower area is made up of Seguin. Rural, agricultural and ranching production occurs between these two urbanized centers due to the land being rich in oil and minerals (Gesick 2015). The ETJs of both of these cities covers nearly the entire watershed.

There has been a significant change in land use since 1960. This can be seen with the conversion of land previously used for agricultural purposes into urban areas, predominately in and around the cities of New Braunfels and Seguin. In 2000, the population of New Braunfels was 36,494 while the population of Seguin was 22,011. In 2010, the populations of New Braunfels grew to 57,740 and Seguin's grew to 25,175, making the percent growth for these cities in a 10 year period 58% and 14%, respectively (U.S. Census 2016). Both cities are projected to have significant increases in population growth within the next several decades. New Braunfels is projected to have a 2050 population of 126,546 while Seguin is projected to grow to 55,756 (Texas Water Development Board 2016). The increase in population within the watershed area may have significant land use changes.

Another significant change in land use has been within the agricultural realm which took place in the 1960s and 1970s by converting cropland to pastureland. Due to low fertility and/or erosion, a portion of the cropland production was marginal, and was changed into rangeland and managed pastures which resulted in a net loss of cropland. Despite this, the area is still dominated by agriculture, with some kind of agricultural production accounting for 92% of the land use. Ranch operations typically involve the raising of cattle and goats, while corn, cotton, sorghum and oat production make up the major row crops in the watershed (Geronimo and Alligator Creeks Watershed Protection Plan 2012).

History

The earliest settlers in the Geronimo Creek watershed were Native Americans who belonged to the Lipan Apache, Comanche and Tonkawa tribes. These tribes were drawn to the area by the springs. The tribes were mostly nomadic, but there is evidence of their presence in the Geronimo Creek in the form of arrowheads, tools and other artifacts found along the creek.

Agriculture has always been a crucial activity in the Geronimo Creek watershed. The town of Geronimo served as the center of the farming and ranching community, due to its cotton gins, grain storage, markets, merchandise, grocery stores and meeting hall (Geronimo and Alligator Creeks Watershed Protection Plan 2012).

Watershed Protection Plan

A Watershed Protection Plan (WPP) for Geronimo Creek was created in 2012. The Texas State Soil and Water Conservation Board (TSSWCB) Regional Watershed Coordination Steering Committee (WCSC) selected Geronimo Creek for the development of a watershed protection plan based on criteria including its presence on the Clean Water Act (CWA) 303(d) List for bacteria, nutrient concerns for the river, the potential for success, ongoing activities, as well as the level of stakeholder interest.

- 303(d) Listing:
    - SegID: 1804A Geronimo Creek – From the confluence of the Guadalupe River south of Seguin in Guadalupe County to the upstream perennial portion north of Seguin in Guadalupe County
        - Bacteria (5c) – First listed 2006
            - 1804A_01 – Entire Body of Water

(TCEQ 2014)

After public meetings were held in New Braunfels and Seguin, the Geronimo and Alligator Creeks Watershed Partnership was formed for the purpose of guiding the WPP development process. Led by the Steering Committee, the Partnership is working with citizens, businesses, public officials and state and federal agencies with authority pertaining to the watershed in order to reestablish the health of the Geronimo and Alligator Creeks Watershed. The Partnership recognizes that any success in improving and protecting the water resources of the area depends on the people who currently live and work within the watershed. The Geronimo and Alligator Creeks Watershed Protection Plan that was created through these efforts will serve as a guiding document for the restoration and protection of the local water resources. (Geronimo and Alligator Creeks Watershed Protection Plan 2012)

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.

Natural sources of warm water are seasonal, 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 release warmer water. Citizen scientist monitoring may not identify fluctuating patterns due to diurnal changes or events such as power plant releases. While citizen scientist data does not show diurnal temperature fluctuations, it may demonstrate the fluctuations over seasons and years.

Dissolved Oxygen

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 stream flow. The TCEQ Water Quality Standards document lists daily minimum Dissolved Oxygen (DO) criteria for specific water bodies and presumes criteria according to flow status (perennial, intermittent with perennial pools, and intermittent), aquatic life attributes, and habitat. These criteria are protective of aquatic life and can be used for general comparison purposes.

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 growth and algae, which may starve subsurface vegetation of sunlight, and therefore limit the amount of DO in a water body due to reduced photosynthesis. This process, known as eutrophication, is enhanced when the subsurface vegetation and algae die and oxygen is consumed by bacteria during decomposition. Low DO levels may also result from high groundwater inflows due to minimal groundwater aeration, high temperatures that reduce oxygen solubility, or water releases from deeper portions of dams where DO stratification occurs. Supersaturation typically only occurs underneath waterfalls or dams with water flowing over the top.

Specific Conductivity and Total Dissolved Solids

Specific conductivity is a measure of the ability of a body of water to conduct electricity. It is measured in micro Siemens per cubic centimeter ($\mu S/cm^3$). A body of water is more conductive if it has more dissolved solids such as nutrients and salts, which indicates poor water quality if they are overly abundant. High concentrations of nutrients can lower the level of 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 Total Dissolved Solids (TDS) can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants. For this report, specific conductivity values have been converted to TDS using a conversion factor of 0.65 and are reported as mg/L.

pH

The pH scale measures the concentration of hydrogen ions on a range of 0 to 14 and is reported in standard units (su). The pH of water can provide useful information regarding acidity or alkalinity. The range is logarithmic; therefore, every 1 unit change is representative of a 10-fold increase or decrease in acidity. 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 power 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. The most suitable pH range for healthy organisms is between 6.5 and 9.

Secchi disk and total depth

The Secchi disk is used to determine the clarity of the water, a condition known as turbidity. The disk is lowered into the water until it is no longer visible, and the depth is recorded. 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 results from sediment washing away from construction sites, erosion of farms, or mining operations. Average Secchi disk transparency (a.k.a. Secchi depth) readings that are less than the total depth readings indicate turbid water. Readings that are equal to total depth indicate clear water. Low total depth observations have a potential to concentrate contaminants.

E. coli Bacteria

E. coli bacteria originate in the digestive tract of endothermic organisms. The EPA has determined *E. coli* to be the best indicator of the degree of pathogens in a water body, which are far too numerous to be tested for directly, considering the amount of water bodies tested. A pathogen is a biological agent that causes disease. The standard for *E. coli* impairment is based on the geometric mean (geomean) of the *E. coli* measurements taken. A geometric mean is a type of average that incorporates the high variability found in parameters such as *E. coli* which can vary from zero to tens of thousands of CFU/100 mL. The standard for contact recreational use of a water body such as Geronimo Creek Watershed is 126 CFU/100 mL. A water body is considered impaired if the geometric mean is higher than this standard.

Nitrate-Nitrogen

Nitrogen is present in terrestrial or aquatic environments as nitrates, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with the 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 livestock and pet waste, excessive fertilizer use, failing septic systems, and industrial discharges that contain corrosion inhibitors. The effect nitrogen has on a water body is known as eutrophication and is described above under the “Dissolved Oxygen” section. Nitrates dissolve more readily than phosphates, which tend to be attached to sediment, and therefore can serve as a better indicator of the possibility of sewage or manure pollution during dry weather.

Texas Surface 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 so that it supports public health and protects 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 (or drinking water). The criteria for evaluating support of those uses include DO, temperature, pH, TDS, toxic substances, and bacteria.

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.

Data Analysis Methodologies

Data Collection

The field sampling procedures are documented in Texas Stream Team Water Quality Monitoring Manual and its appendices, or the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012). Additionally, all data collection adheres to Texas Stream Team's approved Quality Assurance Project Plan (QAPP).

Table 1: Sample Storage, Preservation, and Handling Requirements

Parameter	Matrix	Container	Sample Volume	Preservation	Holding Time
E. coli	Water	Sterile Polystyrene (SPS)	100	Refrigerate at 4ºC*	6 hours
Nitrate/Nitrogen	Water	Plastic Test Tube	10 mL	Refrigerate at 4ºC*	48 hours
Orthophosphate/Phosphorous	Water	Glass Mixing Bottle	25 mL	Refrigerate at 4ºC*	48 hours
Chemical Turbidity	water	Plastic Turbidity Column	50 mL	Refrigerate at 4ºC*	48 hours

*Preservation performed within 15 minutes of collection.

Processes to Prevent Contamination

Procedures documented in Texas Stream Team Water Quality Monitoring Manual and its appendices, 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 (QC) samples are collected to verify that contamination has not occurred.

Documentation of Field Sampling Activities

Field sampling activities are documented on the field data sheet. For all field sampling events the following items are recorded: station ID, location, sampling time, date, and depth, sample collector's name/signature, group identification number, conductivity meter calibration information, and reagent expiration dates are checked and recorded if expired.

For all *E. coli* sampling events, station ID, location, sampling time, date, depth, sample collector's name/signature, group identification number, incubation temperature, incubation duration, *E. coli* colony counts, dilution aliquot, field blanks, and media expiration dates are checked and recorded if expired.

Values for all measured parameters are recorded. If reagents or media are expired, it is noted and communicated to Texas Stream Team.

Sampling is still encouraged with expired reagents and bacteria media; however, the corresponding values will be flagged in the database. Detailed observational data are recorded, including 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 and administrative purposes.

Data Entry and Quality Assurance

Data Entry

The citizen scientists collect field data and report the measurement results on Texas Stream Team approved physical or electronic datasheet. The physical data sheet is submitted to the Texas Stream Team and local partner, if applicable. The electronic datasheet is accessible in the online DataViewer and, upon submission and verification, is uploaded directly to the Texas Stream Team Database.

Quality Assurance & Quality Control

All data are reviewed to ensure that they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to specified monitoring procedures and project specifications. The respective field, data management, and Quality Assurance Officer (QAO) data verification responsibilities are listed by task in the Section D1 of the QAPP, available on the Texas Stream Team website.

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. If there are errors in the calibration log, expired reagents used to generate the sampling data, or any other deviations from the field or *E. coli* data review checklists, the corresponding data is flagged in the database.

When the QAO receives the physical data sheets, they are validated using the data validation checklist, and then entered into the online database. Any errors are noted in an error log and the errors are flagged in the Texas Stream Team database. When a citizen scientist enters data electronically, the system will automatically flag data outside of the data limits and the citizen scientist will be prompted to correct the mistake or the error will be logged in the database records. The certified QAO will further review any flagged errors before selecting to validate the data. After validation the data will be formally entered into the database. Once entered, the data can be accessible through the online DataViewer.

Errors, which may compromise the program's ability to fulfill the completeness criteria prescribed in the QAPP, will be reported to the Texas Stream Team Program Manager. If repeated errors occur, the citizen scientist and/or the group leader will be notified via e-mail or telephone.

Data Analysis Methods

Data are compared to state standards and screening levels, as defined in the Surface Water Quality Monitoring Procedures, to provide readers with a reference point for amounts/levels of parameters that may be of concern. The assessment performed by TCEQ and/or designation of impairment involves more complicated monitoring methods and oversight than used by volunteers and staff in this report. The citizen water quality monitoring data are not used in the assessments mentioned above, but are intended to inform stakeholders about general characteristics and assist professionals in identifying areas of potential concern.

Standards & Exceedances

The TCEQ determines a water body to be impaired if more than 10% of samples, provided by professional monitoring, from the last seven years, exceed the standard for each parameter, except for *E. coli* bacteria. When the observed sample value does not meet the standard, it is referred to as an exceedance. At least ten samples from the last seven years must be collected over at least two years with the same reasonable amount of time between samples for a data set to be considered adequate. The 2014 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Geronimo Creek Watershed, as seen below in Table 2.

Table 2: Summary of Surface Water Quality Standards for the Geronimo Creek Watershed

Parameter	Texas Surface Water Quality Standard 2014
Water Temperature (°C)	32.2
Total Dissolved Solids (mg/L)	400
Dissolved Oxygen (mg/L)	5.0
pH (su)	6.5-9.0
E.coli (CFU/100 mL)	126 (geomean during sampling period)

Methods of Analysis

All data collected from Geronimo Creek were exported from the Texas Stream Team database and were then grouped by site. Data was reviewed and, for the sake of data analysis, only one sampling event per month, per site was selected for the entire study duration.

Once compiled, data was sorted and graphed in Microsoft Excel 2010 using standard methods. Trends over time were analyzed using a linear regression analysis in Minitab v 15. Statistically significant trends were added to Excel to be graphed. The cut off for statistical significance was set to a p-value of ≤ 0.05. A p-value of ≤ 0.05 means that the probability that the observed data matches the actual conditions found in nature is 95%. As the p-value decreases, the confidence that it matches actual conditions in nature increases.

For this report, specific conductivity measurements, gathered by volunteers, were converted to TDS using the TCEQ-recommended conversion formula of specific conductivity 0.65. This conversion was made so that volunteer gathered data could be more readily compared to state gathered data. Geomeans were calculated for *E. coli* data for trends and for each monitoring site.

Geronimo Creek Watershed Data Analysis

In May 2015, the National Oceanic and Atmospheric Administration observed a total of 9.56 inches of rain at the Seguin 2.7 ESE weather station. On several occasions, the USGS gage for the Guadalupe River at FM 1117 near Seguin, TX recorded a Daily maximum discharge of over 10,000 cubic feet per second, during the year of 2015. Impacts of flooding can cause changes in the turbidity of the stream, and consequently alter the amount of total dissolved solids in the water. This area has shown signs of drought recovery, but some drought impacts remain.

Geronimo Creek Watershed Map

All shapefiles were downloaded from reliable federal, state, and local agencies.

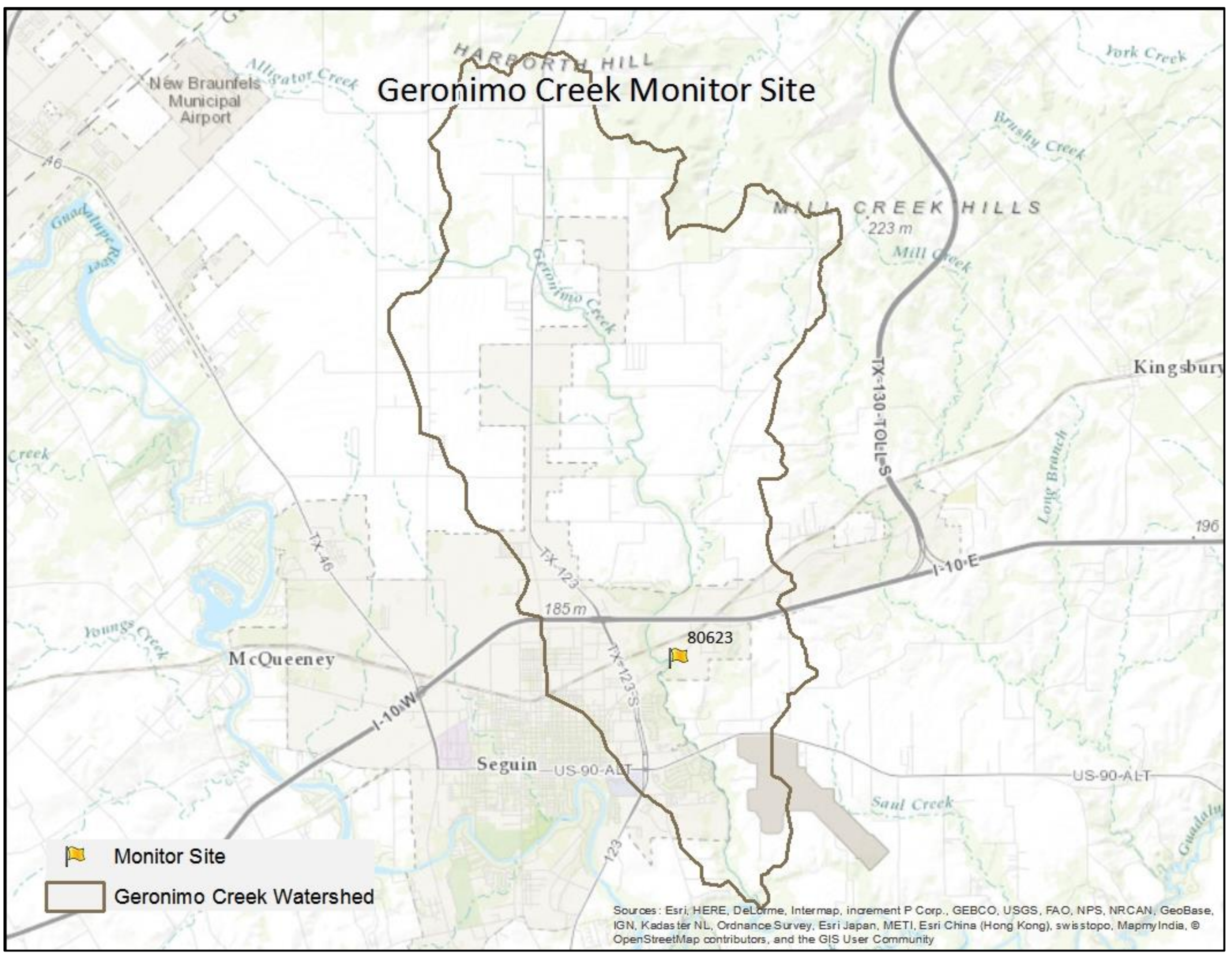

Figure 1: Map of the Geronimo Creek Watershed with Texas Stream Team Monitor Sites

Only one site found within Geronimo Creek was tested by citizen scientists for water quality data: site 80623 is Geronimo Creek at the Seguin Outdoor Learning Center as noted on Figure 1. The site is located at the bend in the creek downstream of the Highway 90 crossing. The area is heavily wooded with oak and pecan trees.

Geronimo Creek Watershed Trends over Time

Sampling Trends over Time

Sampling in the Geronimo Creek Watershed began in January of 2010 and continues to this day. A total of 51 monitoring events from 1 site have been analyzed. Monthly monitoring occurred on a consistent basis starting in 2011. Sampling was conducted in the morning between 10:00 and 11:00.

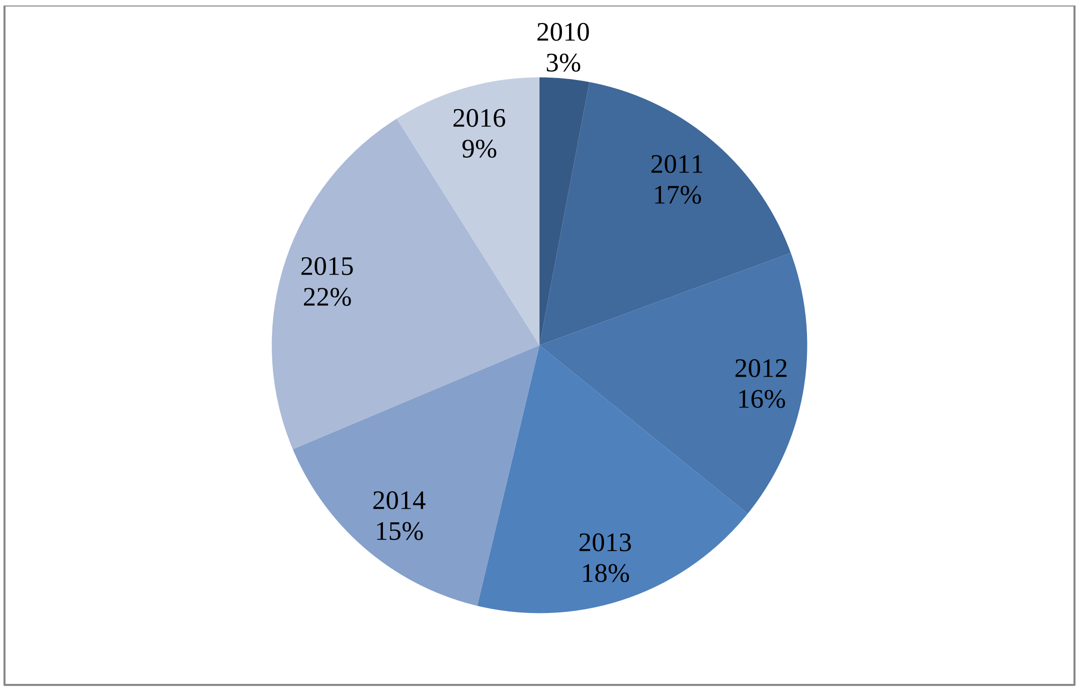

Figure 2: Breakdown of monitoring events by year.

Table 3: Descriptive parameters for all sites in the Geronimo Creek Watershed

Geronimo Creek Watershed January 2010 – June 2016				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	62	479 ± 69	130	618
Water Temperature (°C)	66	20.3 ± 5.6	7.0	28.5
Dissolved Oxygen (mg/L)	66	6.6 ± 1.4	4.6	10.0
pH	66	7.5 ± 0.14	7.0	8.0
E. coli	50	208	1	2500
Nitrates	51	4.0 ± 2.0	1.0	9.0

There were a total of 67 sampling events between 1/2/2010 and 06/18/2016. Mean is listed for all parameters except for E. coli which is represented as the geomean.

Trend Analysis over Time

Air and water temperature

A total of 66 air and water temperature samples were recorded in the Geronimo Creek Watershed between 2010 and 2016. Water temperature never exceeded the TCEQ optimal temperature of 32.2 °C. The mean water temperature was 19.8 °C. Water temperature ranged from a low of 7.0 °C in January of 2015, to a high of 28.5 °C in July of 2015. Air temperature ranged from a low of 1.8 °C in February of 2011, to a high of 30.5 °C in July of 2014.

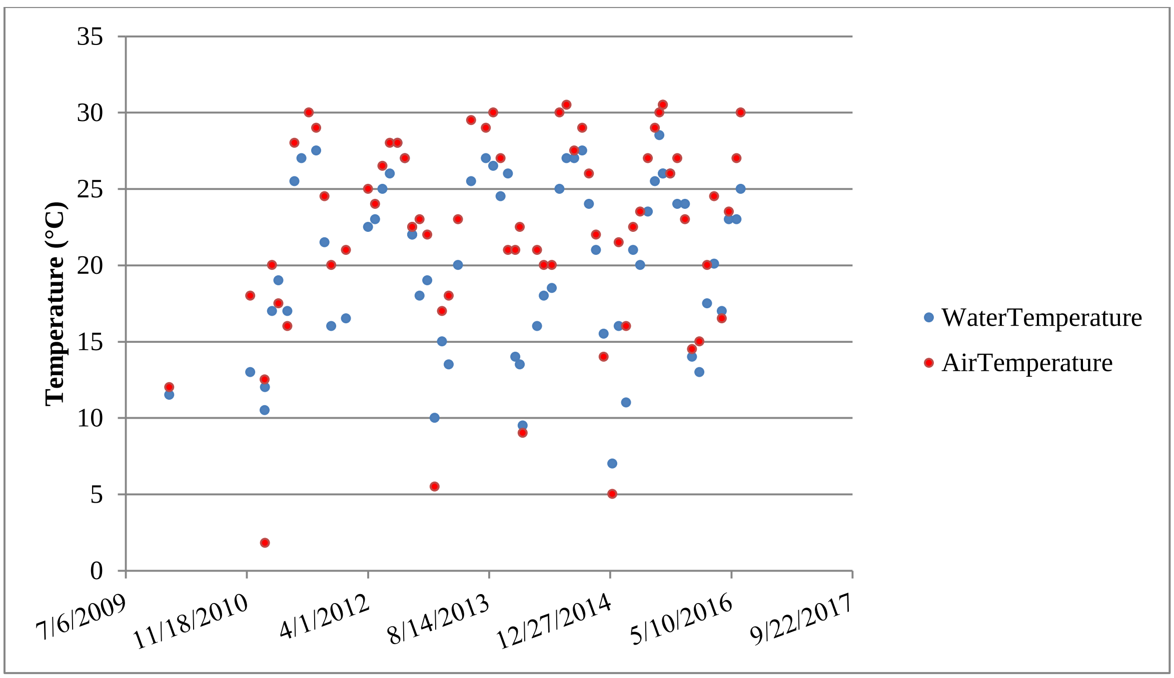

Figure 3: Air and water temperature over time at all sites within the Geronimo Creek Watershed

Total Dissolved Solids

Citizen scientists conducted a total of 62 total dissolved solids measurements within the watershed. The mean TDS concentration for site 80623 was 479 mg/L. The concentration of TDS ranged from a low of 130 mg/L in June 2016 to a high of 618 mg/L in July 2015. There was a significant decreasing trend in TDS concentrations observed over time in the watershed ($p = 0.022$). However, the low R^2 value of 0.08 indicates a fairly weak relationship in the variation of the data.

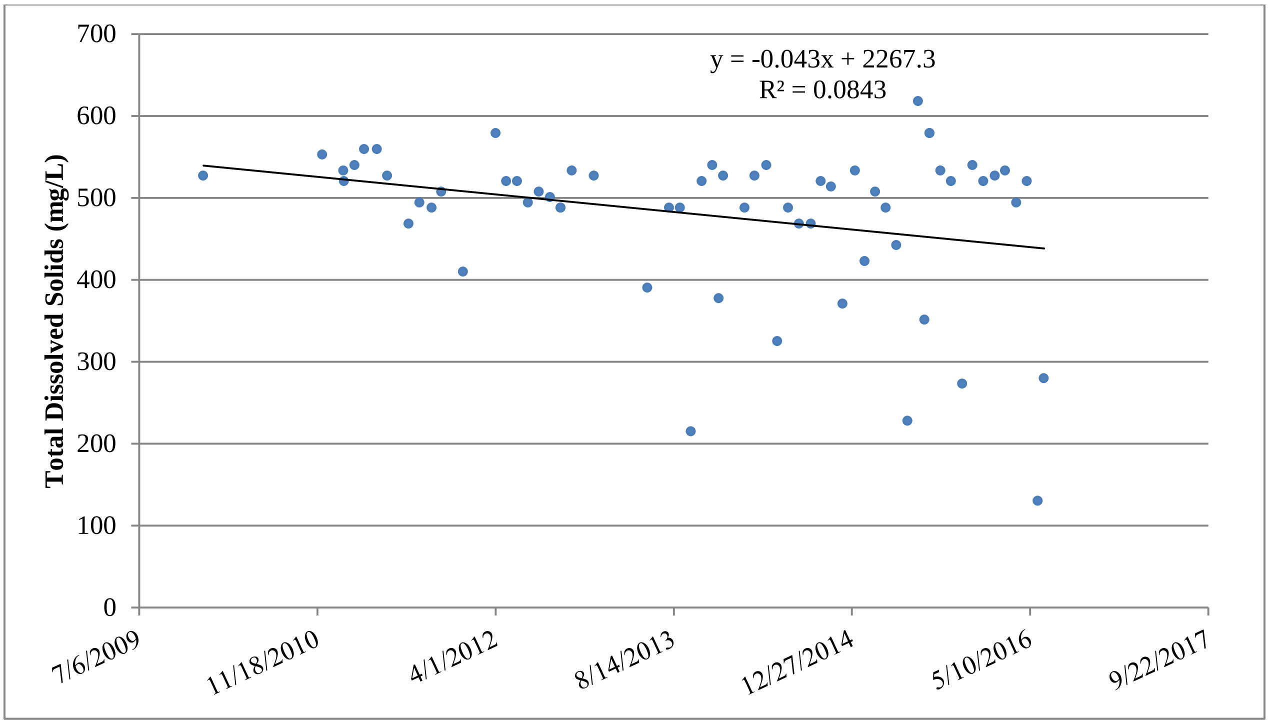

Figure 4: Total dissolved solids over time at the site within the Geronimo Creek Watershed

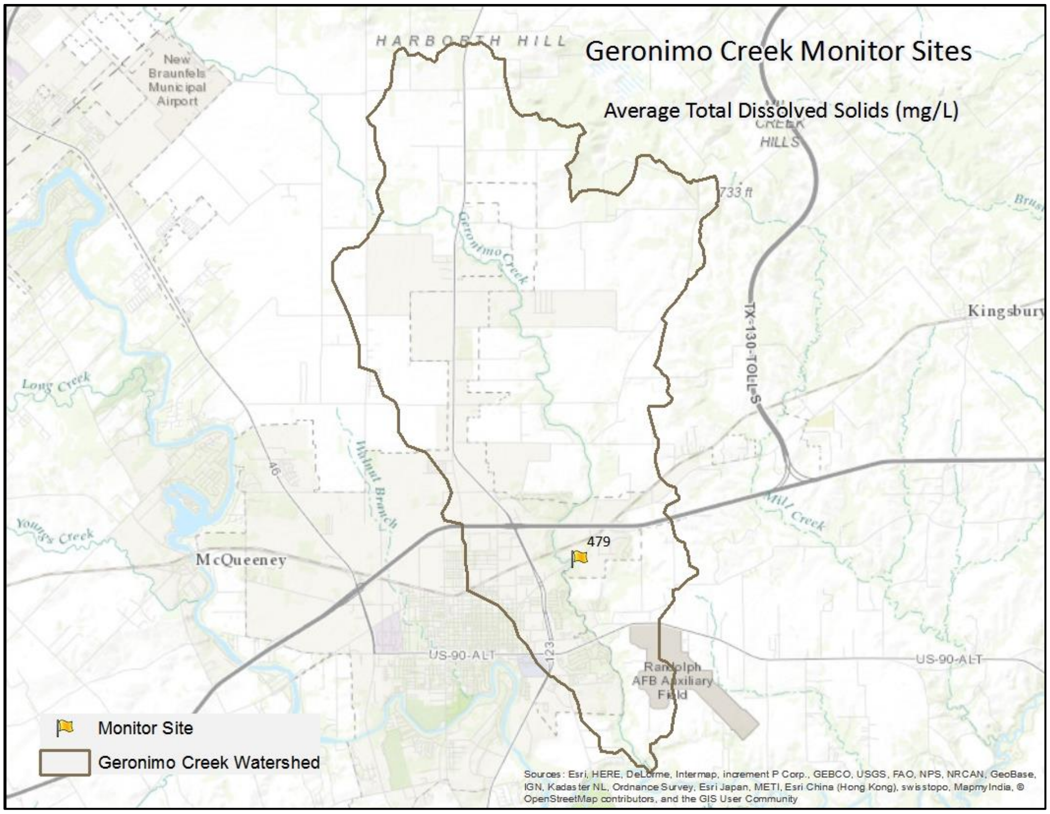

Figure 5: Map of the average total dissolved solids for the site in the Geronimo Creek Watershed

Dissolved Oxygen

Citizen scientists collected a total of 67 dissolved oxygen samples in the watershed. The mean DO concentration was 6.6 mg/L. The minimum DO concentration was 4.6 mg/L in June of 2013 and the maximum DO concentration was 10.0 mg/L which was recorded in January of 2015. There was not a significant relationship in dissolved oxygen over time that was observed.

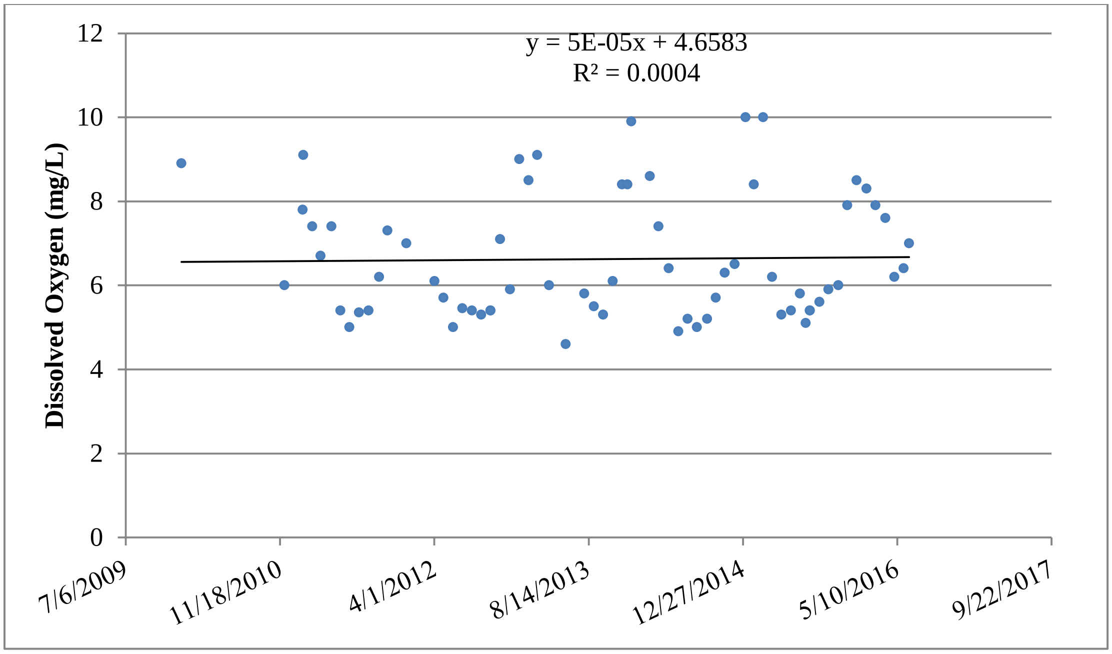

Figure 6: Water temperature and dissolved oxygen over time at all sites within the Geronimo Creek Watershed

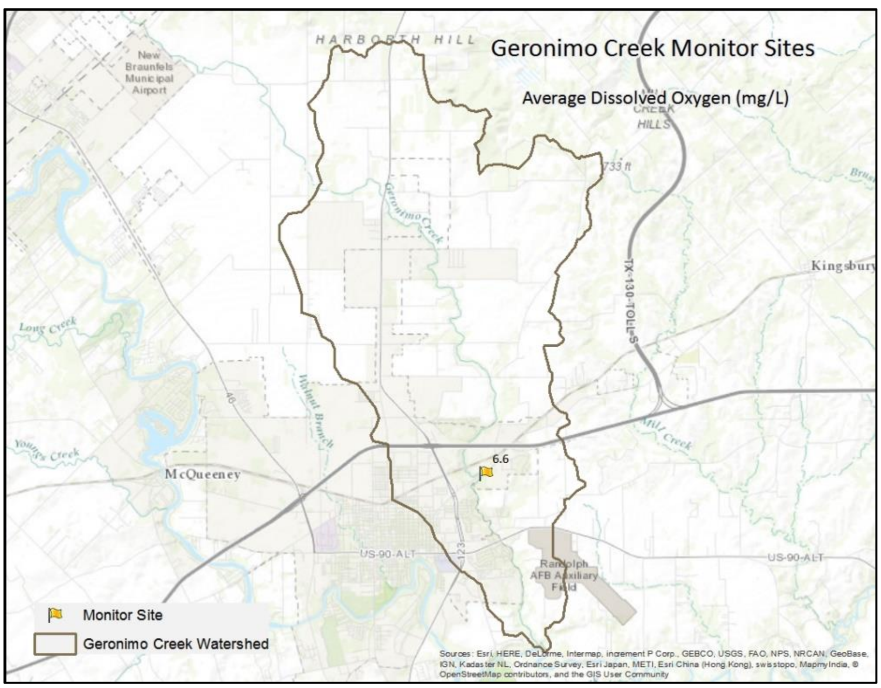

Figure 7: Map of the average dissolved oxygen for the site in the Geronimo Creek Watershed

pH

Citizen scientists took 66 pH measurements within the watershed. The mean pH was 7.5 with the pH ranging from a low of 7.0 in October of 2013, to a high of 8.0 in January and February of 2011. There was a significant decrease in pH values observed over time at this site, but the R-squared value of .096 suggests a weak relationship between the variables and variance within the dataset.

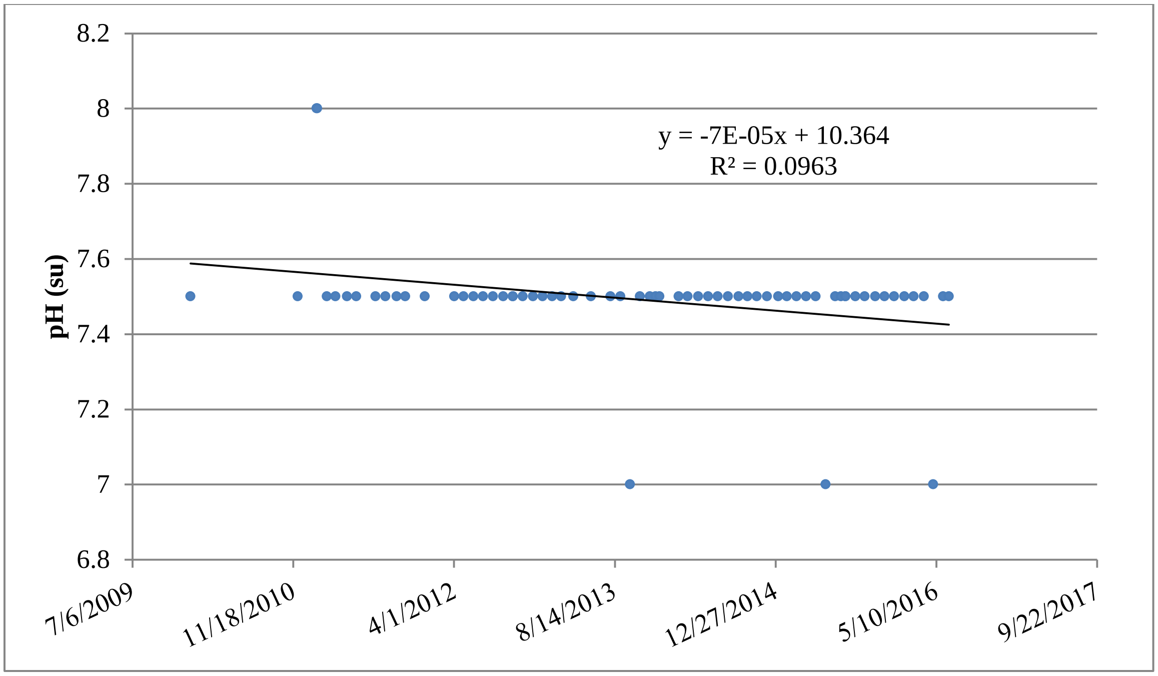

Figure 8: pH over time at the site within the Geronimo Creek Watershed

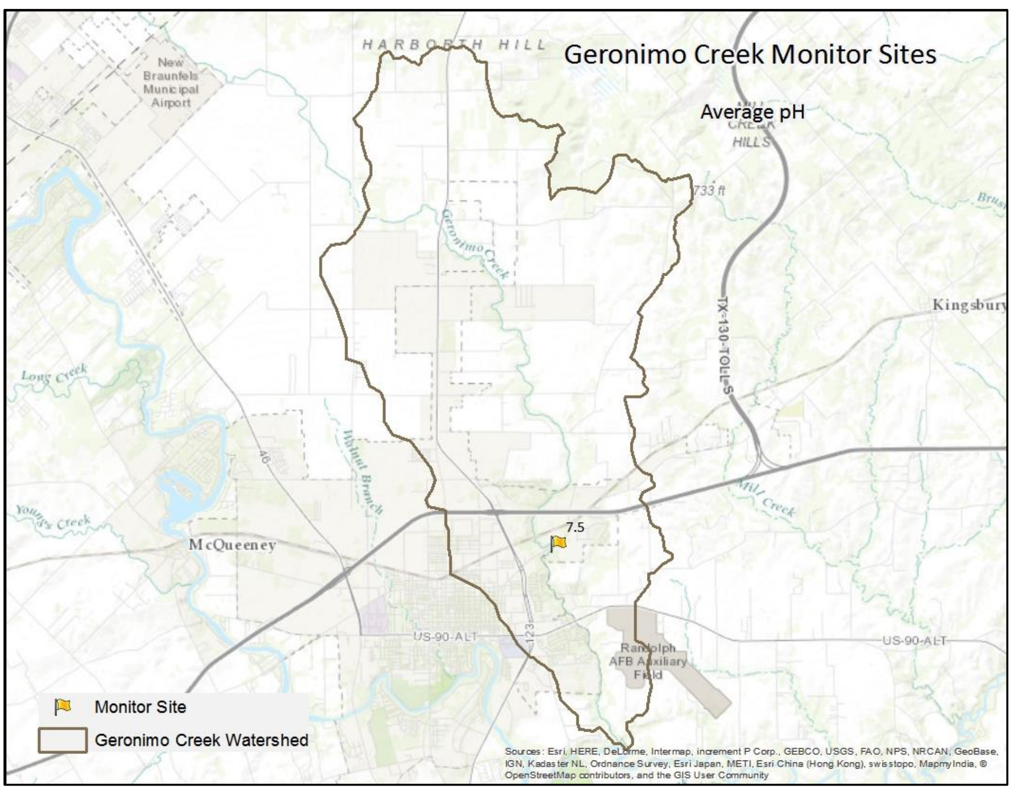

Figure 9: Map of the average pH for the site in the Geronimo Creek Watershed

Secchi disk and total depth

The Secchi disk depth was greater than the total depth for all but two of the 50 monitoring events. The mean Secchi disk depth was 0.39 m, and the mean total depth was 0.4 m.

Field Observations

The flow varied from low to high in the watershed throughout the time period. Algae was never present and the water color varied from no color to dark green to tan. Water clarity was usually cloudy or turbid with a few clear samples.

E. coli Bacteria

There were 50 E. coli samples taken in this watershed. The geomean for E. coli was 208 CFU/100 mL. The minimum E. coli count was <1 CFU/100 mL on multiple occasions and the maximum E. coli count was 2500 CFU/100 mL in December of 2014. There was no significant relationship in E. coli concentrations over time observed.

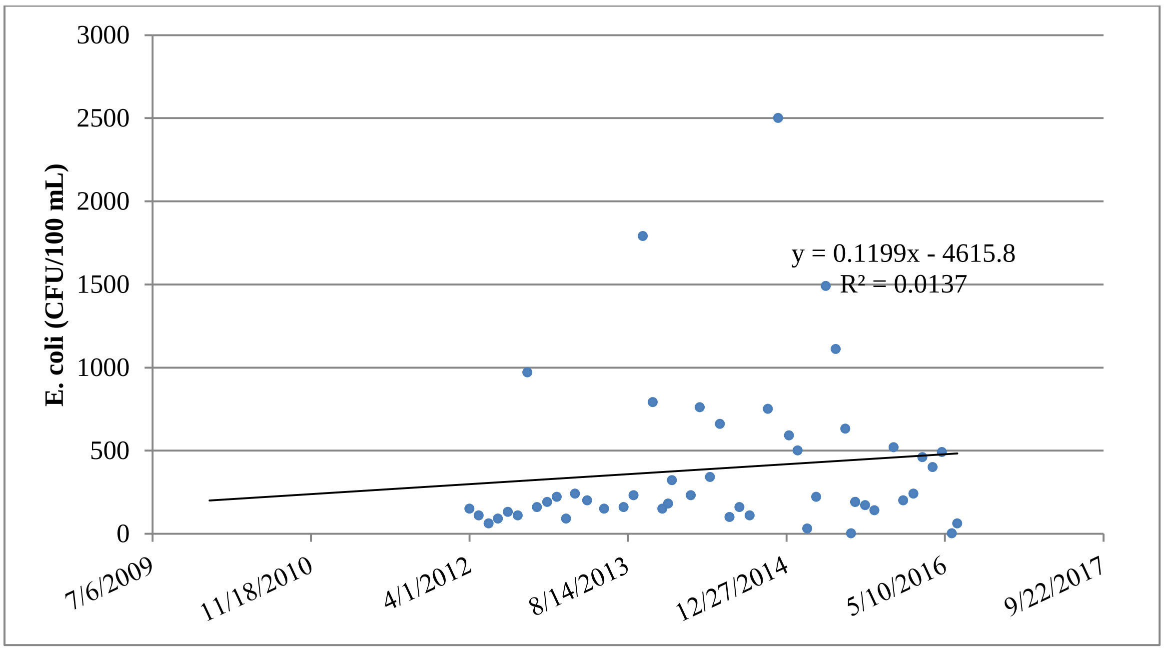

Figure 10: E. coli in the Geronimo Creek Watershed.

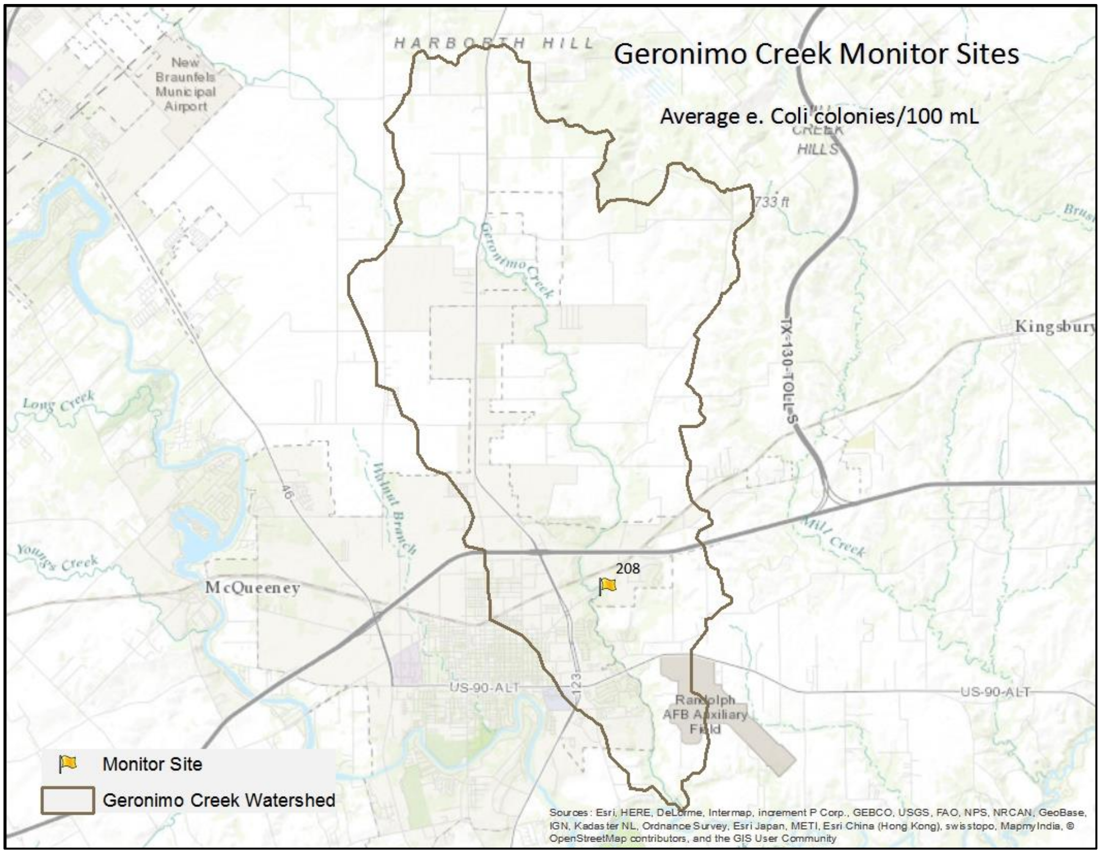

Figure 11: Map of the average e. Coli colonies for the site in the Geronimo Creek Watershed

Nitrate-Nitrogen

There were 51 Nitrate-Nitrogen samples collected in the Geronimo Creek Watershed. The Nitrate-Nitrogen measurements ranged from a low of 1.0 mg/L on multiple occasions, to a high of 9.0 mg/L in April, 2012. There was a significant decrease in Nitrate-Nitrogen concentrations over time ($p = 0.014$). The R-squared value of .12 conveys that the sampling dates reflect approximately 12% of the variance within the dataset.

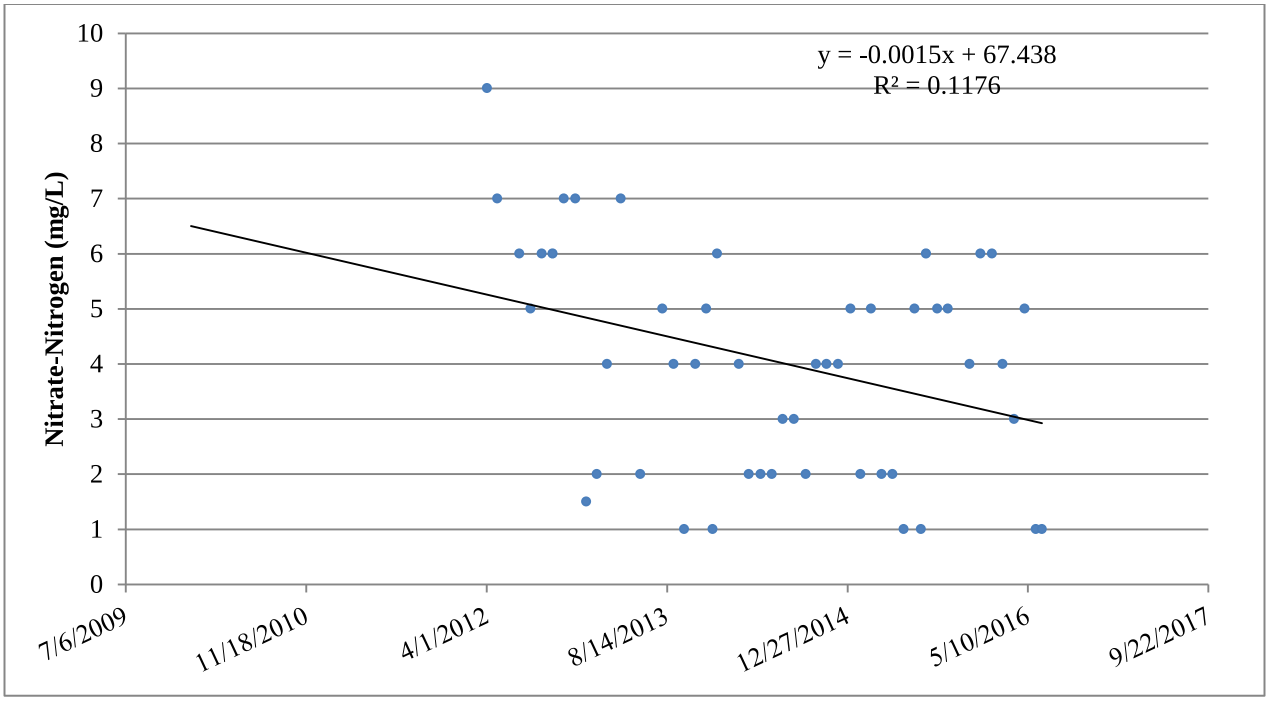

Figure 12: Nitrate-Nitrogen in the Geronimo Creek Watershed.

Geronimo Creek Watershed Summary

The Geronimo Creek Watershed is located in both the Comal and Guadalupe counties within the Edwards Plateau and Blackland Prairies ecoregions of Texas. Because of the variance of ecoregions within the watershed, the area has highly variable soils and vegetation types. Over 65 species of fauna may be found within the watershed that are listed as endangered, threatened, or in need of attention including the Comal Blind Salamander, the Fountain Darter and the Golden-Cheeked Warbler. Geronimo Creek is situated within the subtropical climate zone which is known for its hot summers and annual rainfall averages of 31 inches.

The land use within the watershed is that of both rural agriculture and urbanized areas. Both Comal and Guadalupe counties are projected to have significant increases in population by 2050 that could have serious impacts on the watershed. In addition, segments of Geronimo Creek have been listed on the 303(d) list due to E. Coli bacteria. A Watershed Protection Plan has been implemented for this waterway by both the Texas State Soil and Water Conservation Board and the Regional Watershed Coordination Steering Committee.

One site within the watershed was tested by Texas Stream Team citizen scientists from 2010 to 2016 for total dissolved solids (TDS), water temperature, dissolved oxygen (DO), pH, E. coli and nitrates. A significant decrease in TDS was seen over the testing period, whereas DO did not show any significant change over time. However, there was a significant decrease in in pH values observed over time. Algae was never present during any of the sampling times. The geomean for E. coli was 208 CFU/100mL with <1 CFU/100mL occurring on multiple occasions. Nitrates showed a significant decrease over the sampling time. With this watershed's anticipated growth, it may experience significant changes in land use and water quality parameters, necessitating further monitoring by TST citizen scientists.

Get Involved with Texas Stream Team!

Once trained, citizen scientists can directly participate in monitoring by communicating their data to various stakeholders. Some options include: participating in the Clean Rivers Program (CRP) Steering Committee Process, providing information during “public comment” periods, attending city council and advisory panel meetings, developing relations with local Texas Commission on Environmental Quality (TCEQ) and river authority water specialists, and, if necessary, filing complaints with environmental agencies, contacting elected representatives and media, or starting organized local efforts to address areas of concern.

The Texas Clean Rivers Act established a way for the citizens of Texas to participate in building the foundation for effective statewide watershed planning activities. Each CRP partner agency has established a steering committee to set priorities within its basin. These committees bring together the diverse stakeholder interests in each basin and watershed. Steering committee participants include representatives from the public, government, industry, business, agriculture, and environmental groups. The steering committee is designed to allow local concerns to be addressed and regional solutions to be formulated. For more information about participating in these steering committee meetings, please contact the appropriate CRP partner agency for your river basin at:
http://www.tceq.state.tx.us/compliance/monitoring/crp/partners.html.

Currently, Texas Stream Team is working with various public and private organizations to facilitate data and information sharing. One component of this process includes interacting with watershed stakeholders at CRP steering committee meetings. A major function of these meetings is to discuss water quality issues and to obtain input from the general public. While participation in this process may not bring about instantaneous results, it is a great place to begin making institutional connections and to learn how to become involved in the assessment and protection system that Texas agencies use to keep water resources healthy and sustainable.

Sources

Alligator Creeks Watershed Protection Plan. 2012. The Geronimo and Alligator Creeks Watershed Partnership

United States Department of Agriculture Soil Conservation Service. 1984. Soil Survey of Comal and Hays Counties Texas

Gesick, John. Handbook of Texas Online: Segin, *TX*. June 10, 2015. https://tshaonline.org/handbook/online/articles/hes03 (accessed June 19, 2016).

Texas Comission on Environmental Quality (TCEQ). *2014 Texas Integrated Report Index of Water Quality Impairments.* Index, TCEQ, 2014.

Texas Parks and Wildlife. "Rare, Threatened and Endangered Species of Texas." *Texas Parks and Wildlife.* 2016. http://tpwd.texas.gov/gis/rtest/ (accessed June 15, 2016).

Texas Parks and Wildlife. Species of Greatest Convervation Needs. 2016. http://tpwd.texas.gov/huntwild/wild/wildlife_diversity/nongame/tcap/sgcn.phtml (accessed June 2016, 2016).

Texas Water Development Board. "2016 Regional Water Plan - Population Projections for 2020-2070." 2016. http://www2.twdb.texas.gov/ReportServerExt/Pages/ReportViewer.aspx?%2fProjections%2fpop_City&rs:Command=Render (accessed June 15, 2016).

United States Census (U.S. Census). *Quick Facts: Seguin.* 2016. http://www.census.gov/quickfacts/table/PST045215/4866644 (accessed 20 June, 2016).

Appendix A- List of Tables and Figures

Tables

Figures