Salado Creek Watershed Data Report

October 2016

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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 quality 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

Starting at the confluence of the North Salado and South Salado Creeks, Salado Creek (Segment 1243) flows east approximately 27 miles to the Lampasas River at the Village of Salado, Texas, just south of Temple. Salado Creek's watershed encompasses approximately 170 square miles (108,800 acres) within the Brazos River Basin. The watershed is located within Bell and Williamson Counties and includes portions of the Cities of Salado, Sommers Hill, Prairie Dell, Corn Hill, and Florence (TCEQ 2012). A major attribute of the watershed is its springs. It has been reported that they have never stopped flowing, even during periods of severe drought (TPWD 2011, Brune 1981, USGS 2011).

Both Bell and Williamson counties are found on the Balcones Escarpment fault line. The fault line creates a division within the counties which forms two natural regions located on both the east and west side: Blackland Prairie and Edwards Plateau respectively. (TPWD 2011) The soils located within the Blackland Prairie is dominated by dark, loamy to clayey "blackland" soils. The most common type of the dark soils is the Houston Black Clay which is the most suitable soils used for farming. Because of this, most of the eastern portions of both counties are used for agriculture. Soils located within the Edwards Plateau are dark, loamy and clayey with some limy subsoils. Shallow, stony soils are also located within this region and within the watershed. These soils encourage ranching, hardwood and pine production within the area. (Handbook of Texas Online 2010)

Vegetation between natural regions of the watershed also differs. The vegetation found within the Blackland Prairie is wooded along its stream systems. The riparian vegetation consists of mesquite, oak, pecan and elm trees. In addition, tall grasses are also found within this region. The vegetation types and patterns make the Blackland Prairie a prime location for agricultural production. Much of the watershed found within this region is prime farmland. Vegetation found within the Edwards Plateau is that of tall to mid grasses, post and live oak, mesquite and junipers. (Handbook of Texas Online 2010) Topographically, the watershed contains rolling to steep hills on shallow soils and Edwards Plateau Limestone (TPWD 2011); therefore, the area is conducive to elevated levels of runoff from major storm events which could potentially lead to severe flooding (CTCoG 2011).

The watershed is also home to various types of wildlife which include the Salado salamander (*Eurycea chisolmensis*). This species is endemic to the Salado Springs which are found along Salado Creek on the southern portion of the watershed. (Sansom, Herron and Gary 1999, TPWD 2011).

Both Bell and Williamson counties also have several federal and state listed endangered or threated species which include:

Amphibians	Georgetown Salamander	Fishes	Sharpnose Shiner
	Jollyville Plateau Salamander		Smalleye Shiner
	Salado Springs Salamander	Insects	Coffin Cave Mold Beetle
Arachnids	Bone Cave Harvestman		Tooth Cave Ground Beetle
Birds	American Peregrine Falcon	Mammals	Red Wolf
	Bald Eagle	Mollusks	False Spike Mussel
	Black-Capped Vireo		Smooth Pimpleback
	Golden-Cheeked Warbler		Texas Fawnsfoot
	Interior Least Tern	Reptiles	Texas Horned Lizard
	Peregrine Falcon		Timber Rattlesnake
	Red Knot	Plants	Bracted Twistflower
	Whooping Crane		

Bell and Williamson Counties may also see several Species of Greatest Conservation Need (SGCN). These species are in decline or they are rare and are in need of attention in order to recover and prevent them from becoming listed species (TPWD 2016):

Amphibians	Southern Crawfish Frog	Plants	Elmendorf's Onion
Arachnids	Bandit Cave Spider		Glass Mountains Coral-Root
Birds	Mountain Plover		Gravelbar Brickellbush
	Sprague's Pipit		Osage Plains False Foxglove
	Western Burrowing Owl		Plateau Loosestrife
Crustaceans	An Amphipod		Plateau Milkvine
	Bifurcated Cave Amphipod		Scarlet Leather-Flower
	Ezell's Cave Amphipod		Sycamore-Leaf Snowbell
Fishes	Guadalupe Bass		Texabama Croton
Insects	A Mayfly		Texas Almond
Mammals	Cave Myotis Bat		Texas Fescue
	Plains Spotted Skunk		Texas Milk Vetch
Reptiles	Spot-Tailed Earless Lizard		Tree Dodder
	Texas Garter Snake		

Land Use

A wide range of land uses are present within the Salado Creek watershed which include recreation, commercial, agriculture, municipal, and residential (TCEQ 2012). The watershed contains numerous springs, historical sites, geological formations of interest, and mineral outcrops within its borders. Both Bell and Williamson counties make up approximately 2,190 square miles. As of 2002, the area is home to over 4,590 farms and ranches which cover approximately 1,615 square miles (~1,000,000 acres) or approximately 75% of the land within the counties. The chief agricultural products produced are mainly cattle, corn, grain, wheat, cotton, and sorghum (Handbook of Texas Online 2010).

Both counties are projected to have significant population growths within the next several decades. In 2010, the populations for both Bell and Williamson counties were that of 310,235 and 422,679 respectively (U. S. Census 2016). The projected population of Bell County in 2050 is 560,252 while Williamson County is expected to have a population of 1,195,374 people (TWDB 2016). For Bell County that approximately an 81% increase and Williamson County is projected to more than double population by 2050. This significant increase in population will alter current land uses. Agricultural land uses may become urbanized with the increased population. This may have significant impacts on an area that is already prone to having severe flooding as surface areas may be converted to impermeable surfaces. Urban development is relatively high within the watershed, yet few flood control measures are in place to protect nearby properties (TCEQ 2012, CTCoG 2011). In addition, the increase in population may also bring increased demands on the watershed's recreational capabilities (CTCoG 2011).

Elevated levels of fecal coliform have also been detected on the creek in the past, which have prompted warnings for citizens recreating within the watershed (Temple Daily News). Because of the watershed's location atop the Edwards Aquifer, a primary focus for maintaining acceptable water quality is through proper groundwater management (CUWCD 2000).

Recreation within the watershed is present and usually occurs between FM 2843 and FM 1123. During periods of heavy rainfall, this area experiences white water rafting, heavy kayak and canoeing and other recreational activities. However, Salado Creek must show some type of rise in water levels for this type of aquatic recreation to occur. If the creek or areas of the watershed are going through dry or drought periods, the water and discharge levels do not allow extensive recreational uses. (TPWD 2016)

A major area of recreation within the watershed can be found between FM 2843 and FM 1123 located in Bell County. It has been reported that white water rafting is possible in this area during periods of consistent rainfall (TPWD 2016).

Impairments

The Salado Creek watershed does not have any current impairments listed on the 2014 Texas Integrated Report - Texas 303(d) List (Category 5). However, this area has seen impairments listed on previous listing in 2003 which have since been removed. These impairments have included the presence of the bacteria *E. coli* above 200 milligrams which is considered unsafe for recreational activities such as swimming that is seen frequently within this watershed. (Coppedge 2003) In addition to bacterial listings, the watershed has also experienced several point source and non-point source chemical contaminations that took place between the 1980s through the 1990s. These include but are not limited to petroleum underground storage tank leakages, unleaded gasoline spills with direct impacts to both the groundwater and surface water of Salado Creek, domestic well contaminations of BTEX (benzene, toluene, ethylbenzene, and xylenes) which derive from volatile organic compounds found with gasoline, and domestic well contaminations of Total Petroleum Hydrocarbons (TPH). (Sansom, Herron and Gary 1999)

TMDL & Watershed Protection

The Texas Commission on Environmental Quality commissioned a TMDL project for Salado Creek Watershed from 2002-2005 to sample for low dissolved oxygen measurements on Salado and Rocky Creeks (TCEQ 2012). However, those measurements were found to be in compliance with water quality standards, and a formal TMDL was not recommended for Salado Creek "unless conditions change" (TCEQ 2012).

Although the nearby Lampasas River watershed has an active Watershed Protection Plan (WPP), Salado Creek is not contained within the Lampasas watershed and is therefore not part of the WPP (Lampasas River WPP). Current watershed protection efforts include stream gauge monitoring of springs flowing out from the Edwards Aquifer on Salado Creek to monitor streamflow (CUWCD 2000) and a Flood Protection Planning grant application to the Texas Water Development Board by Bell County (CTCoG 2011). In addition, monitoring of the waterways within the watershed have been a high priority considering the watersheds history of both biological and chemical contaminations.

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.

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 a volunteer monitors. Testing for orthophosphate gives us 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 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 orthophosphate has on a water body is known as eutrophication and is described above under the “Dissolved Oxygen” section.

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.

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 monitors 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 monitor enters data electronically, the system will automatically flag data outside of the data limits and the monitor 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 monitor 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 Salado Creek Watershed, as seen below in Table 2.

Table 2: Summary of Surface Water Quality Standards for the Salado 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 Salado Creek were exported from the Texas Stream Team database and were then grouped by site. 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.

Salado Creek Watershed Data Analysis

Salado Creek Watershed Maps

Numerous maps were prepared to show spatial variation of the parameters. The parameters mapped include DO, pH, and TDS. There is also a reference map showing the locations of all active sites. For added reference points in all maps, layers showing monitoring sites, cities, counties, and major highways were included. All shapefiles were downloaded from reliable federal, state, and local agencies.

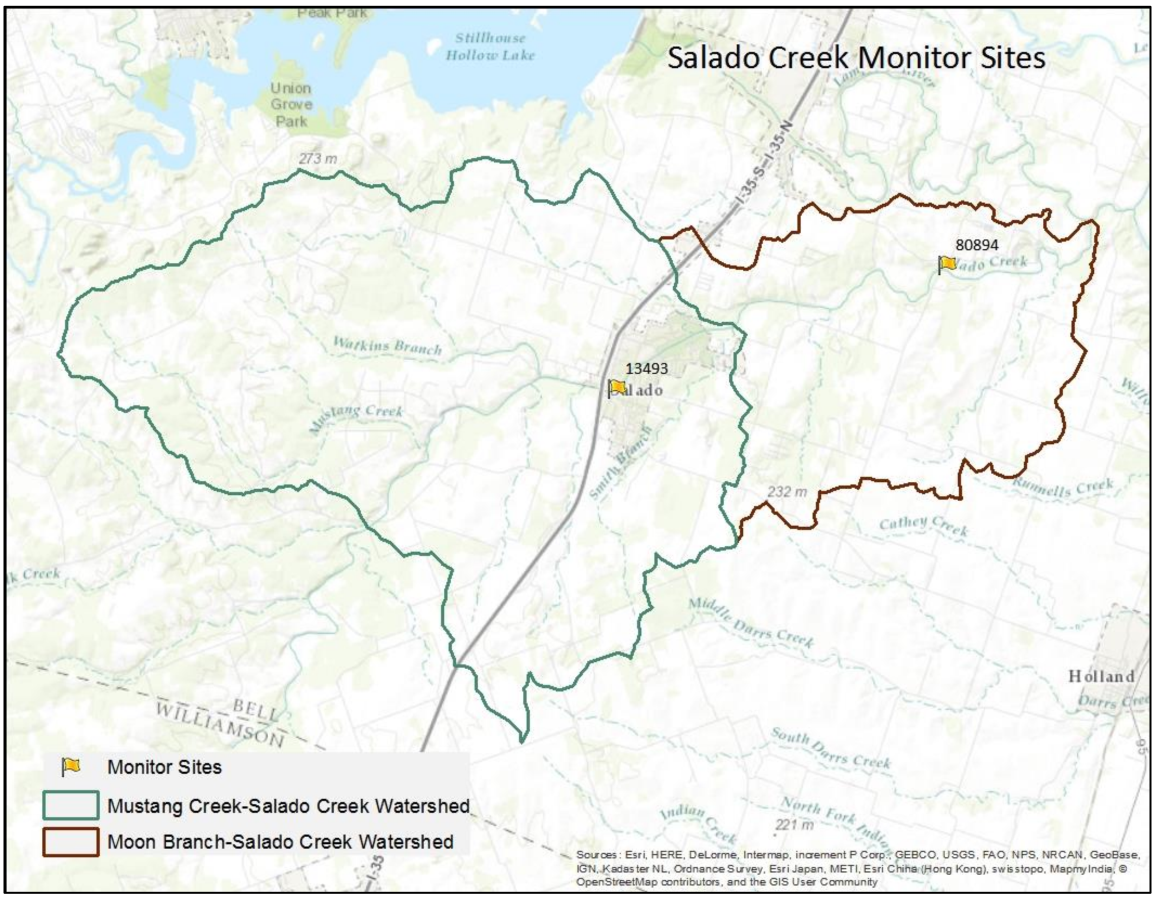

Figure 1: Map of the Salado Creek Watershed with Texas Stream Team Monitor Sites

Salado Creek Watershed Trends over Time

Sampling Trends over Time

Sampling in the Salado Creek Watershed began in 1991. There was sporadic monitoring at site 13493 near the I35 Bridge through 2004, and then the site went inactive until 2012. Monitoring in the watershed picked up again in 2012 and continues through 2016.

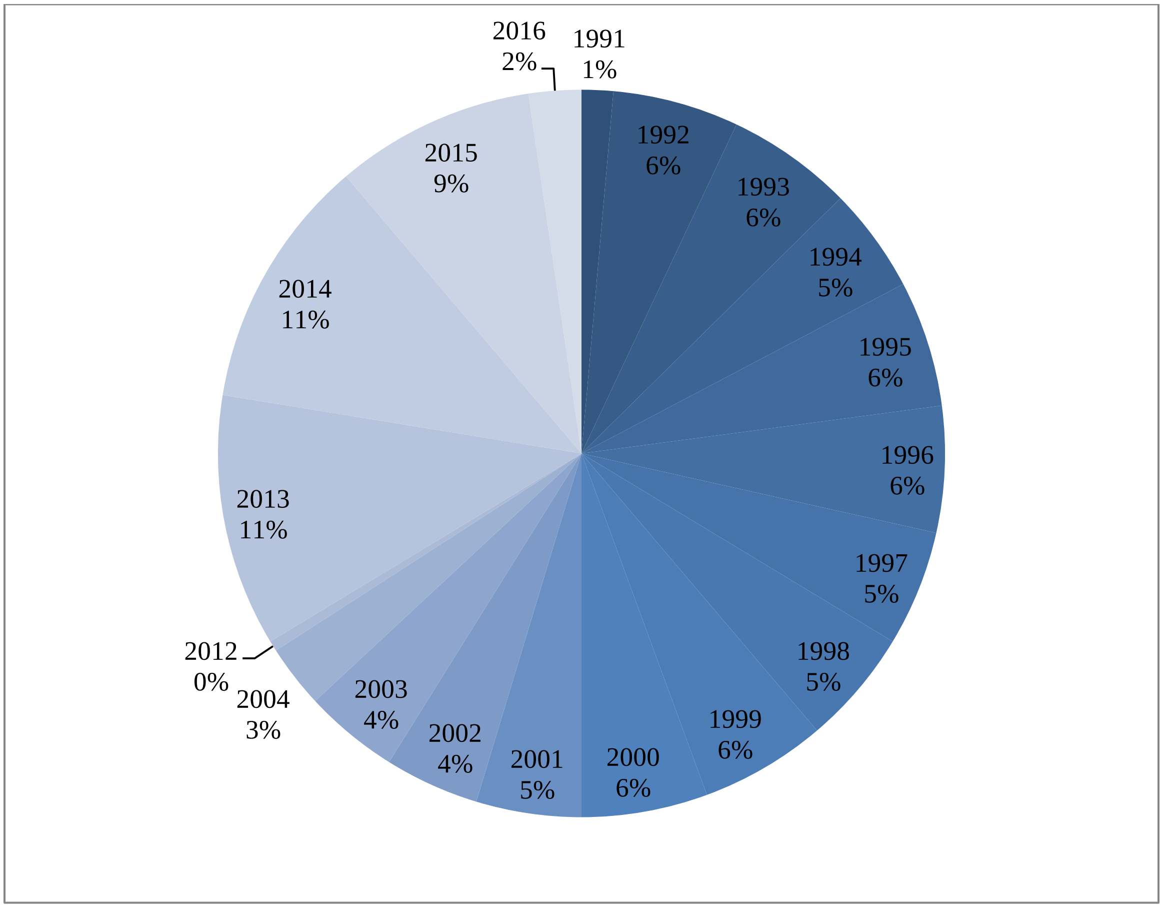

Figure 2: Breakdown of monitoring events by year.

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

Salado Creek Watershed October 1991 – July 2015				
Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	182	311 ± 36	195	442
Water Temperature (°C)	214	19.5 ± 5.3	5.0	32.0
Dissolved Oxygen (mg/L)	197	7.3 ± 1.8	2.4	14.0
pH	209	7.5 ± 0.5	6.1	8.8
Nitrates (mg/L)	166	3.4 ± 2.1	0	12
Phosphates (mg/L)	167	0.52 ± 0.65	0	5.07

There were a total of 217 sampling events between 10/30/1991 and 03/20/2016.

Trend Analysis over Time

Air and water temperature

A total of 204 air and 214 water temperature samples were recorded in the Salado Creek Watershed between 1991 and 2015. Water temperatures never exceeded the TCEQ optimal temperature of 32.2 °C. The mean water temperature was 19.5 °C. Water temperature ranged from a low of 5.0 °C in January of 2013 to a high of 32.0 °C in August of 2014. Air temperature ranged from a low of 0.5 °C in February of 1992, to a high of 32 °C in July of 2014.

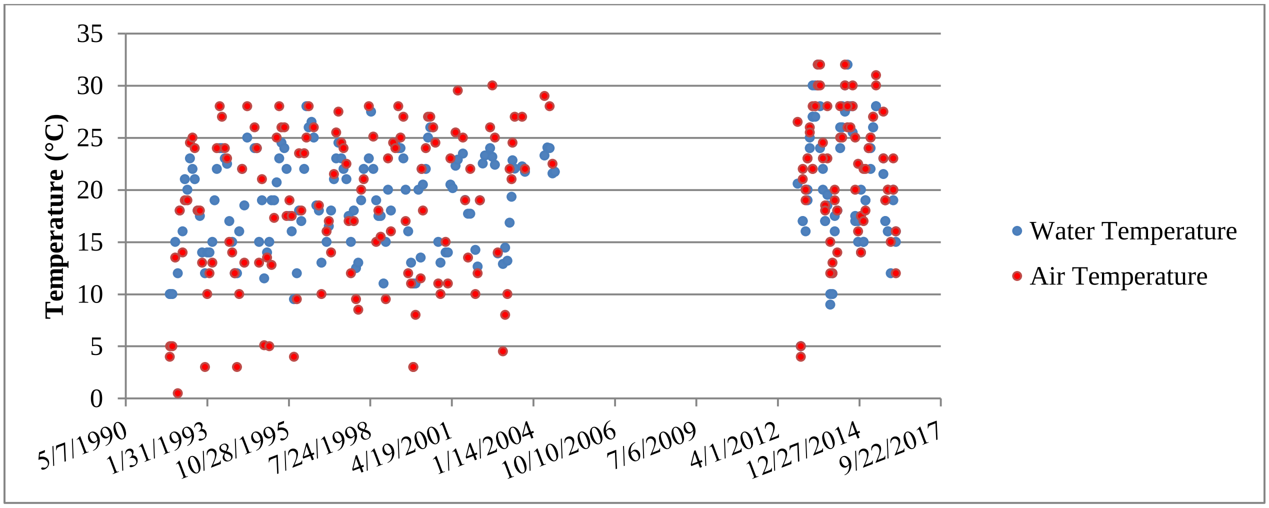

Figure 3: Air and water temperature over time at all sites within the Salado Creek Watershed

Total Dissolved Solids

Citizen scientists conducted a total of 182 total dissolved solids measurements in the watershed. The mean TDS measurement for all sites was 311 mg/L. The concentration of TDS ranged from a low of 195 mg/L in October, 1998 to a high of 442 mg/L in May of 1993. There was no significant relationship between TDS and time observed in the watershed.

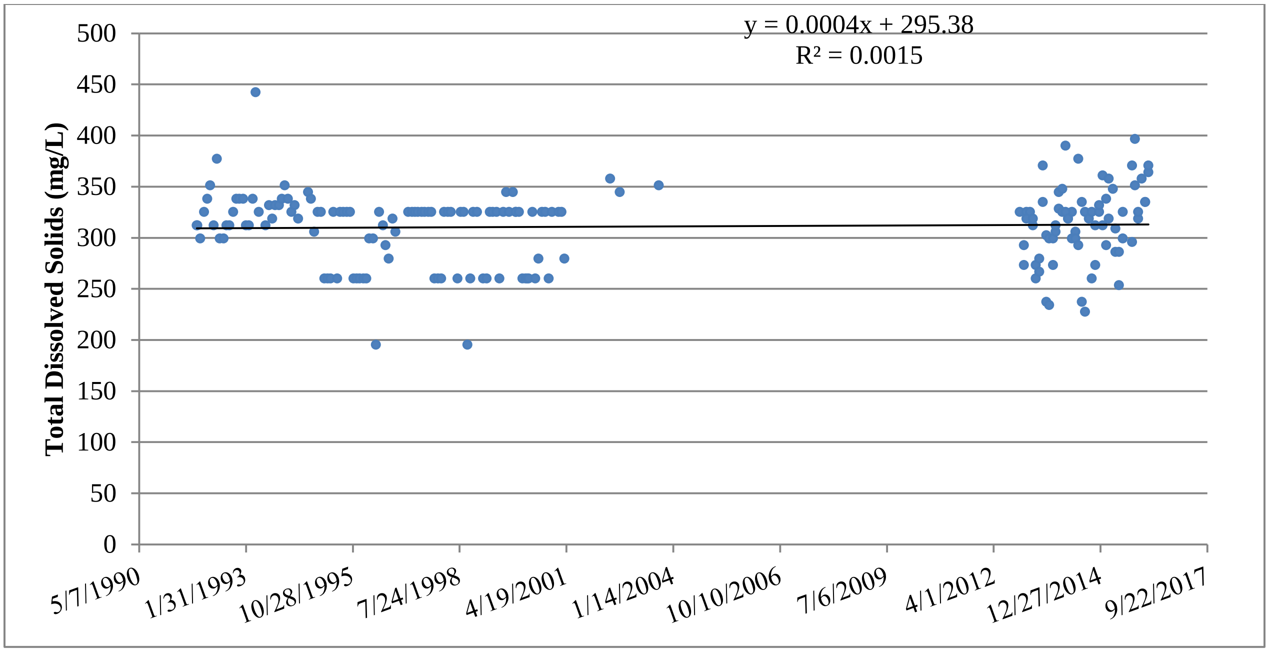

Figure 4: Total dissolved solids over time at all sites within the Salado Creek Watershed

Dissolved Oxygen

Citizen scientists collected a total of 197 dissolved oxygen samples in the watershed. The mean DO concentration was 7.3 mg/L. The minimum DO concentration was 2.4 mg/L in June of 2003. The maximum DO concentration was 14.0 mg/L in January of 2014.

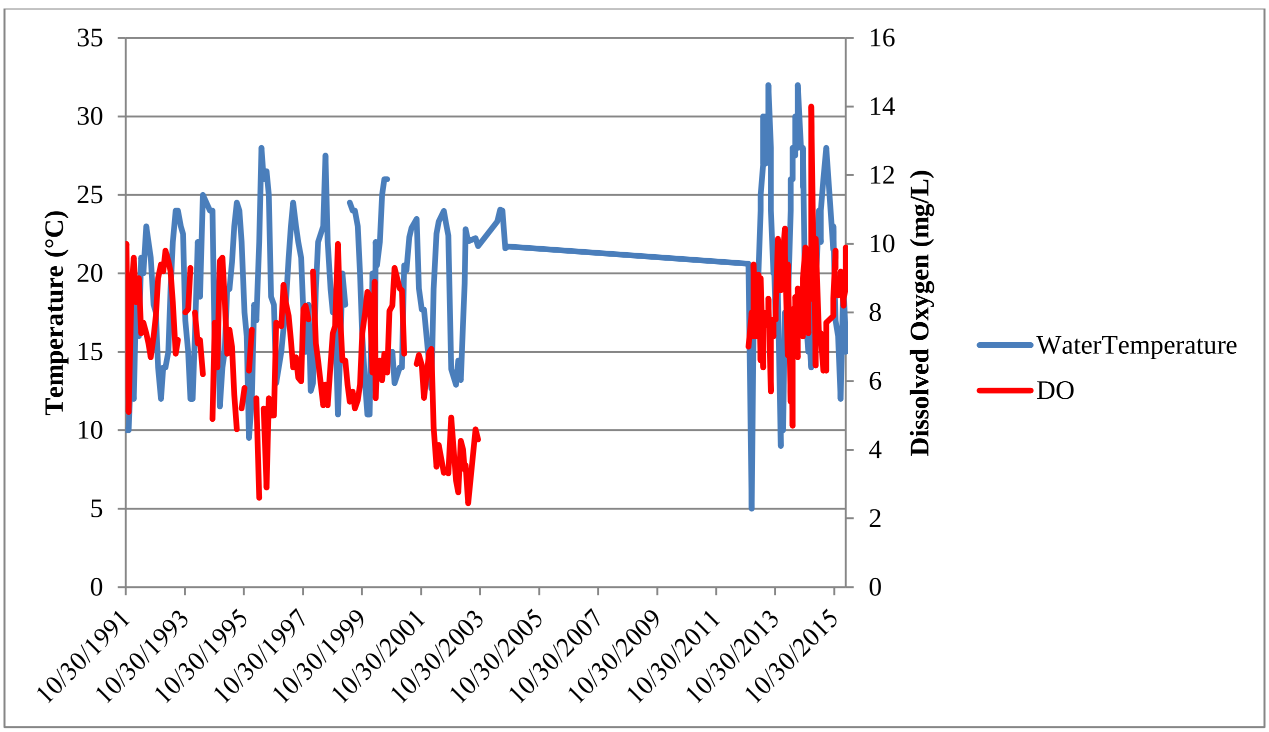

Figure 5: Water temperature and dissolved oxygen over time at all sites within the Salado Creek Watershed

pH

Citizen scientists took 192 pH samples in the watershed. The mean pH was 7.6 and it ranged from a low of 6.1 in October of 2005 to a high of 8.8 in January, 1993. There was a significant decrease in pH over time observed in the watershed (p=0.000). The R^2 of 0.1288 indicates that this relationship explains about 13% of the variation in the data.

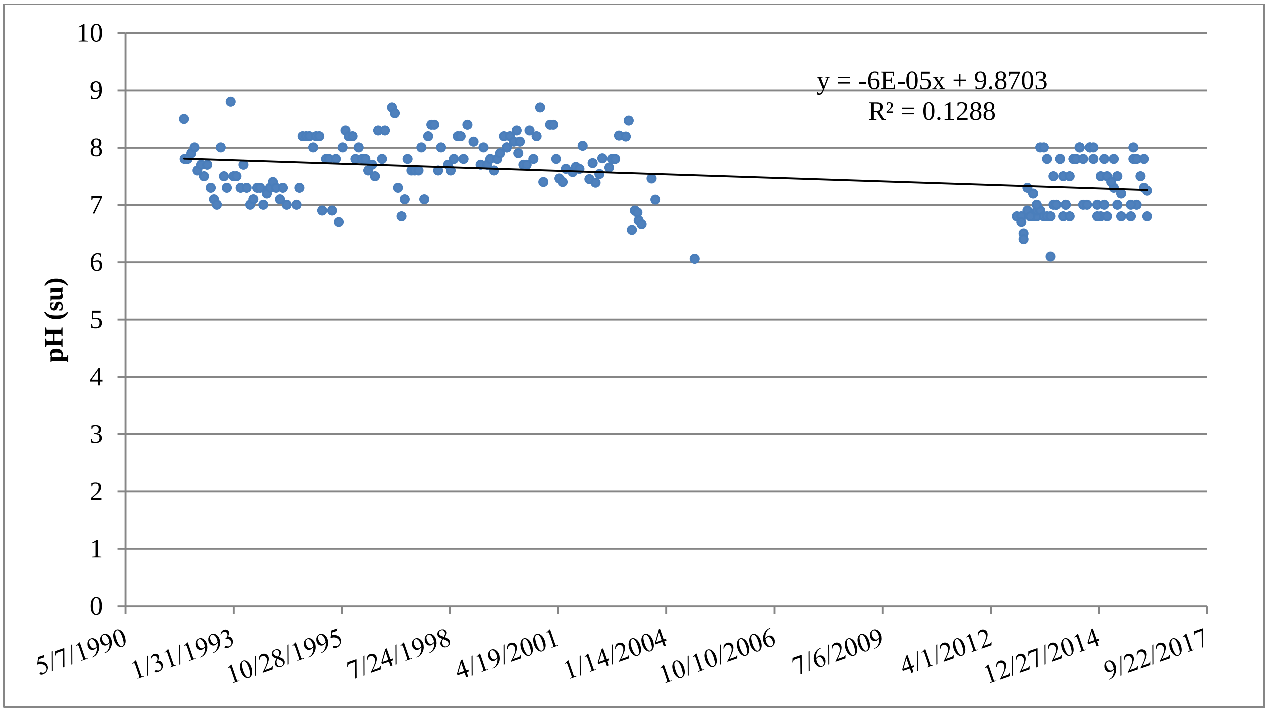

Figure 6: pH over time at all sites within the Salado Creek Watershed

Nitrate-Nitrogen

Citizen scientists collected 166 nitrate samples within this watershed. The mean nitrate concentration in the watershed was 3.4 mg/L. Nitrate-nitrogen concentrations ranged from a low of <1 mg/L in multiple instances to a high of 12 mg/L reported in May of 2015. Nitrate-nitrogen testing was discontinued in 2004 and resumed in 2014. Observed levels of nitrates showed a significant decrease over time (p=0.000), and the R-squared value of 0.1683 explains about 17% of the variation within the data.

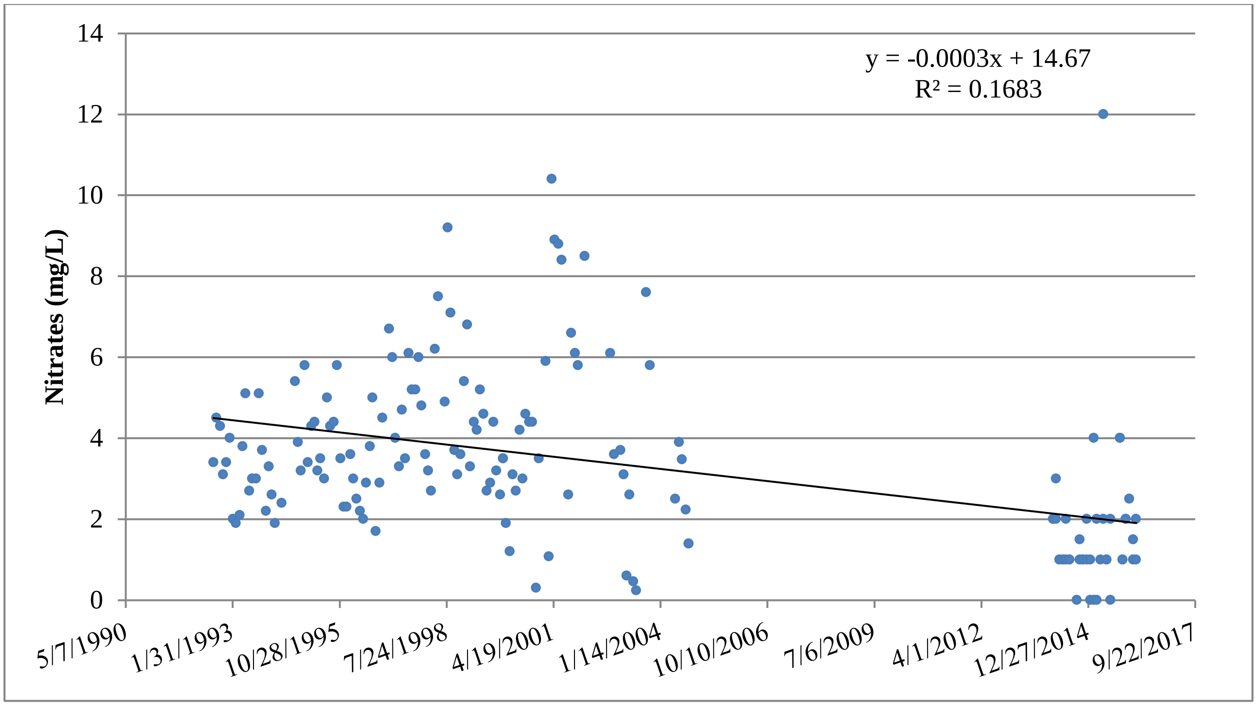

Figure 7: Nitrate-nitrogen over time at all sites within the Salado Creek Watershed

Orthophosphates

Citizen scientists collected 167 phosphate samples within this watershed. The mean orthophosphate concentration in the watershed was 0.52 mg/L. Phosphate concentrations ranged from 0 mg/L in multiple instances to 5.07 mg/L observed in November of 2000. Orthophosphate testing was discontinued in 2004 and resumed in 2014. Levels of orthophosphates decreased significantly over time ($p = 0.000$), although the R-squared value of 0.0785 explains only about 8% of the variance within the data.

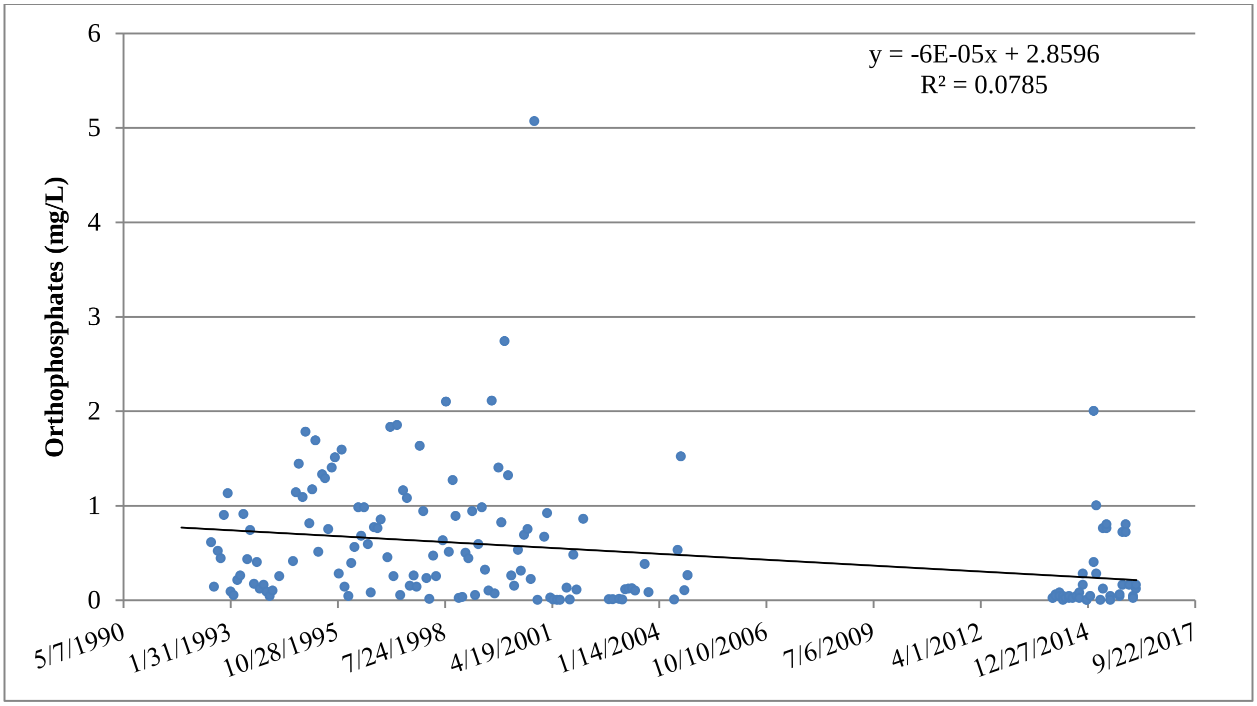

Figure 8: Orthophosphate over time at all sites within the Salado Creek Watershed

Salado Creek Watershed Site by Site Analysis

The following sections will provide a brief summarization of analysis, by site. The average minimum and maximum values recorded in the watershed. These values are reported in order to provide a quick overview of the watershed. The TDS, DO, and pH values are presented as an average, plus or minus the standard deviation from the average. Please see Table 4 on the following page, for a quick overview of the average results.

As previously mentioned in the 'Water Quality Parameters' section, TDS is an important indicator of turbidity and specific conductivity. The higher the TDS measurement, the more conductive the water is. A high TDS result can indicate increased nutrients present in the water. Site 13493 had the highest overall average for TDS, with a result of 310 mg/L. Site 80894 had the lowest average TDS, with a result of 301mg/L.

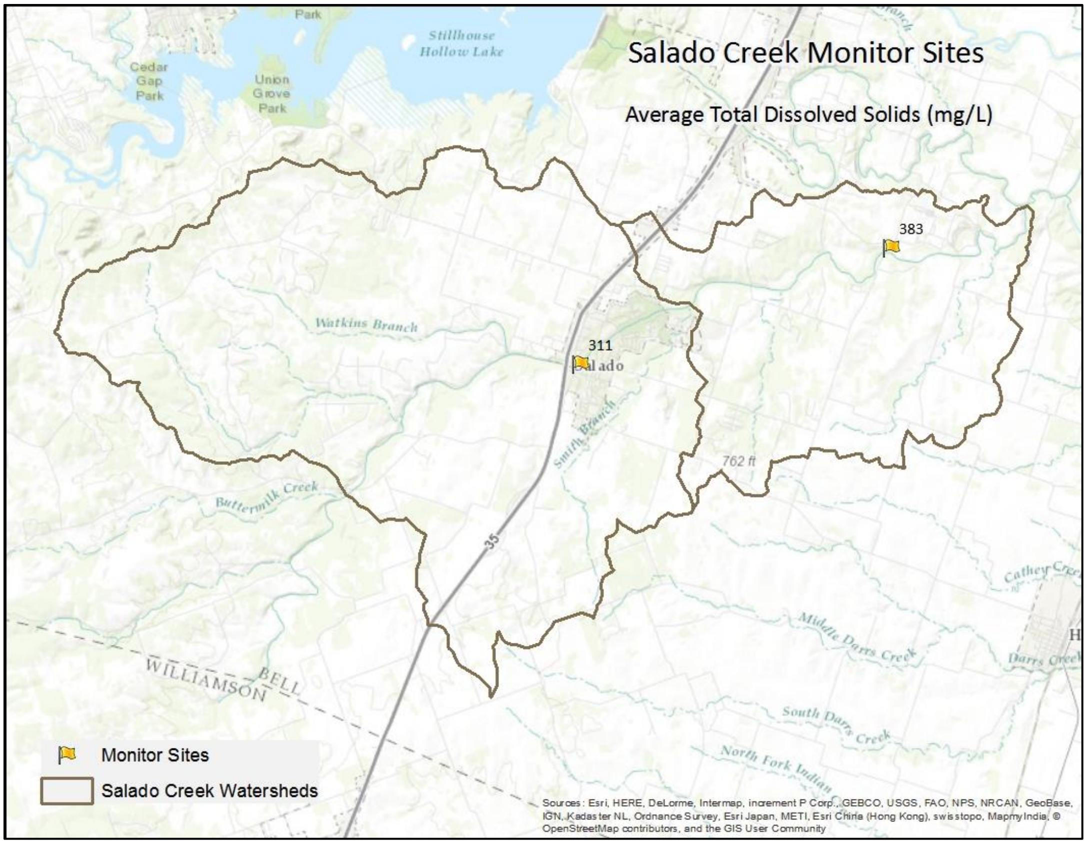

Figure 9: Map of the average total dissolved solids for sites in the Salado Creek Watershed

The DO measurement can help to understand the overall health of the aquatic community. If there is a large influx of nutrients into the water body than there will be an increase in surface vegetation growth, which can then reduce photosynthesis in the subsurface, thus decreasing the level of DO. Low DO can be dangerous for aquatic inhabitants, which rely upon the dissolved oxygen to breathe. The DO levels can also be impacted by temperature; a high temperature can limit the amount of oxygen solubility, which can also lead to a low DO measurement. Site 13493 had the lowest average DO reading, with a result of 6.9mg/L. Site 80894 had the highest average DO reading, with a result of 8.7 mg/L.

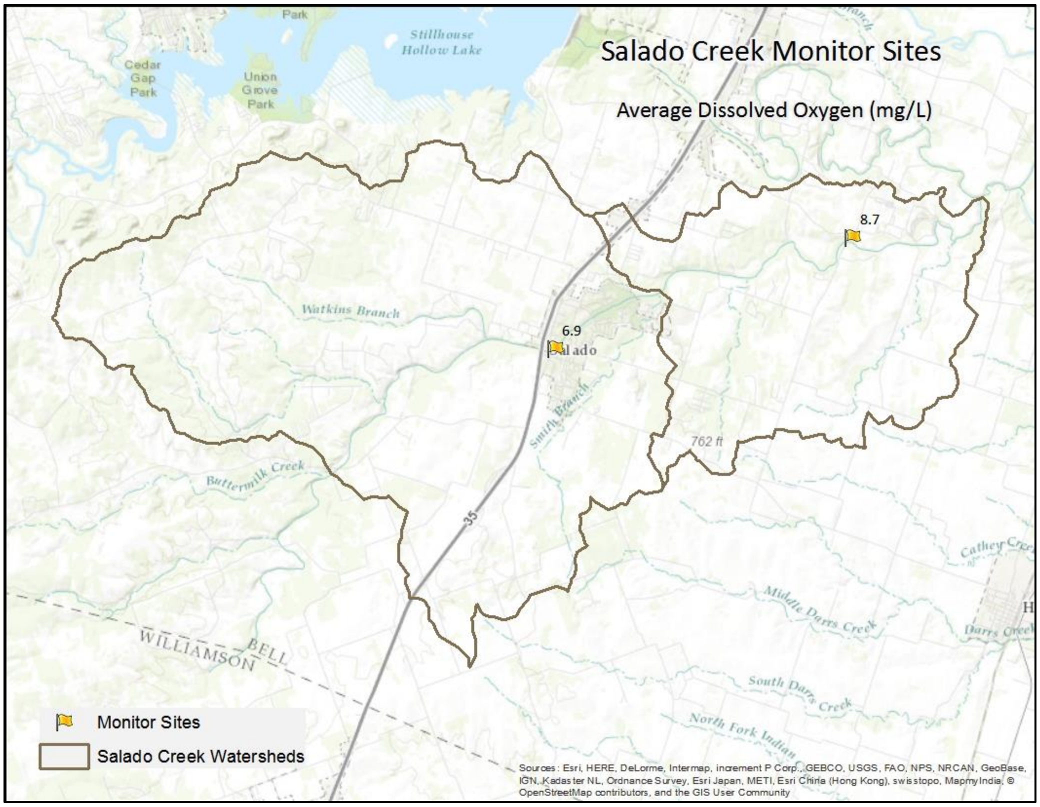

Figure 10: Map of the average dissolved oxygen for sites in the Salado Creek Watershed

The pH levels are an important indicator for the overall health of the watershed as well. Aquatic inhabitants typically require a pH range between 6.5 and 9 for the most optimum environment. Anything below 6.5 or above 9 can negatively impact reproduction or can result in fish kills. There were no reported pH levels outside of this widely accepted range. Site 13493 had the highest average pH level, with a result of 7.6. Site 80894 had the lowest average pH level, with a result of 7.4.

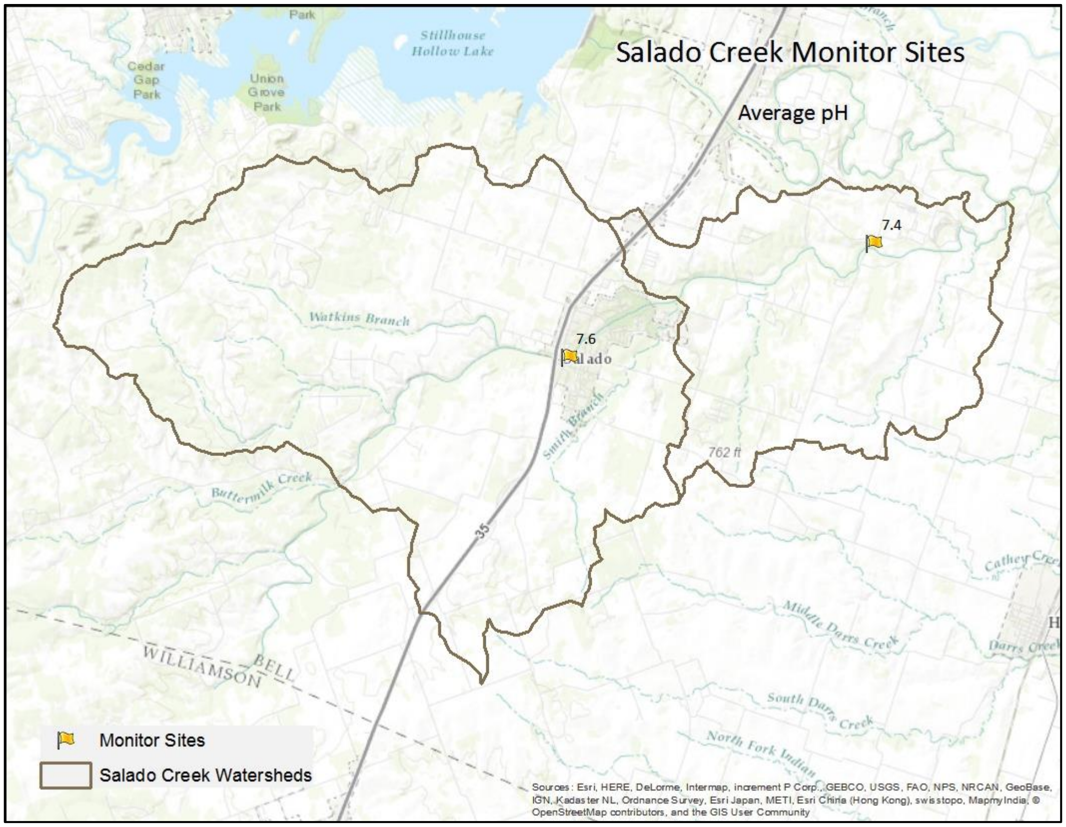

Figure 11: Map of the average pH for sites in the Salado Creek Watershed

Please see Table 4 for a summary of average results at all sites. It is important to note that there was variation in the number of times each site was tested, the time of day at which each site was tested, and the time of month the sampling occurred. While this is a quick overview of the results, it is important to keep in mind that there is natural diurnal and seasonal variation in these water quality parameters. Texas Stream Team citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Table 4: Average Values for all sites

Site Number	TDS (mg/L)	DO (mg/L)	pH
13493	310	6.9	7.6
80894	301	8.7	7.4

Site 13493– Salado Creek at Stagecoach Dam

Site Description

This site is near a low water dam on the creek near the Stagecoach Inn. It is less than 200 yards downstream of the I35 bridge and immediately upstream of the Main Street Bridge. This area is a small park on both sides of the creek. There is very little riparian vegetation, and the banks of the creek are mowed.

Sampling Information

This site was sampled 180 times between 10/30/1991 and 3/20/2016. Most sampling originally occurred between 9:00 and 10:00 until the years 2013 to 2015 when the sampling usually took place between the hours of 13:00 and 14:00.

Table 5: Descriptive parameters for Site 13493

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	147	312 ± 34.6	195	442
Water Temperature (°C)	178	19.2 ± 4.9	5.0	30.0
Dissolved Oxygen (mg/L)	161	6.9 ± 1.8	2.4	10.5
pH	173	7.6 ± 0.5	6.1	8.8
Nitrate-nitrogen (mg/L)	143	3.7 ± 2.1	<1	12
Orthophosphates (mg/L)	144	0.57 ± 0.68	0	5.07

Site was sampled 175 times between 10/30/1991 and 3/20/2016.

Air and water temperature

There were 178 water and 168 air temperature samples taken at this site. The mean water temperature was 19.2 °C and ranged from a low of 5.0 °C in 2013 to a high of 30.0 °C in August 2013. Air temperature ranged from a low of 0.5 °C in February of 1992 to a high of 32.0 °C in August of 2013.

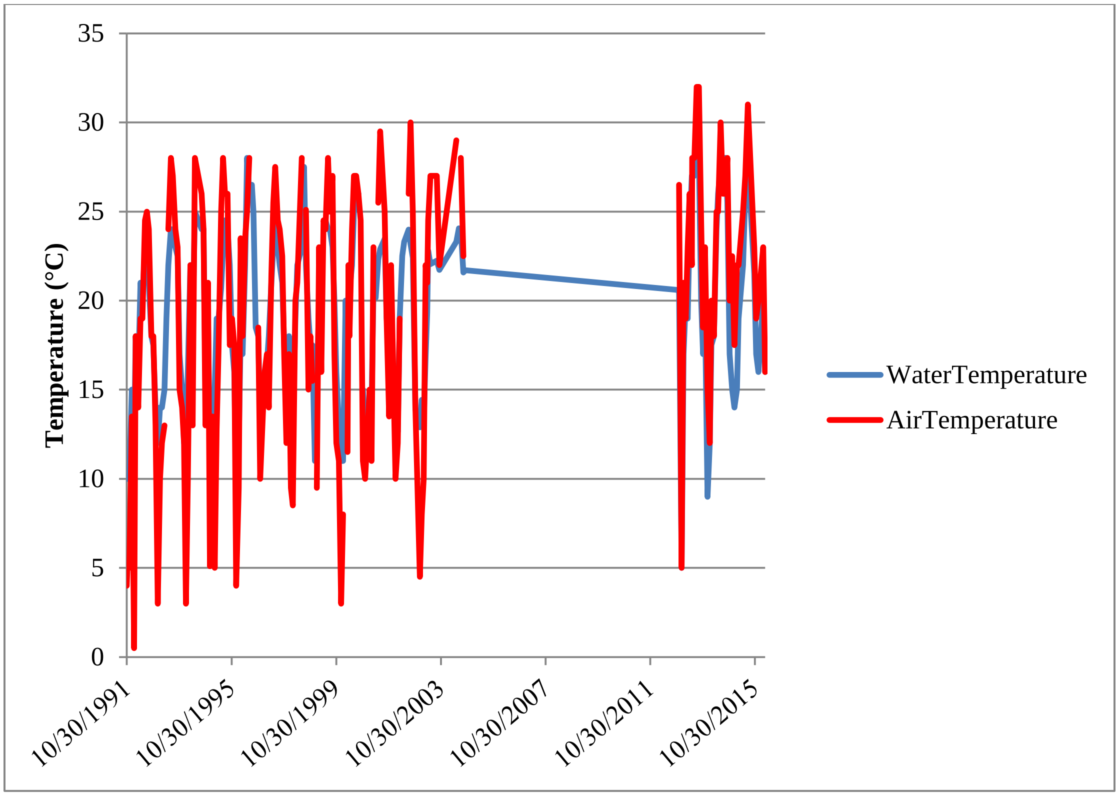

Figure 12: Air and water temperature at site 13493

Total Dissolved Solids

Citizen scientists took a total of 147 total dissolved solid measurements at this site. The mean TDS concentration was 312 mg/L. The minimum TDS concentration was 195 mg/L and was taken in October of 1998. The maximum TDS concentration was 442 mg/L and was taken in May of 1993. There was no significant increase or decrease in TDS concentrations over time observed at this site.

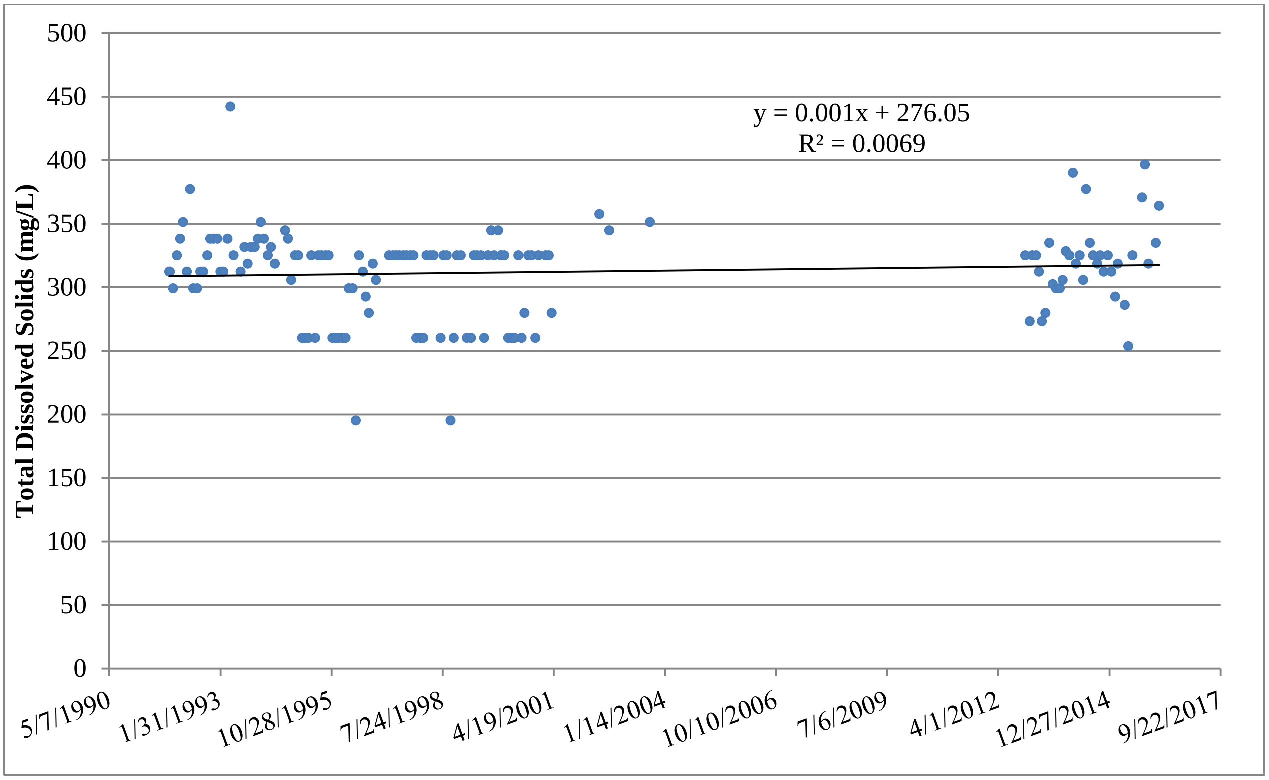

Figure 13: Total dissolved solids at site 13493

Dissolved Oxygen

Citizen scientists took 161dissolved oxygen measurements at this site. The mean DO concentration was 6.9 mg/L. The minimum DO concentration was 2.4 mg/L and was recorded in June of 2003. The maximum DO concentration was 10.5 mg/L and was taken in June of 1996. There was no significant correlation between dissolved oxygen and time observed at this site.

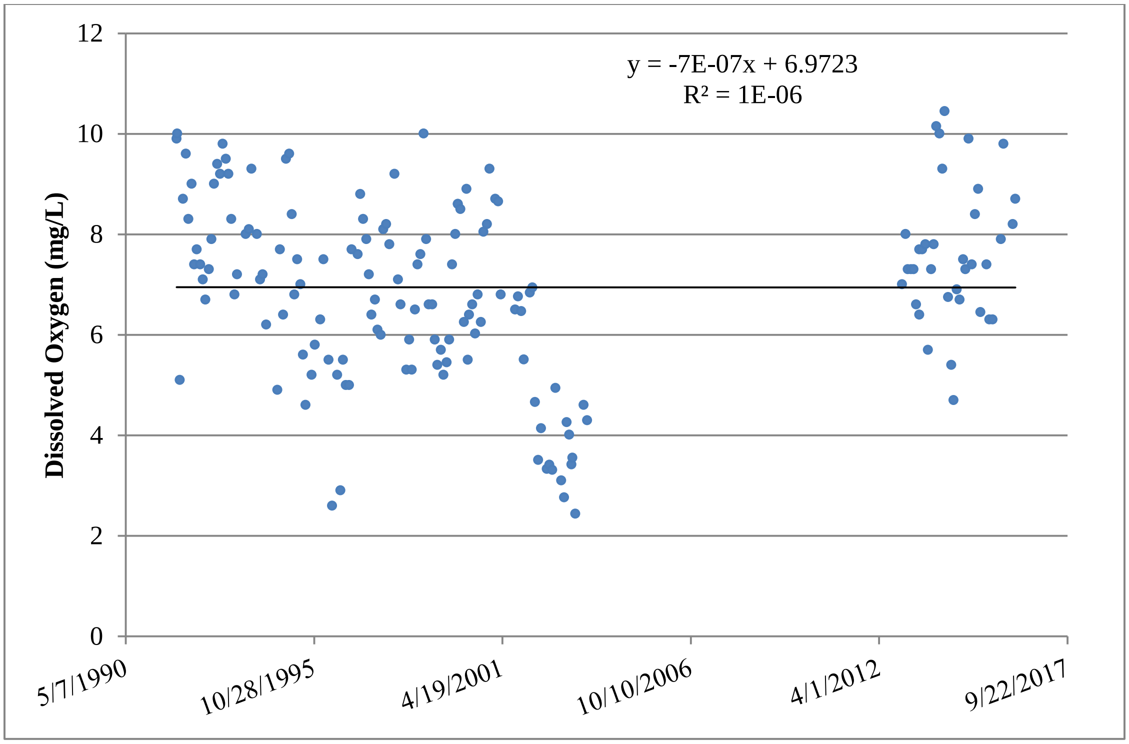

Figure 14: Dissolved oxygen at site 13493

pH

Citizen scientists took 173 pH measurements at this site. The mean pH was 7.6 and the pH ranged from 6.1, recorded in October of 2004, to 8.8 in January of 1993. There was a significant decrease in pH over time ($p = 0.000$) and the R-squared value of 0.1489 explains about 15% of the variance within the data.

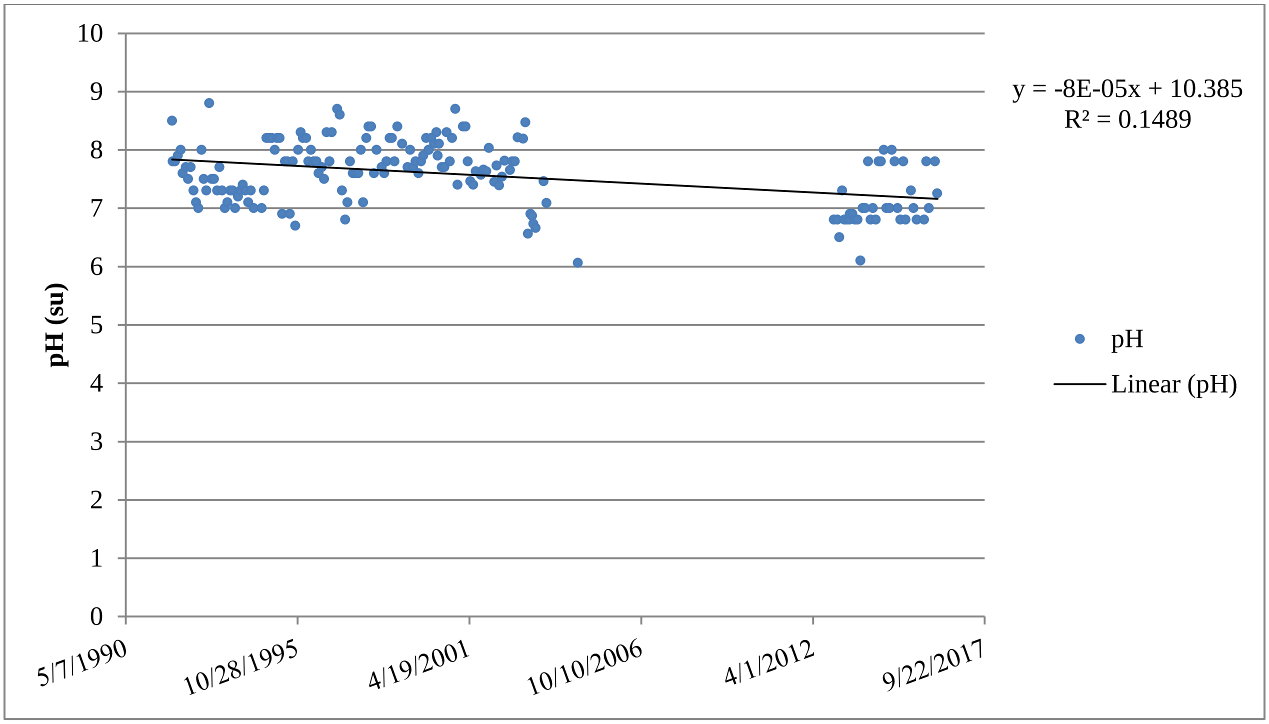

Figure 15: pH at site 13493

Nitrate-Nitrogen

Citizen scientists took 143 nitrate-nitrogen samples at this site. The mean nitrate level was 3.7 mg/L and values ranged from less than 1 mg/L on multiple occasions to 12 mg/L on May of 2015. Levels of nitrates decreased significantly over time ($p = 0.001$), but the low R-squared value of 0.0682 suggests a weak relationship between the two variables and the overall variance in the data.

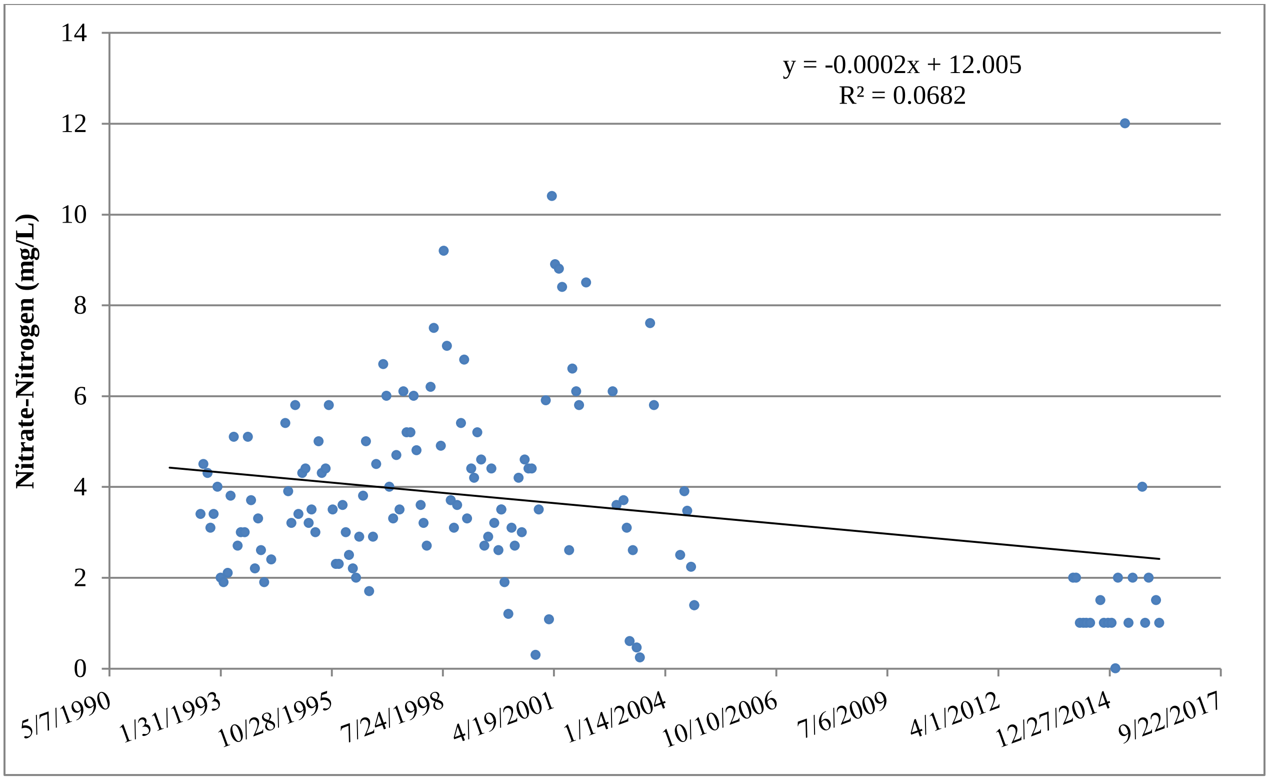

Figure 16: Nitrate-nitrogen at site 13493

Orthophosphates

Citizen scientists took 144 orthophosphate samples at this site. The mean orthophosphate level was 0.57 mg/L and values ranged from 0 mg/L on multiple occasions to 5.07 mg/L on November of 2000. There was a significant decrease in observed phosphate values over time ($p = 0.01$), but the low R-squared value of 0.0456 suggests a weak relationship between the variables and the overall variance within the data.

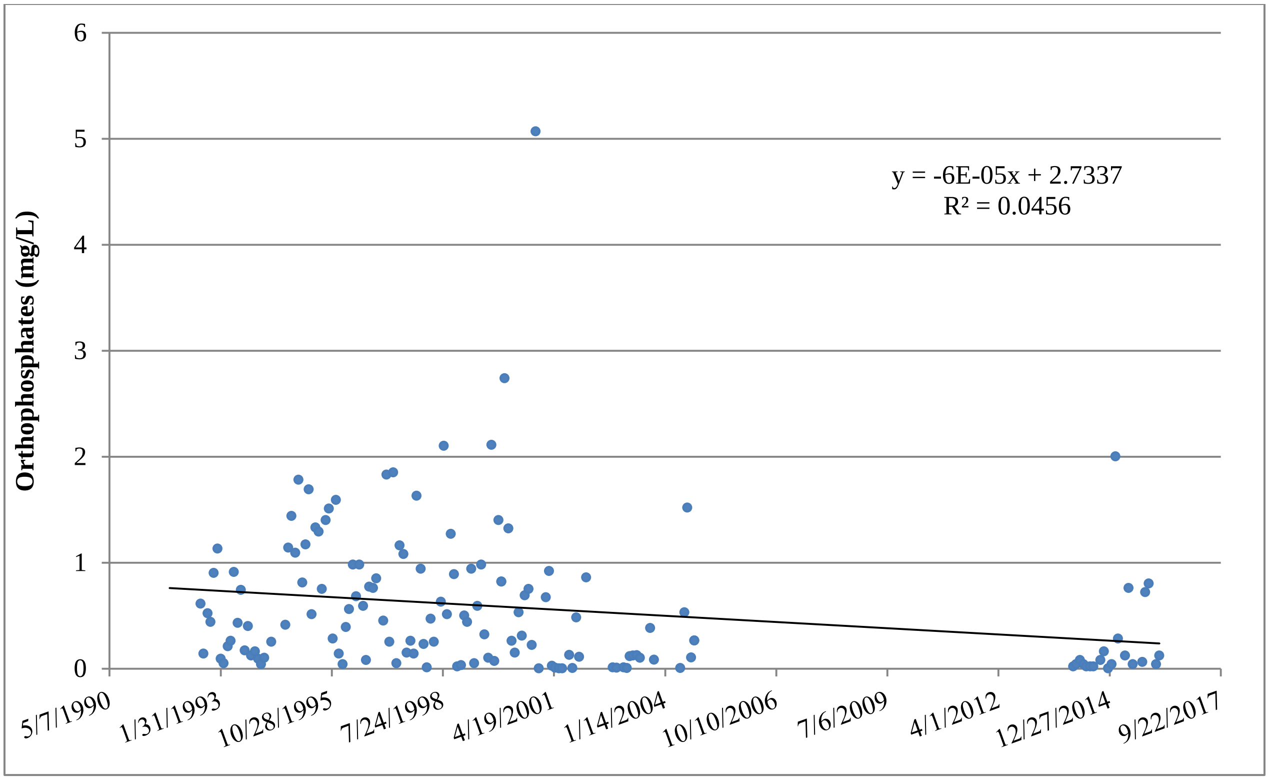

Figure 17: Orthophosphates at site 13493

Field Observations

Flow was most often normal at this site. The algae cover was absent or rare. Water color was usually a reddish color from 1991-1998 and clear, and mostly without color from 2000-2015. Water clarity was recorded as clear in the vast majority of sampling events.

Site 80894 – Salado Creek at Armstrong Crossing

Site Description

This site is located downstream of the Armstrong Road Bridge. The riparian zone is heavily wooded with pecans and oak trees. The surrounding land is mostly rural ranches and farmland.

Sampling Information

This site was sampled 37 times between 1/11/2013 and 3/20/2016. This site was sampled in the afternoon between the hours of 13:00 and 15:00.

Table 6: Descriptive parameters for Site 80894

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	35	306 ± 38	228	371
Water Temperature (°C)	36	20.8 ± 6.6	5.0	32.0
Dissolved Oxygen (mg/L)	36	8.7 ± 1.2	6.7	14.0
pH	36	7.4 ± 0.5	6.4	8.0
Nitrate-nitrogen (mg/L)	22	1.39 ± 1.0	<1	4
Orthophosphates (mg/L)	22	0.22 ± 0.30	0	1

Site was sampled 37 times between 1/11/2013 and 3/20/2016.

Air and water temperature

There were 36 air and water temperature samples taken at this site. The mean water temperature was 20.8 °C. The minimum water temperature was 5.0 °C and was recorded in January, 2013. The maximum water temperature was 32.0 °C and was recorded in August of 2013. The air temperature ranged from a low of 4.0 °C in January, 2013 to a high of 32 °C in July of 2014.

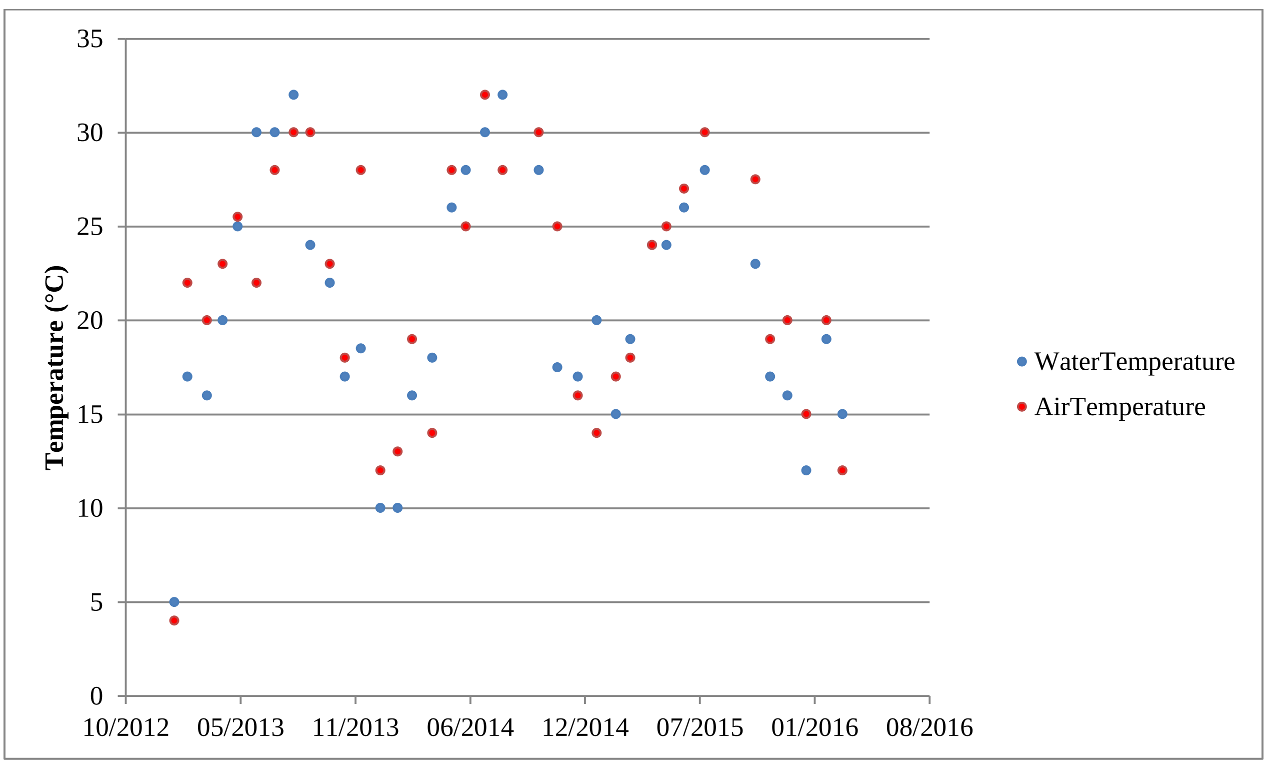

Figure 18: Air and water temperature at site 80894

Total Dissolved Solids

Citizen scientists took 35 total dissolved solids measurements at this site. The mean TDS concentration was 306 mg/L. The minimum TDS concentration was 228 mg/L and was recorded in August of 2014. The maximum TDS concentration was 371 and was recorded in July of 2013. There was a significant increase in TDS values observed over time at this site. However, the R-squared value of 0.088 conveys that the sampling date only represents about 9% of the variance within the TDS data.

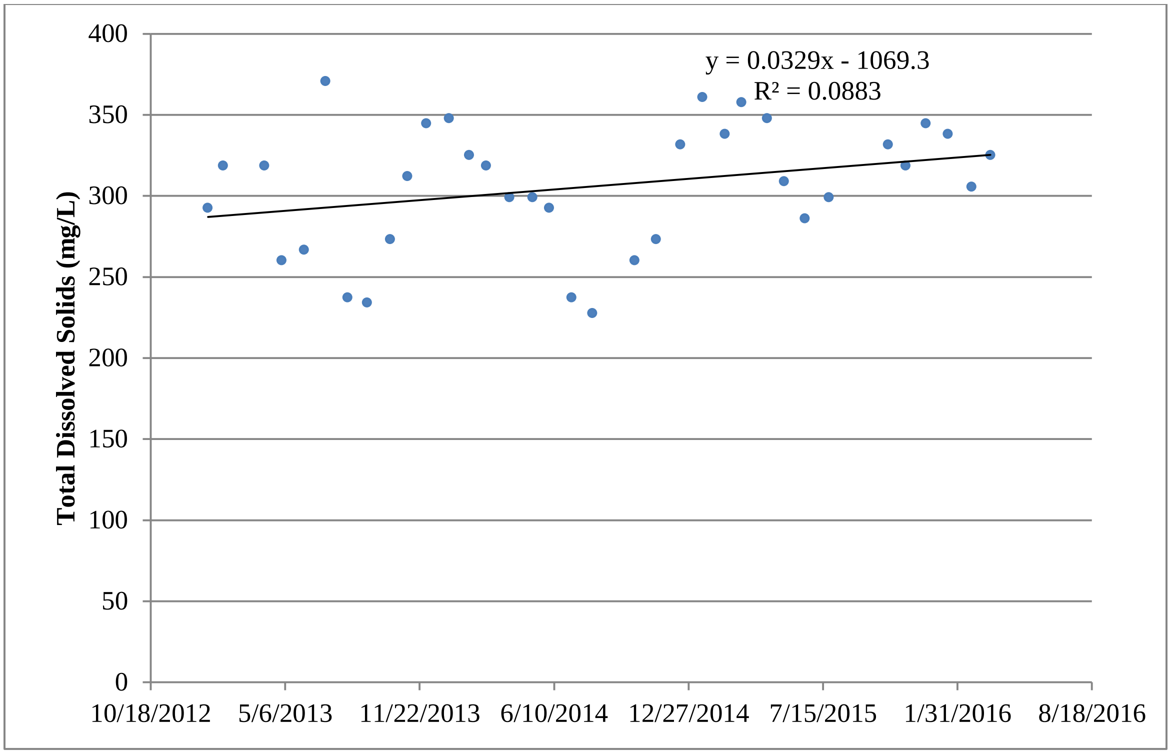

Figure 19: Total dissolved solids at site 80894

Dissolved Oxygen

Citizen scientists took 36 dissolved oxygen measurements at this site. The mean DO concentration was 8.7 mg/L. The minimum DO concentration was 6.7 mg/L and was taken in June of 2015. The maximum DO concentration was 14.0 mg/L and was recorded in January of 2014. There was no significant increase or decrease in observed dissolved oxygen over time at this site.

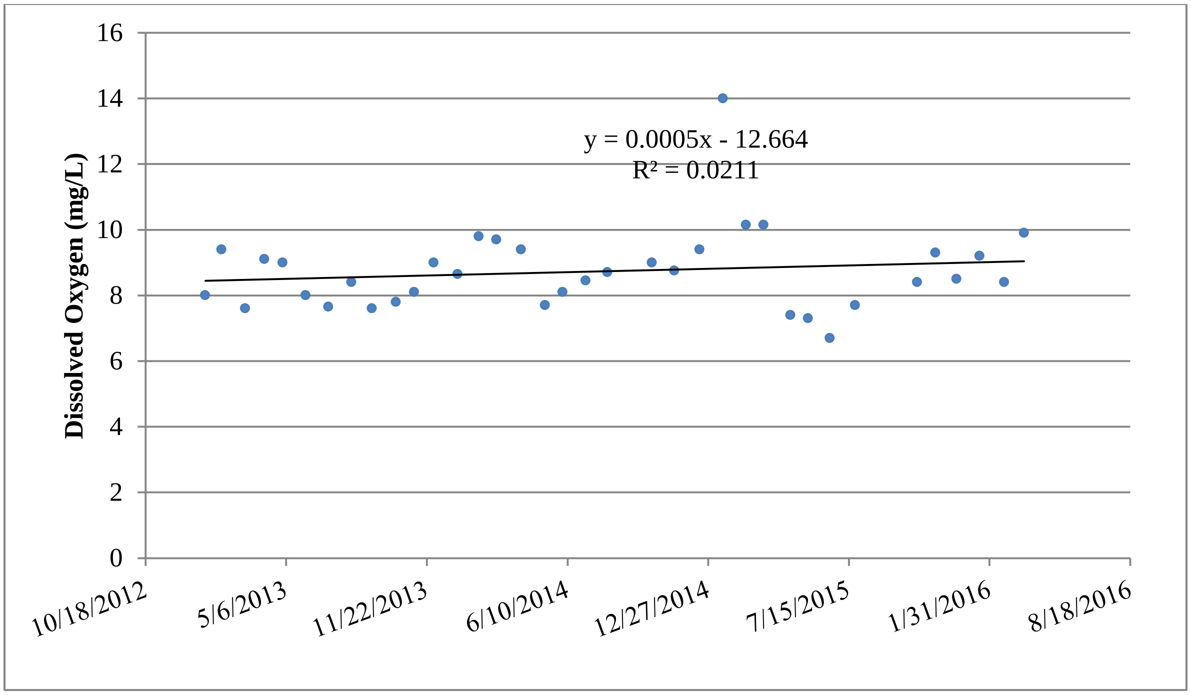

Figure 20: Dissolved oxygen at site 80894

pH

Citizen scientists took 36 pH measurements at this site. The mean pH was 7.4 and it ranged from a low of 6.4 in February of 2013 to a high of 8.0 in October, 2014. There was no significant relationship between pH and time observed at this site.

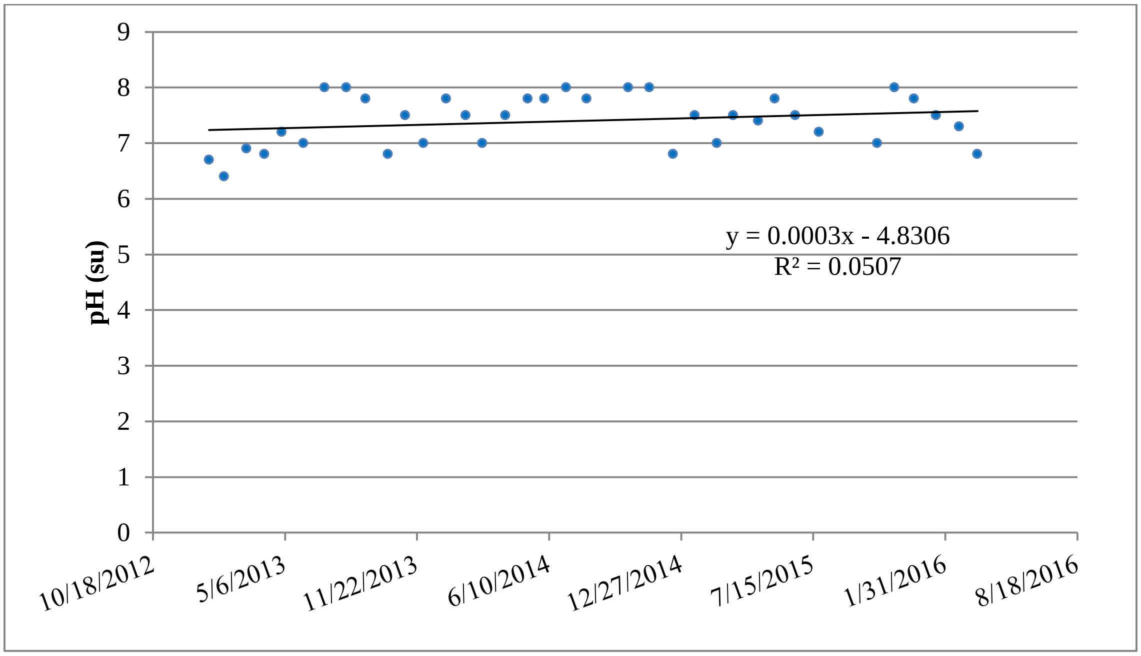

Figure 21: pH at site 80894

Nitrate-Nitrogen

Citizen scientists took 22 nitrate-nitrogen samples at this site. The mean nitrate level was 1.4 mg/L and values ranged from less than 1 mg/L on multiple occasions to 4 mg/L on February of 2015. There was no observed relationship between levels of nitrate-nitrogen and time observed at this site.

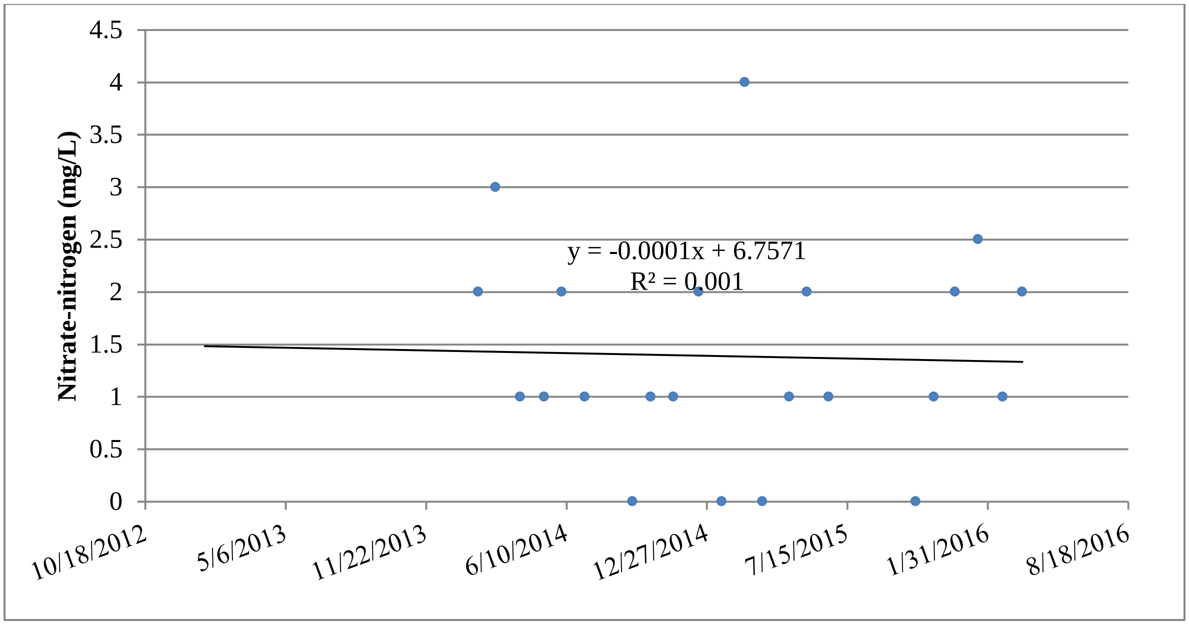

Figure 22: Nitrate-nitrogen at site 80894

Orthophosphates

Citizen scientists took 22 orthophosphate samples at this site. The mean orthophosphate level was 0.22 mg/L and values ranged from 0 mg/L on multiple occasions to 1 mg/L on March of 2015. There was no significant relationship between observed levels of orthophosphate and time at this site.

Field Observations

Flow was recorded as low or normal at this site. Algae was absent or rare. Water color was recorded as no color or light green, and the clarity was always clear.

Salado Creek Watershed Summary

Salado Creek watershed is located in both Bell and Williamson Counties within the Brazos River Basin. One of the major attributes of the watershed is its springs which have never stopped flowing. The watershed is located on the Balcones Escarpment fault line which creates the two natural ecoregions: Blackland Prairies and Edwards Plateau. Because of the differing ecosystems, soils and vegetation within the watershed differ with Blackland Prairies being primarily agriculture and Edwards Aquifer being ranching. The region has over 45 species that are either listed, endangered, or in need of attention which include the Whooping Crane, the Red Wolf, and the Texas Garter Snake. Land use within the watershed is extensive as it consists of recreational activities such as whitewater rafting during select periods of high runoff, agriculture, residential, commercial and municipal.

Both counties the watershed resides in are projected to have significant increases in population by 2050 with bell counties seeing an 81% increase while Williamson county's population is expected to double. This population growth may alter land usage in the area. Currently, there are no segments of Salado Creek on the 303d list nor is the watershed on a TMDL project. There is not an active Watershed Protection Plan (WPP) within the watershed even though it is very near the Lampasas River WPP it is not a part of it. Protection efforts of the watershed are through strict monitoring of the waterways within the watershed.

Two sites within the watershed have been tested from 1991 to 2016 for total dissolved solids (TDS), water temperature, dissolved oxygen (DO), pH, nitrates and phosphates. Water temperatures never exceeded the TCEQ optimal temperatures while the TDS showed no significant changes during the time observed throughout the watershed. The mean DO concentration during the time observed was that of 7.3 mg/L between both sites. Observed pH levels did not show any significant changes over time with the mean being 7.6. Nitrates showed a significant decrease over time and a 17% variation within the time observed. Phosphates showed a significant decrease over time but testing discontinued in 2004. The watershed's expected increase in population will likely necessitate further monitoring by citizen scientists in the future to observe any potential water quality impacts.

Get Involved with Texas Stream Team!

Once trained, citizen monitors 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.

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Appendix A- List of Tables and Figures

Tables

Figures