BARTON CREEK WATERSHED DATA REPORT

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

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INTRODUCTION

Texas Stream Team (TST) is a volunteer-based citizen science 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. TST citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards. Citizen scientists use different methods than the professional water quality monitoring community. TST does not utilize those methods due to higher equipment costs, training requirements, and stringent laboratory procedures that are required of the professional community. However, the data collected by TST 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 7refer to the following sources:

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

The information that TST 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 TST 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 TST 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 (CRP) partner reports
- TCEQ Total Maximum Daily Load (TMDL) reports
- TCEQ and Texas State Soil and Water Conservation Board Nonpoint Source Programs funded reports, including Watershed Protection Plans (WPPs)

Questions regarding this watershed data report should be directed to TST at TxStreamTeam@txstate.edu.

WATERSHED LOCATION AND PHYSICAL DESCRIPTION

Barton Creek Location and Physical Description

Barton Creek originates near the town of Dripping Springs in northern Hays County and flows east through Travis County before reaching the Colorado River in southwest Austin. Barton Creek has a total length of approximately 80 kilometers and winds through hilly, wooded terrain and limestone features that are characteristic of the Central Texas Hill County. Barton Creek flows through private and protected areas and is home to a wide array of wildlife including several endemic, threatened, and endangered species. The creek runs through several significant areas of protected lands that provide water quality and habitat protection, public recreation and a natural oasis for residents and visitors in the heart of Austin. Traveling upstream from its mouth at Ladybird Lake, the creek is flanked by protected land from Zilker Metropolitan Park, the Barton Creek Greenbelt, the Nature Conservancy's Barton Creek Habitat Preserve and up to Shield Ranch in the watershed's central region.

Barton Creek lies within the Barton Springs section of the Edwards Aquifer, which includes 401 square kilometers of Hays and Travis counties in the northwest corner of the aquifer. The Barton Springs section of the Edwards Aquifer feeds Barton Springs, the fourth largest natural spring in Texas, as well as supplies water to 50,000 rural residents (Save Barton Creek Association). Overall, the Barton Creek watershed has a total catchment area of 281.5 square kilometers with 20.2 square kilometers of the watershed in the Edwards Aquifer recharge zone (Barton pdf 2009). A significant portion of Barton Creek also lies within the contributing zone of the Edwards Aquifer. Given its positioning atop the aquifer, maintaining the water quality of Barton Creek is essential, especially considering the rapid development and nonpoint source pollution that threatens the watershed.

Land Protection for Barton Creek

Barton Creek has a significant cultural value to Austin where there is a long history of water quality protection in favor of the iconic waterway and its watershed. One prominent example is Austin's Water Quality Protection Lands Program (WQPL), a project that was implemented in 1998 with the objective to "optimize the quality and quantity of water from project lands to recharge the Barton Springs segment of the Edwards Aquifer" by "protecting and managing land in the recharge and contributing zones of the Barton Springs segment via conservation easements and fee simple purchases" (WQPL, 2015). The WQPL program currently manages over 26,000 acres of land through conservation easements and fee simple land acquisitions. Another prominent example is the Save Our Springs Ordinance (SOS), a citizen-led initiative adopted in 1992 that requires new stormwater discharges to not degrade downstream locations and set rules on the amount of impervious cover that developers can create in the overlying lands above the contributing and recharge zones of the Barton Springs section of the aquifer (City of Austin).

In 1994, the Nature Conservancy purchased a 4,084-acre property located in the central portion of the Barton Creek Watershed where a significant piece of nesting habitat exists for the endangered golden-cheeked warbler. Maintenance of the woodland through species management, deer population control and prescribed burning preserves this space in its natural condition, enhancing the opportunity for increased water quality and quality habitat for downstream species including the rare Barton Springs salamander. The Nature Conservancy's website also states that visitation to the site is limited to arranged visit. This is in contrast to some of the other large, downstream protected areas such as the Barton Creek Greenbelt and Zilker Metropolitan Park, both owned and operated by the City of Austin.

The most upstream, large piece of protected land within the watershed, is a private, conservation easement known as the Shield Ranch. The official website for the ranch describes their mission statement: "…to steward and share Shield Ranch in ways that educate, inspire and transform." A long-standing Texas Stream Team monitoring station at the ranch reflects this mission through the station's usage as a tool for education and monitoring of their land stewardship and restoration activities. The website states that the ranch comprises ten percent of the land within the Barton Creek watershed.

Physiography and Topography

Barton Creek flows through the Edwards Plateau, the physiographic region that makes up the southernmost extent of the Great North American Plains and occupies about 92,980 square kilometers of Central and West Central Texas. The central and western portions of the Edwards Plateau exhibit little relief, except along major stream valleys, and the plateau merges almost imperceptibly into the High Plains region to the northwest. The prominent Balcones Escarpment, which rises several hundred feet above the West Gulf Coastal Plain, forms the arc-shaped southeastern margin of the Edwards Plateau. Headward erosion of the streams flowing across the Edwards Plateau toward the Balcones Escarpment has dissected the southeastern part of the plateau, forming the subregion known as the Balcones Canyonlands. The resulting terrain is generally known as the Texas Hill Country, being characterized by steep canyons, narrow divides, and high gradient streams (LCRA, 2000). Portions of the Barton Creek watershed, including Barton Springs, are located in the Balcones Fault Zone at the southeastern edge of the Balcones Escarpment region of the Edwards Plateau (City of Austin Watershed Protection Department, 2013). The region is characterized by steep, mesic canyons with high-gradient drainages and exposed limestone karstic features including sinkholes, caves, losing streams, and springs (Riskind & Diamond, 1986). Between its source and its mouth, Barton Creek drops 1,000 feet and is flanked by limestone bluffs, canyon walls, sheer cliffs, and heavily vegetated areas. The sandy loam and shallow clay soil surrounding the creek supports a number of plant species including juniper, oak, cottonwood, pecan, willow, dogwood, and redbud trees (TSHA, 2010).

Geology

Northeastern Hays and southwestern Travis County are characterized by karst features such as fractured limestone that is dotted with sinkholes and caves that enhance porosity and permeability to groundwater (Small et al 1996). West of the Balcones Fault Zone and northwest of the Mount Bonnell Fault in Travis

County, the Barton Creek watershed is underlain by the Glen Rose Formation (Johns and Pope, 1998). The Glen Rose Formation is organic limestone deposits from an ancient shallow sea during the Cretaceous era, which is considered the ancient gulf of Mexico, dated approximately 110 million years old (Kuban). The deposits represent both low subtidal zones and supratidal environments. Subtidal areas, or being a part of the neritic zone, lie below the low tide mark while still close to shore, where supratidal areas lie just above high tide lines (GBNP&R, 2018). These zones of the ancient ocean deposited alternating beds of hard limestone and softer marl, or limy clays and shales (Kuban). Eight square miles of this Glen Rose Formation underneath the watershed is within the Edwards Aquifer Recharge Zone (LCRA 2012). Once in the aquifer, water moves northeast to discharge points, predominantly Barton Springs, which is in the last portion of Barton Creek until it widens and empties in Lady Bird Lake. The Barton Spring section of the Edwards Aquifer is comprised of rocks of the lower Cretaceous Kainer and Persons Formations of the Edwards Group, and the overlying Georgetown Formation (Small et al. 1996). The lower end of the Barton Creek watershed is cut by the Balcones Fault Zone, which also plays a vital role in groundwater. Most of the recharge and springflow related to the Edwards Aquifer occurs along the Balcones Fault Zone where faults, fractures, conduits, and dissolution features including sink holes, caves and springs, like Barton Springs, exist. (Ferrill et al. 2004).

Ecoregion and Climate

Barton Creek is located within the Edwards Plateau ecoregion, or as it is commonly known, the Texas Hill Country. Much of the region overlays the Edwards Aquifer which provides baseflow to many of the region's streams. This region consists of 62 rivers, creeks, springs and watersheds, along with 102 landscapes, that are important to conservation (The Nature Conservancy, 2008)[3]. The Edwards Plateau region supports a rich diversity of animals and plants and provides unique habitats, resulting in many species that are endemic, such as the Texas blind salamander, the Balcones ghostsnail, the Tobusch fish-hook cactus, and the famed Texas horned lizard (The Nature Conservancy, 2008). Over 100 of the 400 endemic plants in Texas occur within the Edwards Plateau ecoregion (Texas Parks and Wildlife). The overall terrain comprises nearly 24 million acres of land that is semi- arid, rocky, rugged, and characterized by "rolling hills". The region is traditionally a savanna dominated by flora such as Ashe juniper, various oaks, and the occasional mesquite. Common fauna includes javelinas, ringtails, bobcats, armadillos, raccoons, bass, opossums and badgers and, of course, white-tailed deer. (The Nature Conservancy, 2008). The Edwards Plateau is within the North American Central Flyway and provides corridors for migratory birds as well as the golden-cheeked warbler, which nests only in the hills of central Texas, the black-capped vireo, Acadian flycatcher, summer tanager, indigo bunting, blue-gray gnatcatcher, zone-tailed hawks and bald eagles (The Nature Conservancy, 2008). The region has no designated wet or dry season, and is prone to flooding and droughts. Average rainfall in the western part of the plateau is only 12 inches, while average rainfall in the Austin area is 32 to 34 inches (Flom, 2017). Erosion has created shallow soils less than 10 inches, with yellowish to clay loam surface soil and rocky clay or solid limestone underneath the surface (Texas A&M Forest Service, 2019). This erosion has also created a diverse topography in the region with ranges from 600 feet above sea level in the eastern canyons to 3,000 feet above sea level in the ridges of the central and western areas (Texas A&M Forest Service, 2019).

Land Cover

Land cover, particularly developed land use, plays a role in determining water quality, and both storm flow and base flow. Increased impervious cover, septic systems, organized sewage treatment, and nonpoint source pollution can impact water quality. The Barton Creek watershed mostly contains developed open space, low-to-medium intensity developments, woodland and shrubland (Homer et al. 2007). The watershed likely exhibits high water quality and healthy habitats for aquatic life due to its large, dominating tracts of protected parkland, preserves, and wildlife sanctuaries. In addition to these beneficial lands within the watershed, development within the watershed has been regulated through city ordinances which require developers to limit the amount of their impervious cover.

Lower Colorado River Authority (LCRA): Colorado River Watch Network (CRWN)

The LCRA Colorado River Watch Network (CRWN) is a partner program of Texas Stream Team. As such, CRWN has their own set of procedures and quality system for their citizen monitoring program. For more information on CRWNs data collection procedures please visit the LCRA website. As an independent entity, which does not receive funding from the TCEQ or Texas State University, CRWN manages volunteers, conducts trainings, manages data, and supplies equipment for volunteers within the Colorado River Watershed. However, Texas Stream Team has chosen to include CRWN data information in this data report based on the following points: CRWN is considered as a part of the Texas Stream Team monitoring network, CRWN data is included in the Texas Stream Team database, and CRWN volunteers and state-funded staff are counted as match for the Texas Stream Team grant project.

Endangered Species and Conservation Needs

Barton Creek is valued as a relatively pristine creek in Central Texas, with important habitats providing shelter for a number of threatened and endangered species, along with species of concern. Common names of species listed as rare, threatened, or endangered, under the authority of Texas state law and/or under the US Endangered Species Act, within the counties of Hays and Travis include:

Table 1: Rare, threatened and endangered species located within the study area

AMPHIBIANS	San Marcos salamander
	Texas salamander
	Barton Springs salamander
	Pedernales River Springs salamander
	Blanco River Springs salamander
	Texas blind salamander
	Blanco blind salamander
	Woodhouse's toad
	Strecker's chorus frog
	Barton Springs salamander
	Jollyville Plateau salamander
	Austin blind salamander

	Houston toad
BIRDS	White-faced ibis
	Wood stork
	bald eagle
	zone-tailed hawk
	whooping crane
	piping plover
	mountain plover
	Franklin's gull
	interior least tern
	western burrowing owl
	black-capped vireo
	tropical parula
	golden-cheeked warbler
	swallow-tailed kite
	black rail
	interior least tern
	western burrowing owl
FISH	alligator gar
	american eel
	Texas shiner
	smalleye shiner
	ironcolor shiner
	sharpnose shiner
	chub shiner
	silverband shiner
	headwater catfish
	Guadalupe bass
	fountain darter
	Guadalupe darter
	Mexican goby
	speckled chub
	blue sucker
	western creek chubsucker
MAMMALS	Mexican long-tongued bat
	cave myotis bat
	tricolored bat
	big brown bat

	eastern red bat
	hoary bat
	Mexican free-tailed bat
	big free-tailed bat
	swamp rabbit
	woodland vole
	long-tailed weasel
	mink
	American badger
	plains spotted skunk
	western spotted skunk
	western hog-nosed skunk
	mountain lion
	southern short-tailed shrew
	Aransas short-tailed shrew
REPTILES	Cagle's map turtle
	Texas map turtle
	eastern box turtle
	western box turtle
	American alligator
	slender glass lizard
	spot-tailed earless lizard
	northern spot-tailed earless lizard
	keeled earless lizard
	Texas horned lizard
	western hognose snake
	common garter snake
	Texas garter snake
	western chicken turtle
	Texas tortoise
	American alligator
	timber (canebrake) rattlesnake
CRUSTACEANS	A Copepod *(Cyclops cavernarum)*
	Ezell's Cave amphipod
	Balcones Cave amphipod
	Purgatory Cave Shrimp *(Calathaemon holthuisi)*
	Palaemonetes texanus
	Artesia subterranea

	a cave obligate amphipod *(Texiweckelia texensis)*
	Texas troglobitic water slater
	A Cave obligate isopod *(Lirceolus bisetus)*
INSECTS	Edwards Aquifer diving beetle
	Comal Springs riffle beetle
	a cave-obligate beetle *(Rhadine austinica)*
	a cave-obligate beetle *(Rhadine insolita)*
	a cave-obligate beetle *(Batrisodes grubbsi)*
	Comal Springs dryopid beetle
	Comal Springs diving beetle
	A Mayfly *(Procloeon distinctum)*
	a small minnow mayfly *(Plauditus texanus)*
	American bumblebee
	a snout moth *(Oxyelophila callista)*
	San Marcos saddle-case caddisfly
	a purse casemaker caddisfly *(Ochrotrichia capitana)*
	a microcaddisfly *(Neotrichia juani)*
	Texas austrotinodes caddisfly
	a caddisfly *(Xiphocentron messapus)*
	A cave obligate beetle *(Rhadine subterranea)*
	Kretschmarr Cave mold beetle
	a cave obligate beetle *(Lymantes nadineae)*
	Variable Cuckoo Bumble Bee *(Bombus variabilis)*
	a mining bee *(Andrena scotoptera)*
	a mining bee *(Macrotera parkeri)*
	Comanche harvester ant
	a cave obligate springtail *(Oncopodura fenestra)*
	a microcaddisfly *(Neotrichia juani)*
	Tooth Cave ground beetle
	a cave obligate beetle
	Tooth Cave spider
	Reddell harvestman
	Bone Cave harvestman
ARACHNIDS	a cave-obligate harvestman *(Texella spinoperca)*
	a cave-obligate harvestman *(Texella diplospina)*
	a cave-obligate harvestman *(Texella mulaiki)*
	a cave-obligate harvestman (*Texella grubbi*)
	a cave-obligate harvestman (*Texella renkes*)

	a cave obligate pseudoscorpion *(Tartarocreagris grubbsi)*
	a cave obligate spider *(Cicurina ezelli)*
	a cave obligate spider *(Cicurina russelli)*
	a cave obligate spider *(Cicurina ubicki)*
	Tooth Cave pseudoscorpion
	Bandit Cave spider
	a cave-obligate pseudoscorpion *(Tartarocreagris infernalis)*
	a cave-obligate pseudoscorpion *(Tartarocreagris intermedia)*
	a cave-obligate pseudoscorpion *(Tartarocreagris attenuata)*
	a cave-obligate pseudoscorpion *(Tartarocreagris altimana)*
	a cave-obligate pseudoscorpion *(Tartarocreagris domina)*
	a cave-obligate pseudoscorpion *(Tartarocreagris proserpina)*
	a cave-obligate spider *(Cicurina travisae)*
	a cave-cobweb spider *(Eidmannella reclusa)*
MOLLUSKS	Texas fatmucket
	golden orb
	Texas pimpleback
	Guadalupe Orb *(Cyclonaias necki)*
	false spike mussel
	glossy wolfsnail
	New Braunfels Holospira *(Holospira goldfussi)*
	Edwards Plateau Liptooth
	Balcones Elimia
	Hueco Cavesnail
	Flattened Cavesnail
	Disc Cavesnail
	High-Hat Cavesnail
	Phreatodrobia rotunda
	smooth pimpleback
	Barton Cavesnail
	Pedernales Oval
	High-Hat Cavesnail
PLANTS	plateau milkvine
	gravelbar brickellbush
	narrowleaf brickellbush
	spreading leastdaisy
	Texas barberry
	Heller's marbleseed

	Engelmann's bladderpod
	bracted twistflower
	Texas claret-cup cactus
	tree dodder
	Hill Country wild-mercury
	Texas amorpha
	Hall's prairie clover
	net-leaf bundleflower
	turnip-root scurfea
	canyon mock-orange
	Plateau loosestrife
	scarlet leather-flower
	Osage Plains false foxglove
	Heller's beardtongue
	threeflower penstemon
	Texas seymeria
	sycamore-leaf snowbell
	bigflower cornsalad
	Glass Mountains coral-root
	Warnock's coral-root
	Texas fescue
	Buckley tridens
	Texas wild-rice
	glandular gay-feather
	tree dodder
	Texabama croton
	low spurge
	Texas milk vetch
	Wright's milkvetch
	canyon bean
	Stanfield's beebalm
	Correll's false dragon-head
	Texas almond
	Greenman's bluet
	rock grape
	canyon sedge
	arrowleaf milkvine

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 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.

Table 2: Daily minimum dissolved oxygen requirements for aquatic life

Aquatic Life Sub-category	Daily Minimum Dissolved Oxygen (mg/L)
Exceptional	4.0
High	3.0
Intermediate	3.0
Limited	2.0
Minimal	1.5

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 microsiemens per cubic centimeter ($\mu S/cm^3$). A body of water is more conductive if it has more total dissolved solids (TDS) such as nutrients and salts, which indicates poor water quality if they are overly abundant. High concentrations of nutrients can lower the level of DO, leading to eutrophication. High concentrations of salt can inhibit water absorption and limit root growth for vegetation, leading to an abundance of more drought tolerant plants, and can cause dehydration of fish and amphibians. Sources of TDS can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants. 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.

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 the Barton 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 nitrate-nitrogen, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with TCEQ and other partners. Just like phosphorus, nitrogen is a nutrient necessary for the growth of most organisms. Nitrogen inputs into a water body may be 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 previously in the "Dissolved Oxygen" section (page 14). Nitrate-nitrogen dissolves more readily than orthophosphate, 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 TST 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 TST's approved Quality Assurance Project Plan (QAPP).

Table 3: 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/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 TST 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 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 TST.

Sampling is not encouraged with expired reagents and bacteria media; the corresponding values will be flagged in the database and excluded from data reports. Detailed observational data is 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 TST approved physical or electronic datasheets. The physical datasheet is submitted to the TST and local partner, if applicable. The electronic datasheet is accessible in the online Waterways Dataviewer and, upon submission and verification, is uploaded directly to the TST database.

Quality Assurance and Quality Control

All data is 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 TST 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 is verified and evaluated against project specifications and is 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 TST 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 TST program manager. If repeated errors occur, the monitor and/or the group leader will be notified via email or telephone.

Data Analysis Methods

Data is 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 is 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 and Exceedances

The TCEQ determines a water body to be impaired if more than 10 percent 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 2018 Texas Surface Water Quality Standards report was used to calculate the exceedances for the Barton Creek watershed, as seen on page 20 in Table 4.

Methods of Analysis

All data collected from Barton Creek and its tributaries were exported from the TST database and were then grouped by site. Data was reviewed and, for the sake of data analysis, only one sampling event per day, per site was selected for the entire study duration. If more than one sampling event occurred per day, per site, the most complete, correct, and representative sampling event was selected.

Once compiled, data was sorted and graphed in Microsoft Excel 2010 using standard methods. Statistically significant trends were added to Excel to be graphed. The p-value identified within the equations in the graphs is the level of marginal significance within a statistical hypothesis test representing the probability of the occurrence of a given event. 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 percent. 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. Due to the variability, the geometric mean is used to summarize bacteria data.

Photograph 1: Barton Creek below Barton Springs Pool, September 2011, courtesy of Colorado River Watch Network

Segment No.	Segment Name	Description	Dissolved Oxygen (mg/L)	*E. coli* single sample (CFU/100mL)	*E. coli* geometric mean (CFU/100mL)	Water Temp (°C)	High pH (SU)	Low pH (SU)	TDS (mg/L)
1430	Barton Creek	From the confluence with Lady Bird Lake (formerly Town Lake) in Travis County to FM 12 in Hays County	5.0	394	126	32	9.0	6.5	500

Table 4: TCEQ designated stream segment and standards, as applicable to citizen water quality data in this report.

Photograph 2: Barton Creek @ CR 169 (Bell Springs Rd), January 2019, courtesy of Colorado River Watch Network

BARTON CREEK WATERSHED DATA ANALYSIS

Barton Creek Maps

Numerous maps were prepared to show spatial variation of the parameters. The parameters mapped include DO, pH, TDS, nitrate-nitrogen, and *E. coli*. There is also a reference map showing the locations of all active sites.

Reference points are shown in all maps, layers including monitoring sites, cities, counties, and major highways were included. All of the shapefiles were downloaded from reliable federal, state, and local agencies.

Photograph 3: Barton Creek near Crumley Ranch, January 2018, courtesy of Colorado River Watch Network

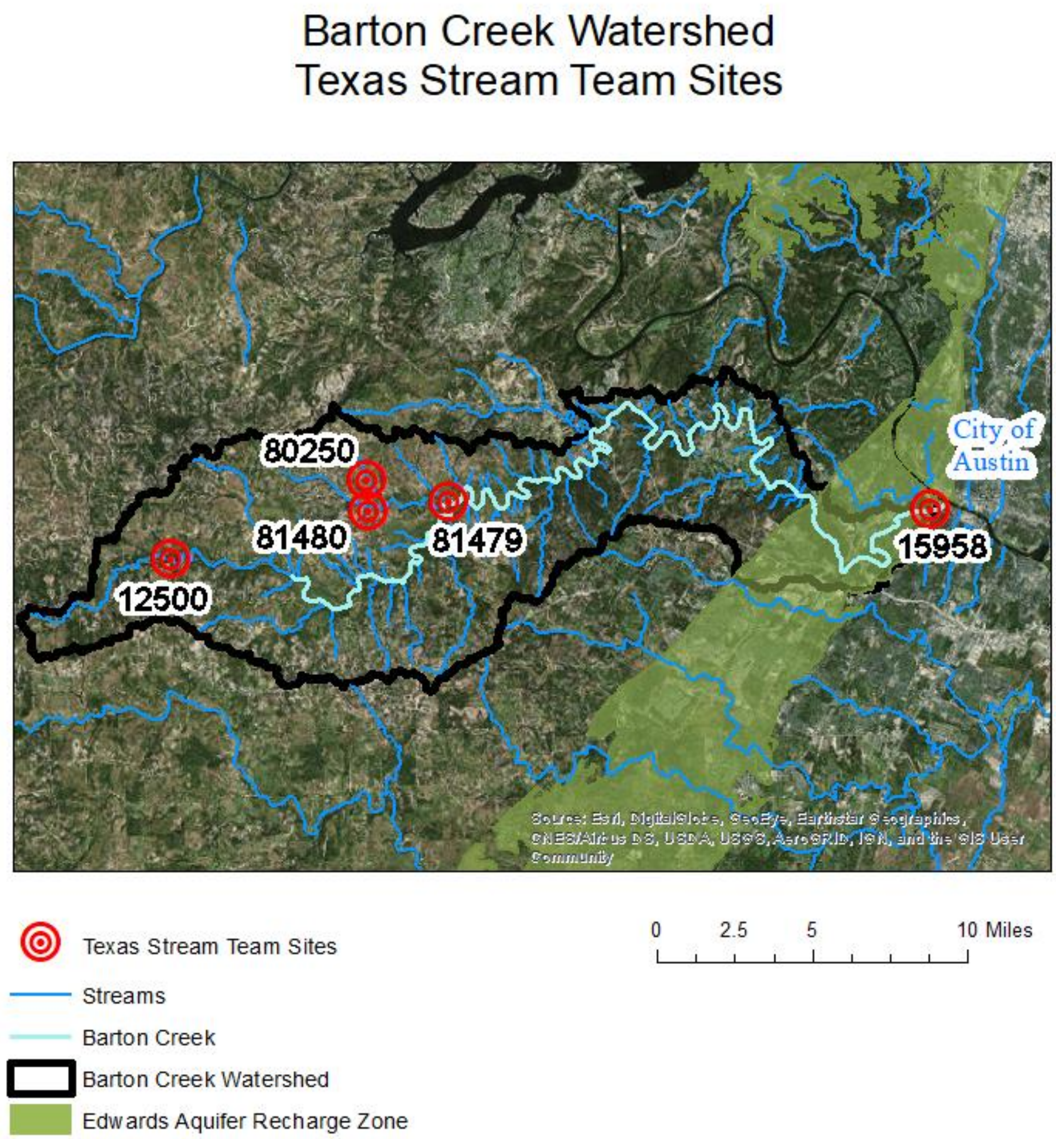

Figure 1: Barton Creek Watershed and active TST sites

Barton Creek Watershed Trends over Time

Sampling Trends over Time

Sampling within the Barton Creek watershed began in April of 1998 and continues to this day. A total of 609 individual monitoring events from 5 sites were analyzed. Monthly monitoring occurred on a near-consistent basis throughout the years, with some lapses during particular years.

Table 5: Descriptive parameters for all sites in the Barton Creek watershed

Barton Creek Watershed January 1996 – September 2018				
Parameter	Number of Samples	*Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	528	448 ± 11	169	793
Water Temperature (°C)	606	20.8 ± 4.8	7.0	32.0
Dissolved Oxygen (mg/L)	597	6.6 ± 1.5	1.8	11.4
pH (su)	588	7.4 ± 0.4	6.0	9.0
E. coli (CFU/100mL)	158	28 ± 386	1	3513
Nitrate-Nitrogen (mg/L)	431	1.13 ± 0.46	1.00	4.00

There was a total of 609 sampling events between 4/3/1996 and 9/7/2018. *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 606 air and water temperatures were collected in the Barton Creek watershed between 1998 and 2018. Water temperature never exceeded the TCEQ optimal temperature of 32.2°C during sampling events. Air temperature varied between 4.0°C and 45.0°C.

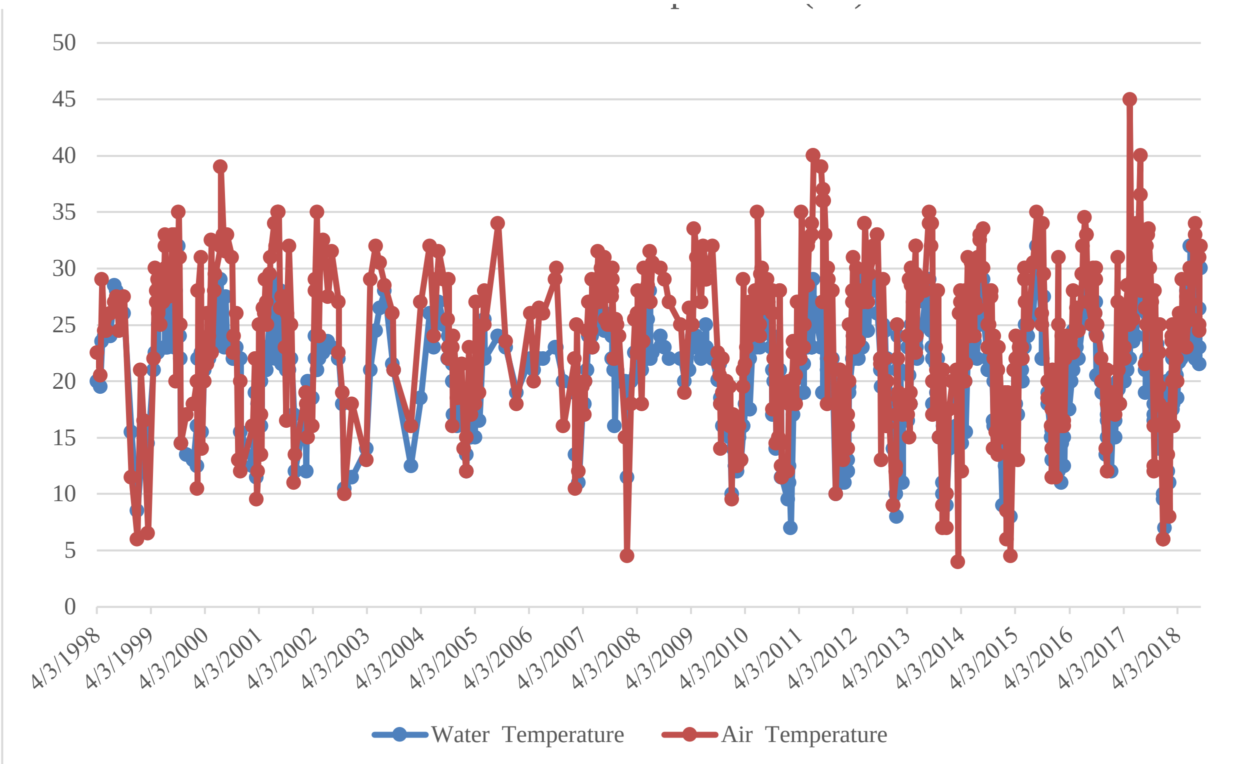

Figure 2: Air and water temperature over time at all sites within the Barton Creek watershed

Photograph 4: Barton Creek near Crumley Ranch, June 2016, courtesy of Colorado River Watch Network

Total Dissolved Solids

Citizen scientists collected 528 TDS samples within the watershed. The average TDS measurement for all sites was 448 mg/L.

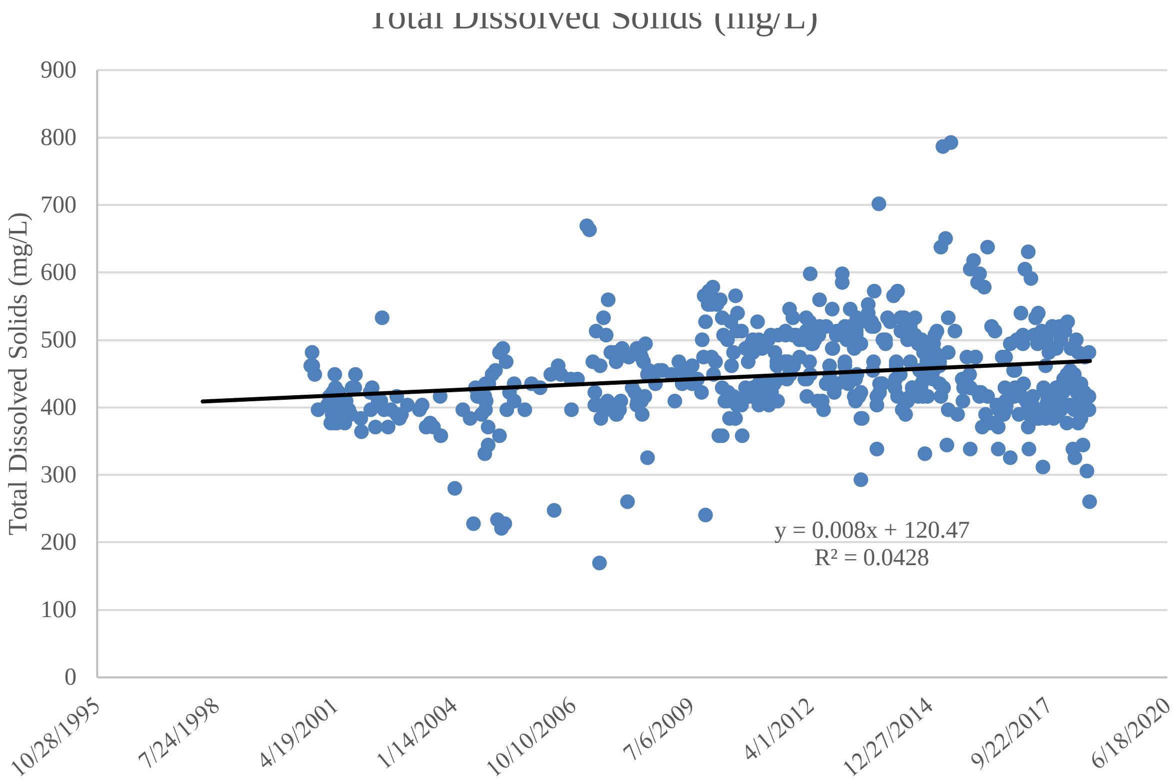

Figure 3: Total dissolved solids over time at all sites within the Barton Creek watershed

Dissolved Oxygen

Citizen scientists collected a total of 597 DO samples in the Barton Creek watershed. The mean DO was 6.6 mg/L. Measurements ranged from a low of 1.8 mg/L in June of 2011 and to a high of 11.4 mg/L in February of 2005.

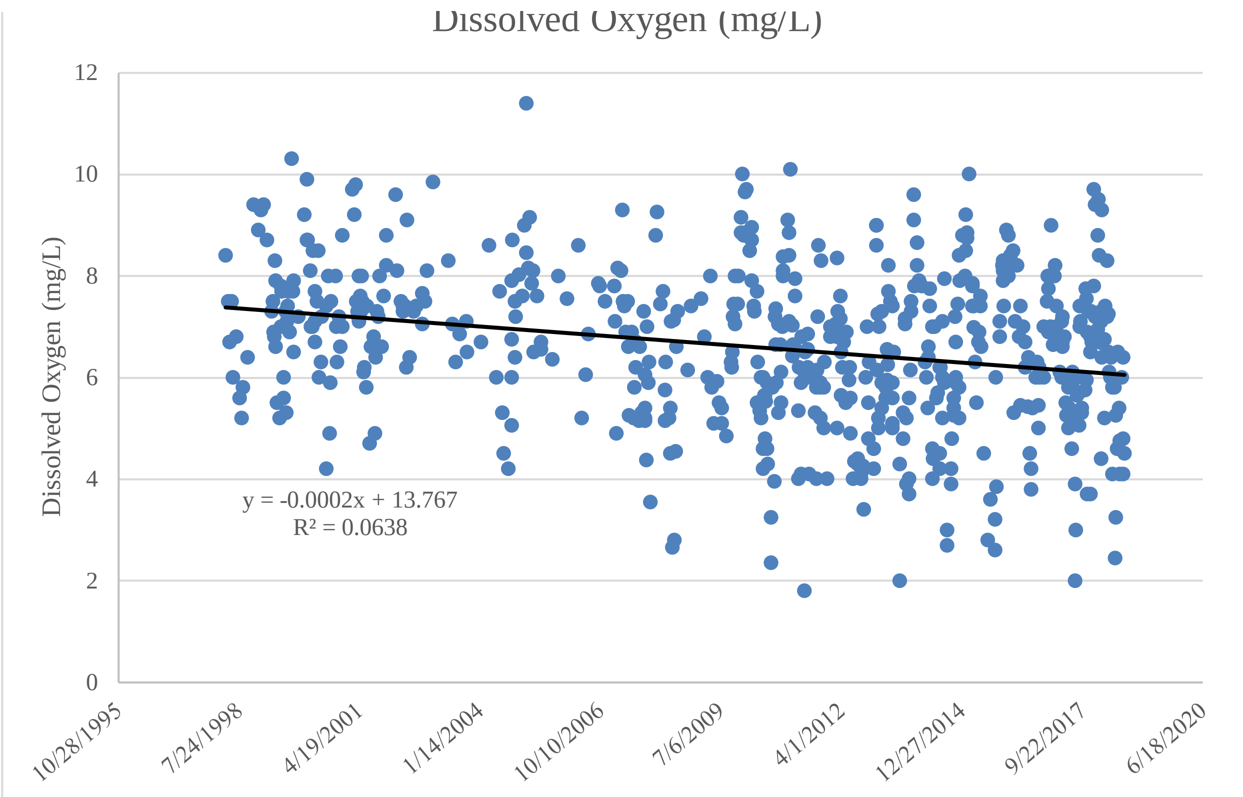

Figure 4: Dissolved oxygen over time at all sites in the Barton Creek watershed

pH

The pH was measured during 588 of the 609 sampling events within the Barton Creek watershed. The mean pH was 7.4 with values ranging from 6.0 to 9.0.

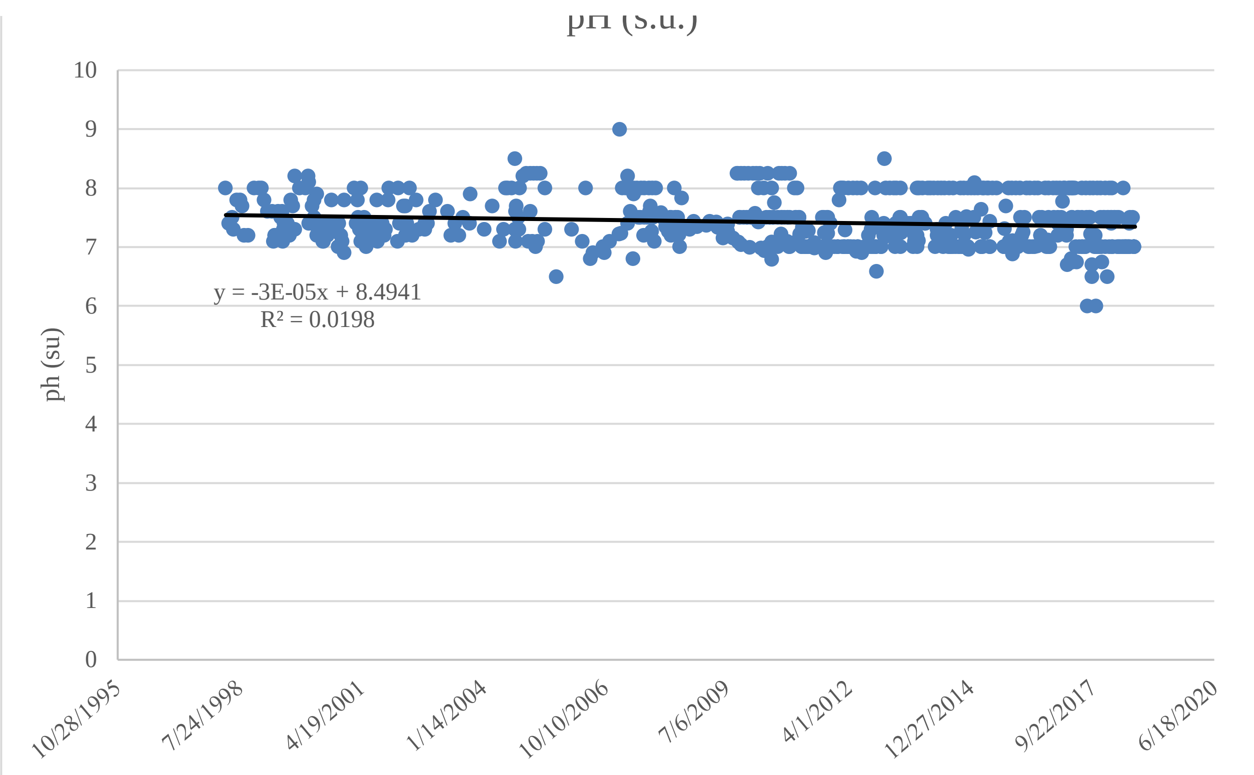

Figure 5: pH over time at all sites within the Barton Creek watershed

E. coli Bacteria

E. coli samples were taken throughout a quarter of the sampling events within Barton Creek watershed. A total of 158 *E. coli* samples were taken. The geomean for *E. coli* was 28 CFU/100 mL. The *E. coli* counts ranged from 1 CFU/100mL (no bacteria detected) to a high of 3513 CFU/100mL in October of 2011.

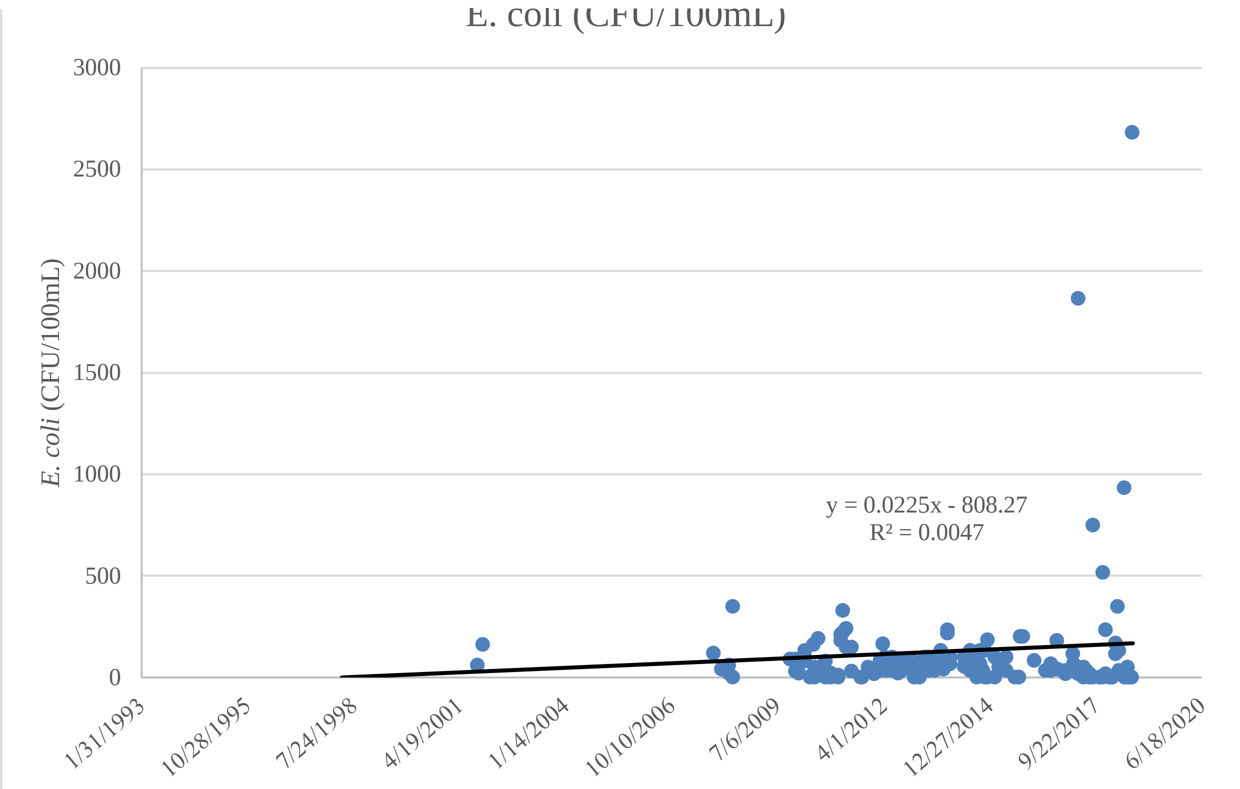

Figure 6: *E. coli* over time at all sites within the Barton Creek watershed

Nitrate-Nitrogen

Nitrate-nitrogen concentrations were taken at nearly all of the selected sites in the Barton Creek watershed except for Site 80250 – Rocky Creek Branch near Crumley Ranch, where only one nitrate-nitrogen sample was taken. A total of 431 nitrate-nitrogen samples were taken. The mean nitrate-nitrogen concentration in the watershed was 1.13 mg/L from values ranging from 1.0 mg/L to a high of 4.0 mg/L.

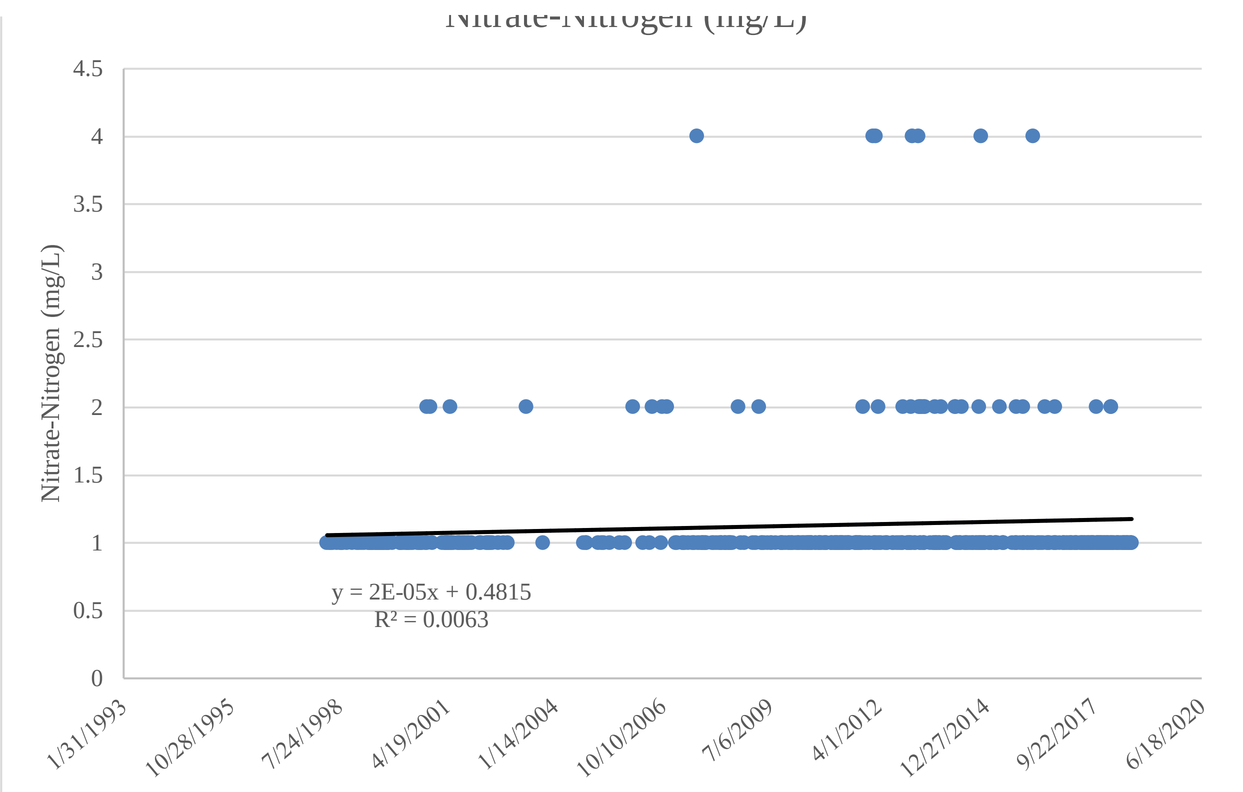

Figure 7: Nitrate-nitrogen over time at all sites within the Barton Creek watershed

BARTON CREEK WATERSHED SITE BY SITE ANALYSIS

The following sections will provide a brief summarization of analysis by site. The average minimum and maximum 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. The *E. coli* is presented as a geomean. Please see Table 6 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 80250 – Rocky Creek Branch near Crumley Ranch had the highest overall average for TDS, with a result of 505 ± 81 mg/L. Site 12500 – Barton Creek @ CR 169 (Bell Springs Rd) had the lowest average TDS, with a result of 375 ± 40 mg/L.

Photograph 5: Barton Creek @ CR 169 (Bell Springs Rd), February 2019, courtesy of Colorado River Watch Network

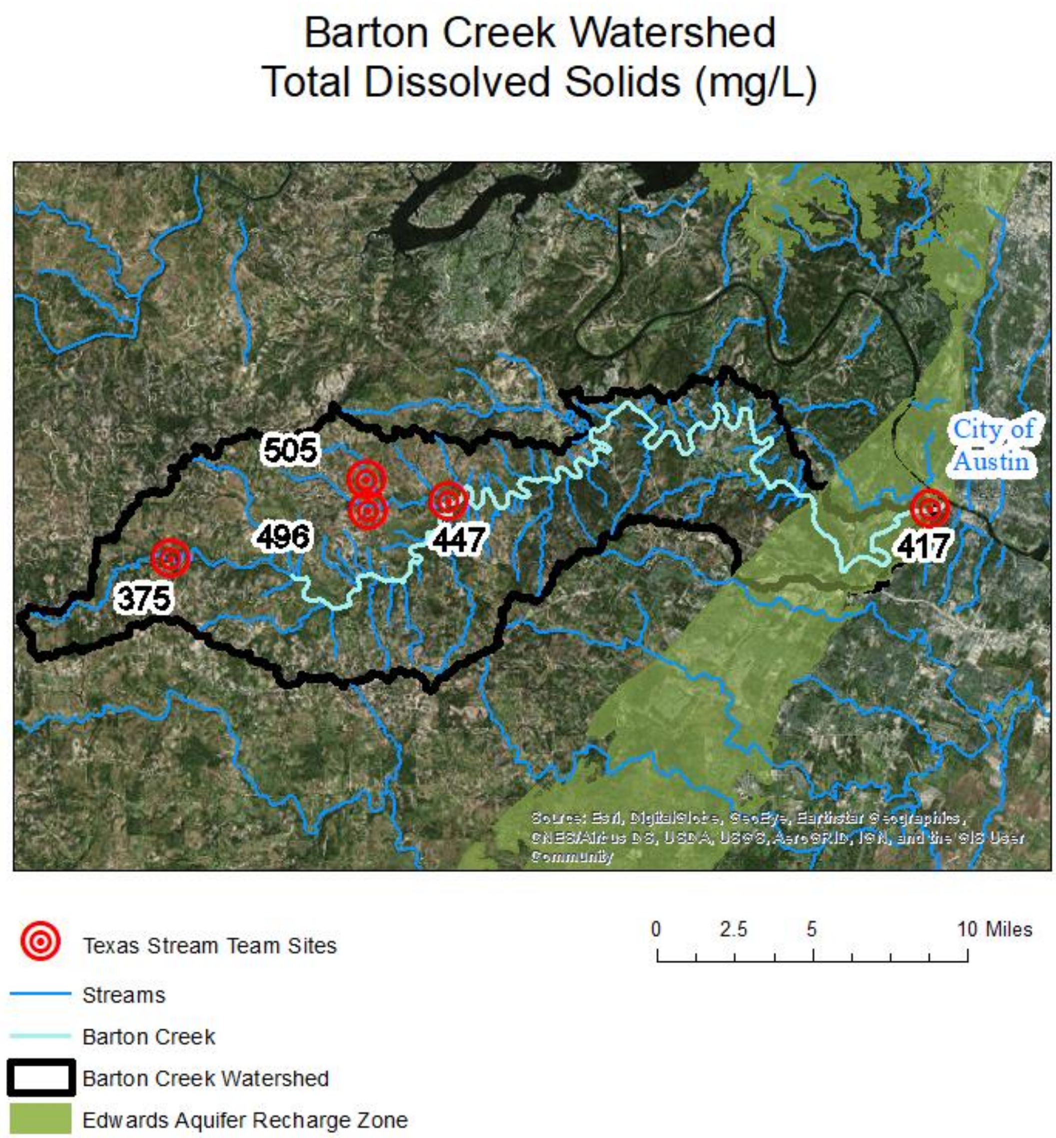

Figure 8: Map of the average total dissolved solids for sites in the Barton Creek watershed

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 then 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 DO 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 81480 – Rocky Creek @ Shield Ranch had the lowest average DO reading, with a result of 5.7 ± 1.9 mg/L. Site 12500 Barton Creek @ CR 169 (Bell Springs Rd) had the highest average DO reading, with a result of 7.1 ± 1.5 mg/L.

Photograph 6: Barton Creek @ Twin Boulders, November 2007, courtesy of Colorado River Watch Network

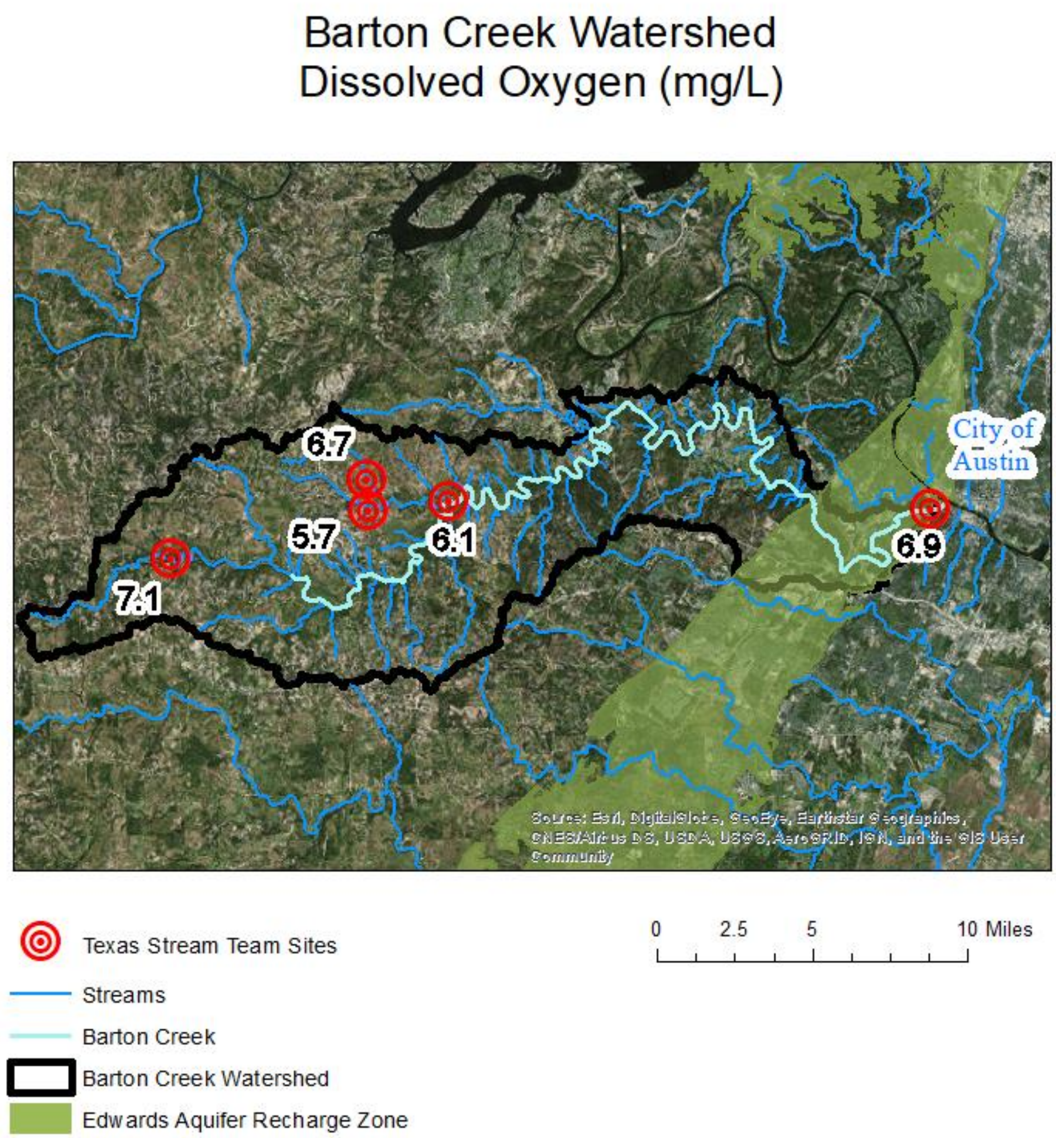

Figure 9: Map of the average dissolved oxygen concentration for sites in the Barton Creek watershed

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 of fish species and/or can result in fish kills. There were only two instances in August and October of 2017 that were below this widely accepted range, these instances occurred at Site 15958 – Barton Creek below Barton Springs Pool. Site 80250 – Rocky Creek Branch near Crumley Ranch, had the highest average pH level, with a result of 8.0 ± 0.2. Site 81480 – Rocky Creek @ Shield Ranch, and Site 15958 – Barton Creek below Barton Springs Pool, both had the lowest average pH level, with a result of 7.2 ± 0.3.

Photograph 7: Barton Creek @ Shield Ranch, August 2007, courtesy of Colorado River Watch Network

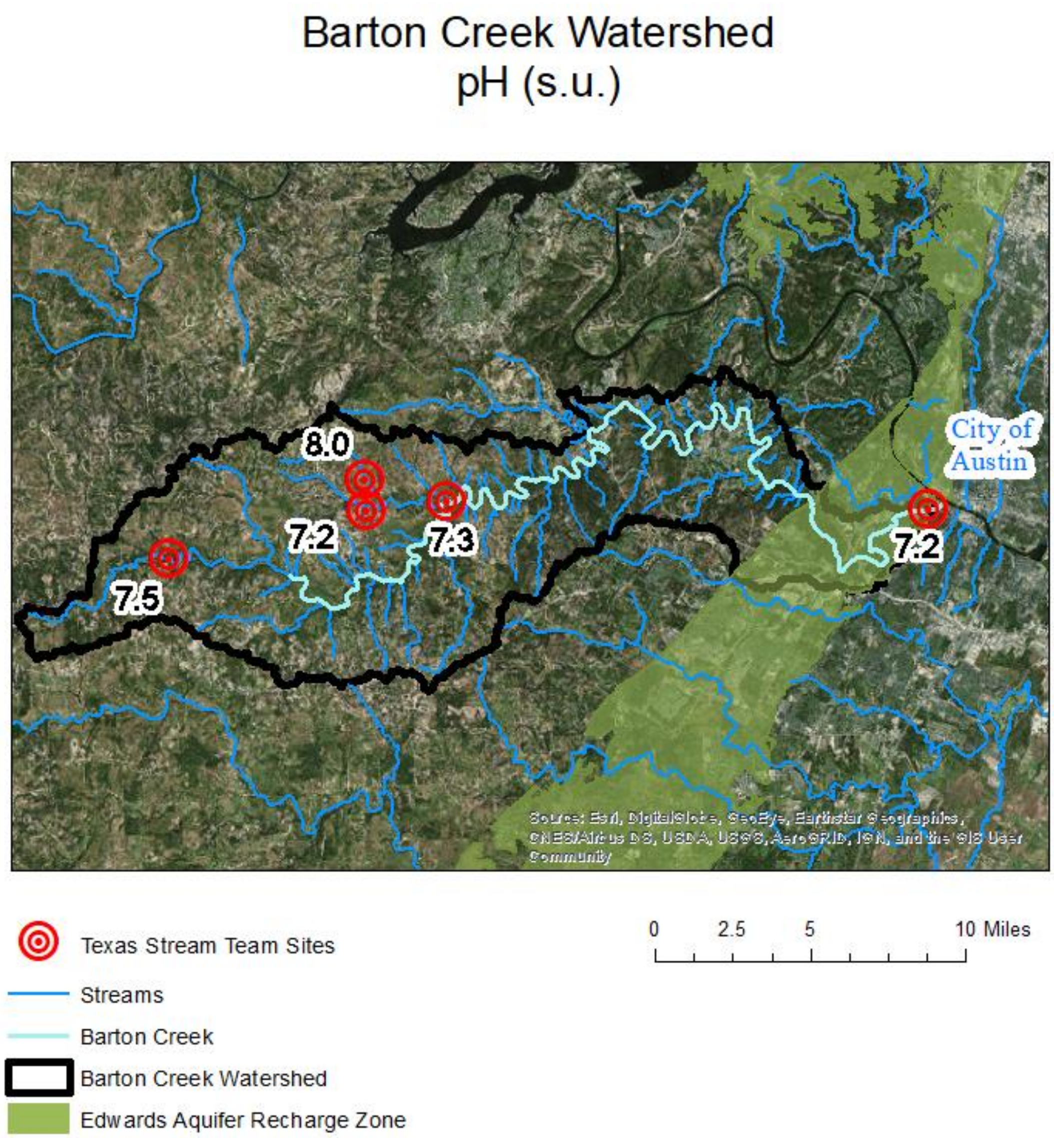

Figure 10: Map of the average pH for sites in the Barton Creek watershed

E. coli can be used as an indicator of the degree of pathogens in a water body. Its presence above the TCEQ surface water quality standard for a single sample (394 CFU/100mL) or geometric mean (126 CFU/100mL) indicates a possible human health risk for primary contact recreation. Site 81480 – Rocky Creek @ Shield Ranch, Site 81479 – Barton Creek @ Twin Boulders, and Site 15958 – Barton Creek below Barton Springs Pool, each had between a total of 13 to 74 sampling events. These three sites had a geometric mean which satisfied the TCEQ surface water quality standard.

Photograph 8: Barton Creek @ Twin Boulders, July 2007, courtesy of Colorado River Watch Network

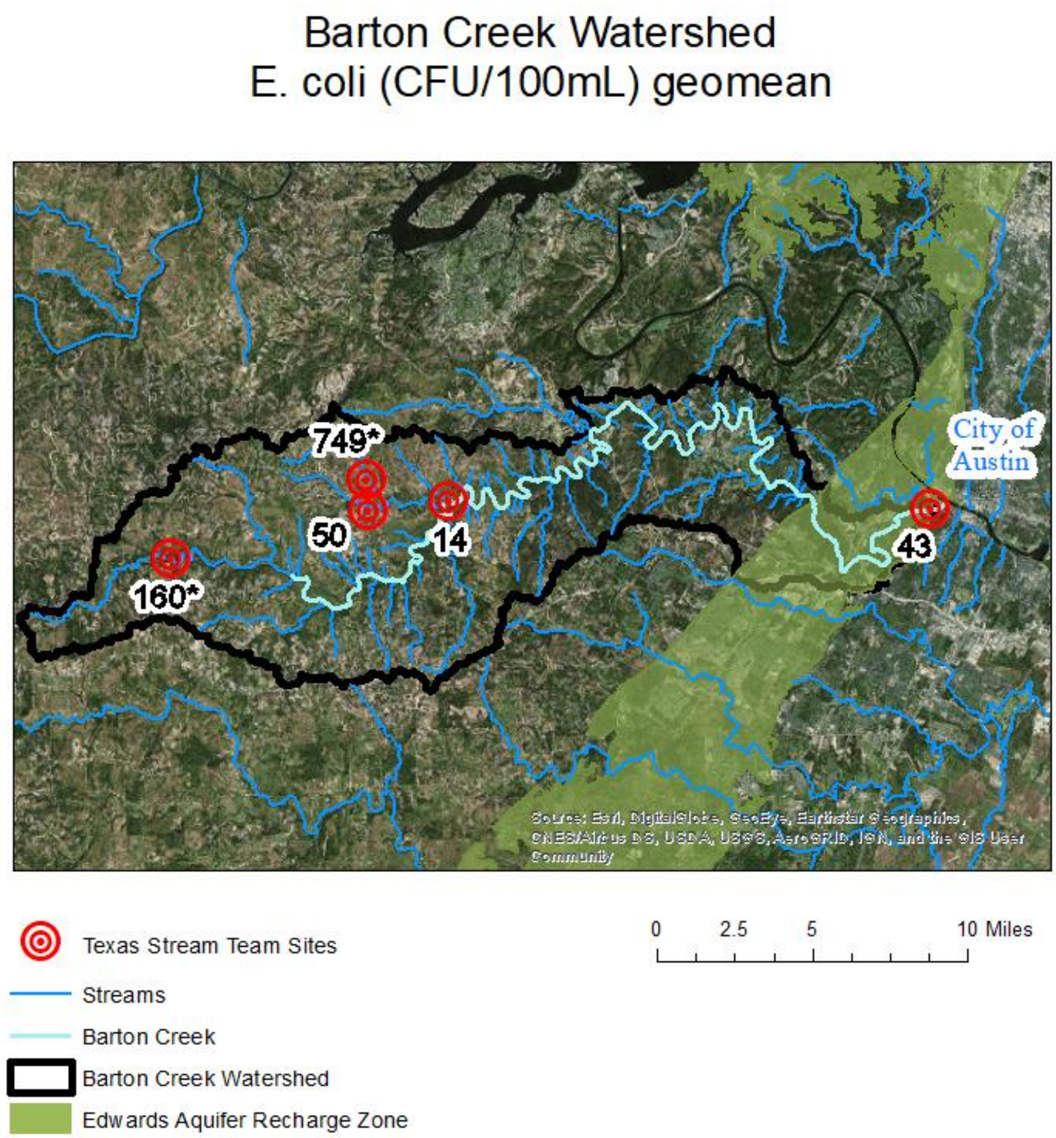

Figure 11: Map of the *E. coli* geomean for sites in the Barton Creek Watershed

*Site 12500 – Barton Creek @ CR 169, and Site 80250 – Rocky Creek Branch near Crumley Ranch, each had only one *E. coli* sample taken throughout the study period which resulted in 160 and 749 CFU/100mL, respectively.

Nitrates are essential plant nutrients, but in excess amount they can cause significant water quality problems. Excess nitrates can cause hypoxia (low DO) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors. Sites had between a total of one and 213 monitoring events for nitrate-nitrogen. Most sites had an average nitrate-nitrogen concentration of 1.00 mg/L. Site 15958 – Barton Creek below Barton Springs Pool, had the highest average nitrate-nitrogen concentration with 1.26 mg/L.

Photograph 9: Barton Creek below Barton Springs Pool, September 2011, courtesy of Colorado River Watch Network

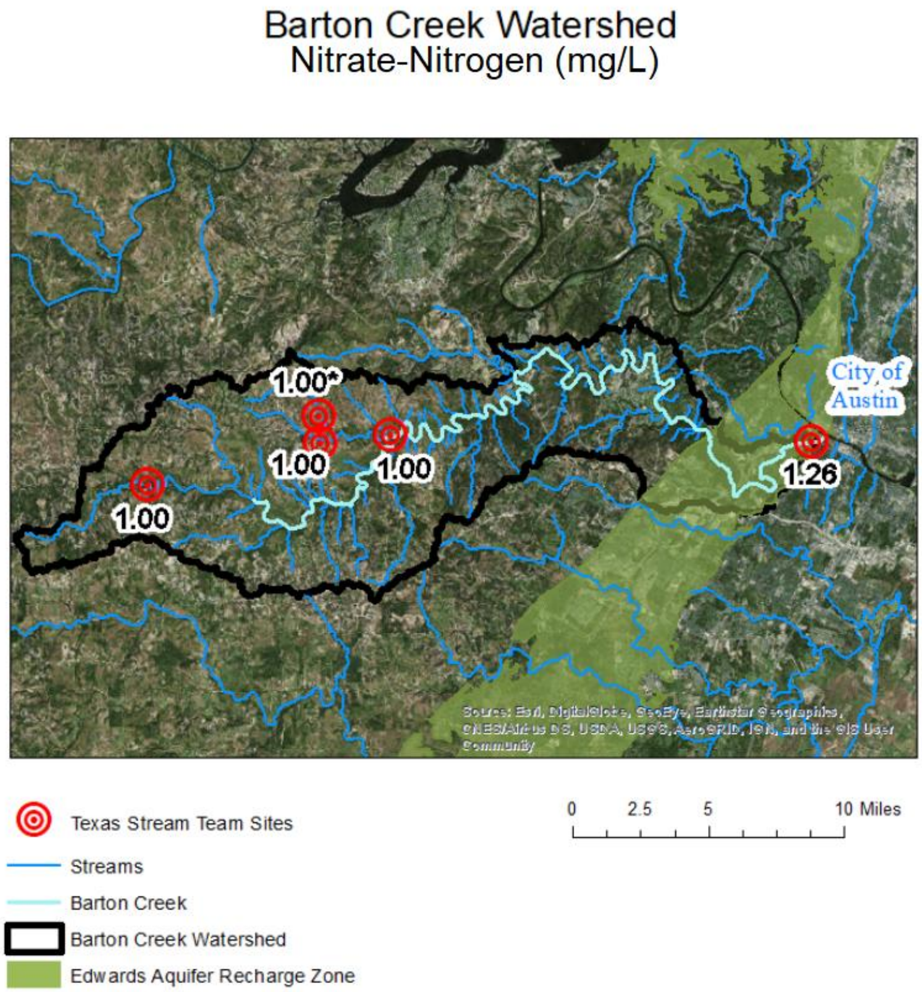

Figure 12: Map of the average nitrate-nitrogen for sites in the Barton Creek watershed

*Site 80250 – Rocky Creek Branch near Crumley Ranch, only had one sampling event for nitrate-nitrogen, resulting in a nitrate-nitrogen concentration of 1.00 mg/L.

See Table 6 below 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. TST citizen scientist data is not used by the state to assess whether water bodies are meeting the designated surface water quality standards.

Table 6: Average values for all Barton Creek watershed sites

Site Number	TDS (mg/L)	DO (mg/L)	pH (su)	*E. coli* (CFU/100 mL) *geomean	Nitrate-Nitrogen (mg/L)
12500	375 ± 40	7.1 ± 1.5	7.5 ± 0.3	160 ± 0	1.00 ± 0.00
80250	505 ± 81	6.7 ± 1.6	8.0 ± 0.2	749 ± 0	1.00 ± 0.00
81480	496 ± 42	5.7 ± 1.9	7.2 ± 0.2	50 ± 89	1.00 ± 0.00
81479	447 ± 86	6.1 ± 1.6	7.3 ± 0.3	14 ± 405	1.00 ± 0.00
15958	417 ± 49	6.9 ± 1.1	7.2 ± 0.3	43 ± 820	1.26 ± 0.62

Site 12500 – Barton Creek @ CR 169 (Bell Springs Rd) Northwest of Dropping Springs

Site Description

This site is located on an intermittent stream within the city of Dripping Springs, Hays County, on the western extreme of the Barton Creek watershed below a low water crossing of Hays County Road 169, also known as Bell Springs Rd. Several seasonal springs exist within the area. The surrounding, upstream lands are mostly undeveloped, are predominantly rangeland and woodland, and include several low-impact developments, wineries, and an olive farm.

Sampling Information

This site was sampled 89 times between 4/3/1998 and 9/7/2018. There was a lapse of sampling activity between February 2005 and December 2015. The time of sampling for this site ranged from 8:05 to 17:30. Barton Creek @ CR 169 has experienced consistent monthly monitoring since February 2016.

Table 7: Descriptive parameters for Site 12500

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	56	375 ± 40	228	449
Water Temperature (°C)	89	21.1 ± 6	7.0	30.0

Dissolved Oxygen (mg/L)	88	7.1 ± 1.5	4.2	11.4
pH (su)	86	7.5 ± 0.3	7.0	8.2
E. coli (CFU/100ml)	1	160 ± 0	160	160
Nitrate-Nitrogen (mg/L)	56	1.00 ± 0.0	1.0	1.0

Site 12500 was sampled 89 times between 4/3/1998 and 9/7/2018.

Air and Water Temperature

Air and water temperatures were taken 89 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 34.5°C taken in July of 2016, and the lowest temperature of 6.0°C taken in January of 1999. The mean water temperature was 21.1°C and the water temperature ranged from a low of 7°C recorded in January of 2018 to a high of 30.0°C in both August and September of 2018.

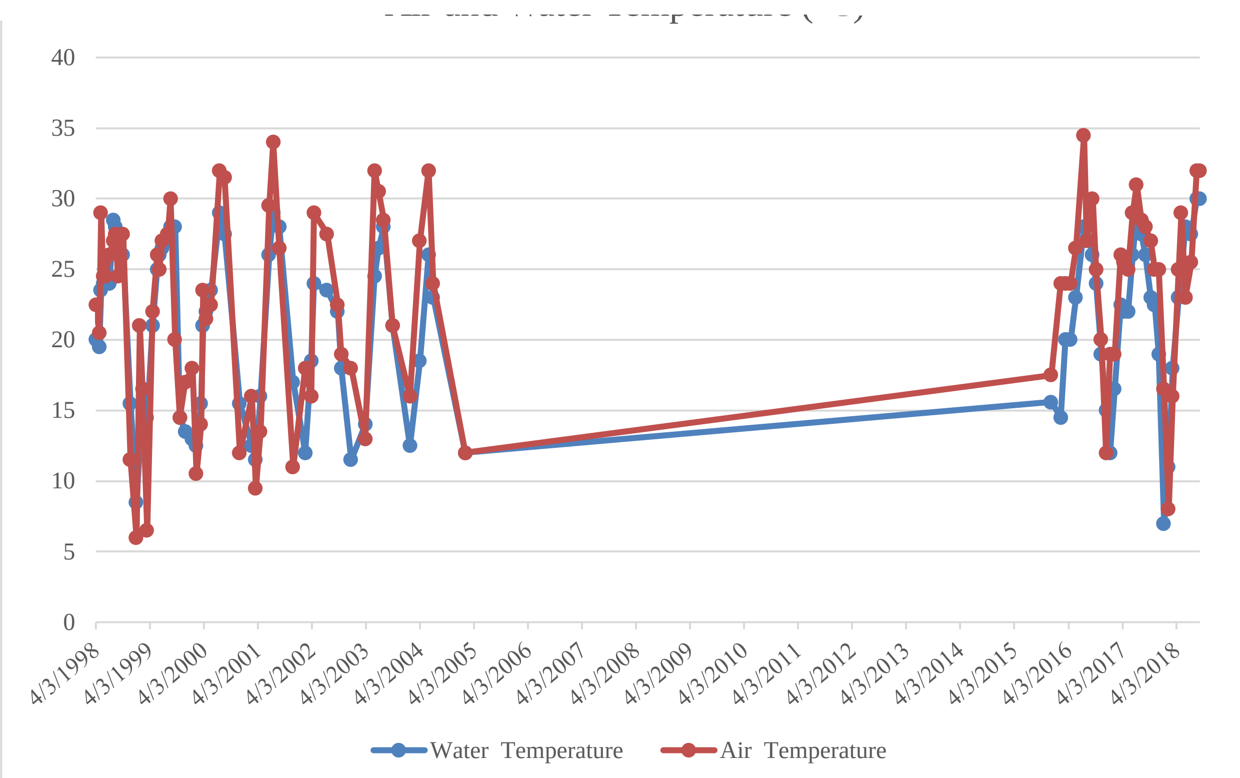

Figure 13: Air and water temperature at Site 12500

Total Dissolved Solids

Citizen scientists sampled TDS at this site 56 times between 12/1/2000 and 9/7/2018. The mean TDS concentration was 375 mg/L. The concentration of TDS ranged from a minimum of 228 mg/L in June of 2004 to a maximum of 449 mg/L in March of 2018.

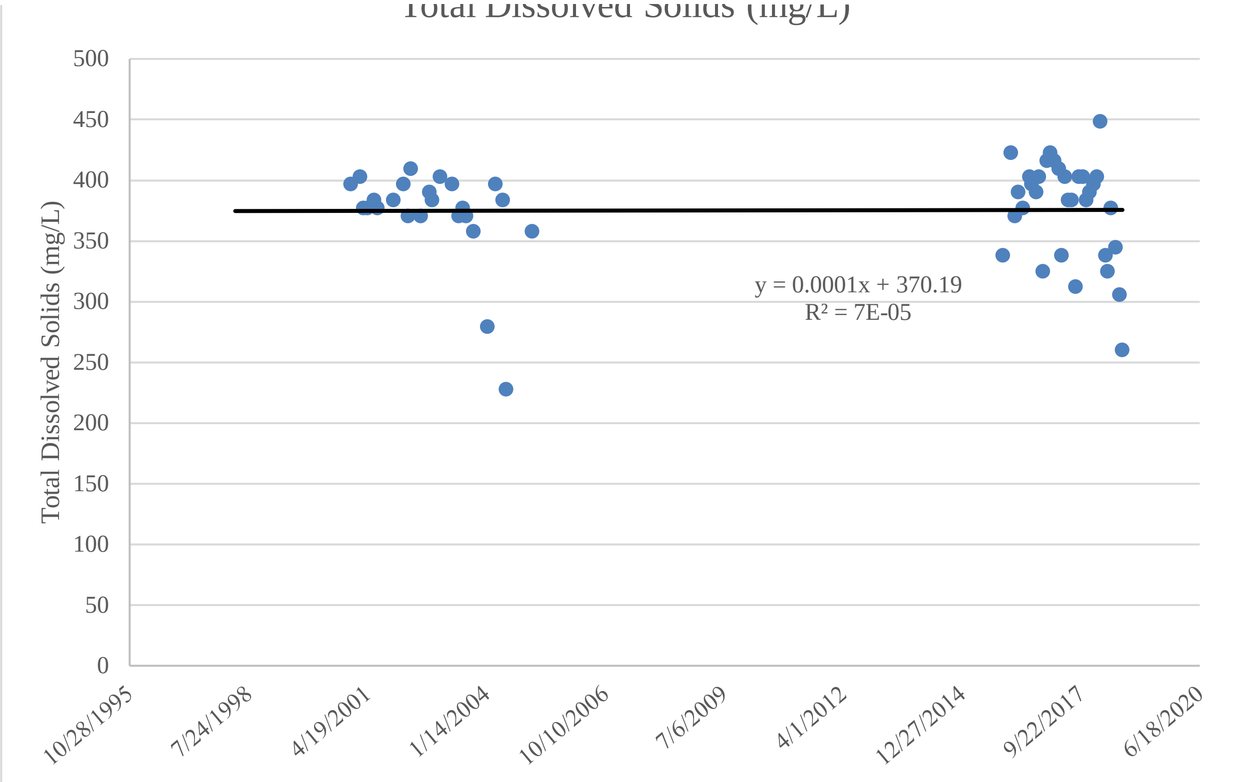

Figure 14: Total dissolved solids at Site 12500

Dissolved Oxygen

Citizen scientists took 88 DO samples at this site between 4/3/1998 and 9/7/2018. The mean DO concentration was 7.1 mg/L. DO concentrations ranged from a low of 4.2 mg/L in July of 2000 to a high of 11.4 mg/L in February of 2000.

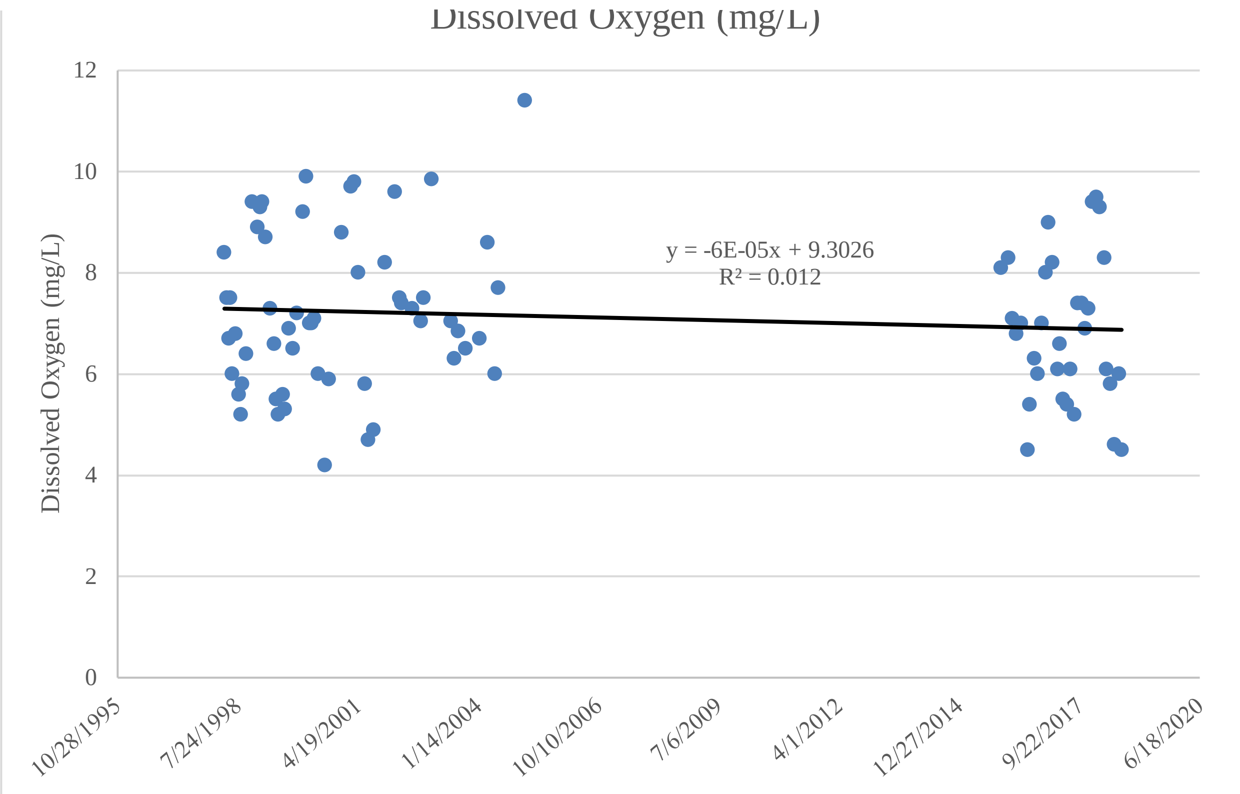

Figure 15: Dissolved oxygen at Site 12500

pH

There were 86 pH measurements taken at this site between 4/3/1998 and 9/7/2018. The mean pH was 7.5 and pH ranged from a low of 7.0 taken on numerous occasions to a high of 8.2 taken in October of 1999.

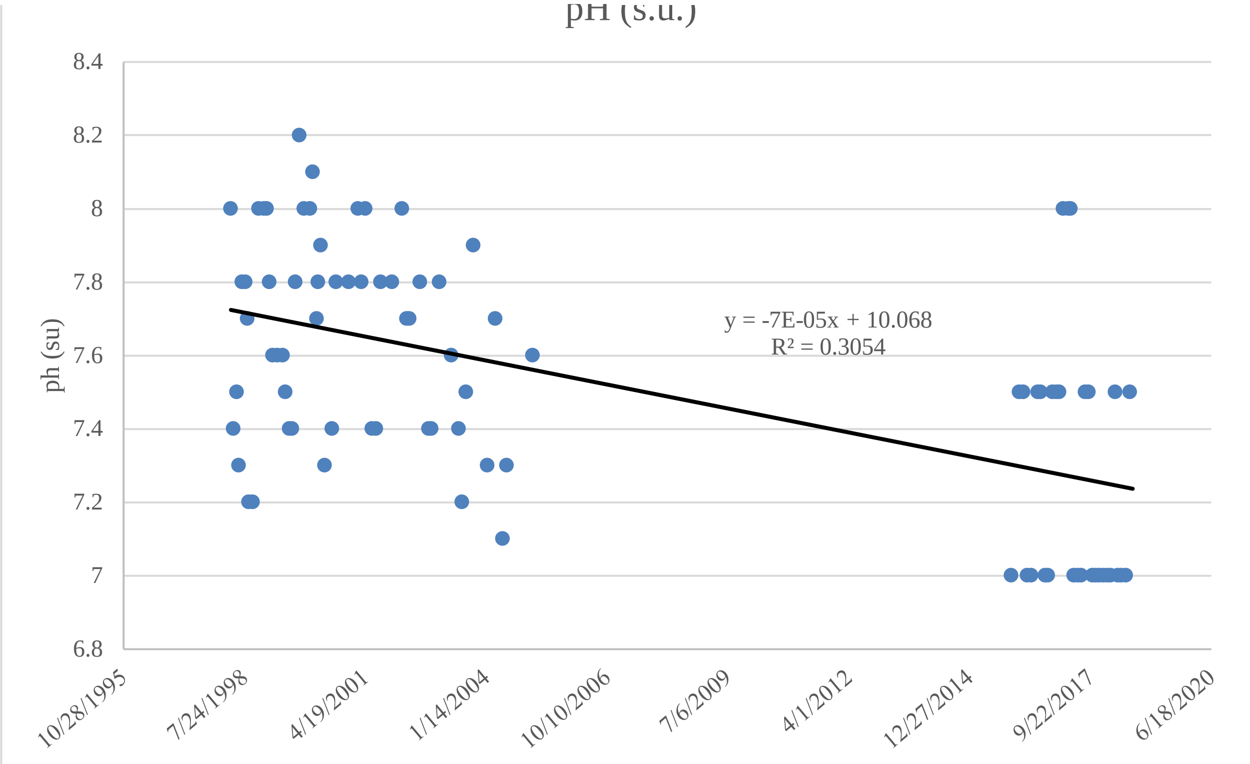

Figure 16: pH at Site 12500

E. coli

There was 1 *E. coli* measurement taken at this site between on 11/27/2001 resulting in 160 CFU/100mL.

Nitrate-Nitrogen

There were 56 nitrate-nitrogen measurements taken at this site between 4/3/1998 and 9/7/2018 all producing results of 1 mg/L.

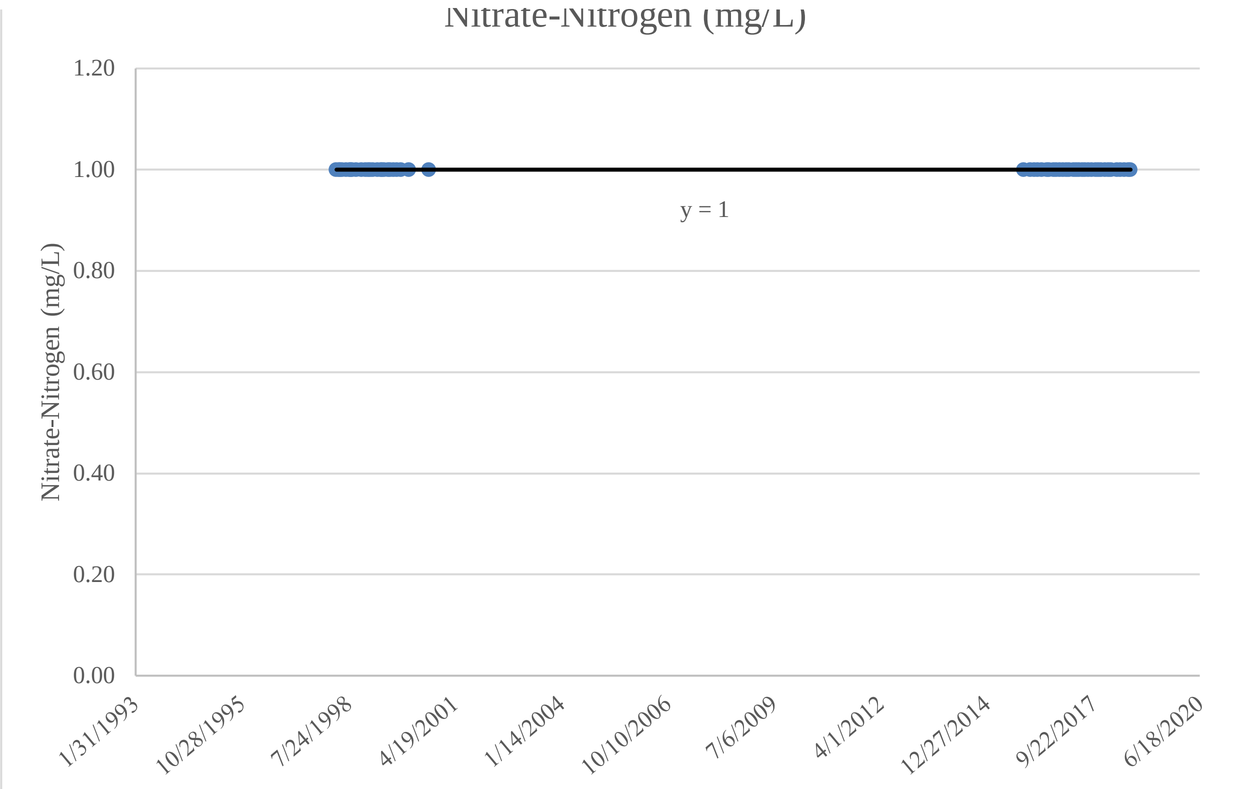

Figure 17: Nitrate-nitrogen at Site 12500

Site 80250 – Rocky Creek Branch near Crumley Ranch

Site Description

Rocky Creek Branch is a small intermittent tributary to Rocky Creek, which feeds into Barton Creek in Travis County from its 4.3-kilometer, meandering creek-bed. Rocky Creek Branch is well into the uplands of the north-central portion of the Barton Creek watershed. The watershed of Rocky Creek Branch is mostly undeveloped rangeland and woodland; however, the extreme uplands of the watershed are experiencing an increasing amount of master-planned single-family, low-impact development. This TST station is located on private property, permission to monitor has been given by the property owner.

Sampling Information

This site was sampled 115 times between 7/18/2004 and 6/3/2018. The time of sampling for this site ranged from 7:30 to 16:00. Rocky Creek Branch near Crumley Ranch has been experiencing near-consistent monthly monitoring since January 2012.

Table 8: Descriptive parameters for Site 80250

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	111	505 ± 81	247	793

Water Temperature (°C)	115	18.7 ± 5.4	7.0	29.5
Dissolved Oxygen (mg/L)	113	6.7 ± 1.6	2.7	10.1
pH (su)	111	8.0 ± 0.2	7.5	9.0
E. coli (CFU/100ml)	1	749 ± 0	749	749
Nitrate-Nitrogen (mg/L)	1	1.0 ± 0	1.0	1.0

Site 80250 was sampled 115 times between 7/18/2004 and 6/3/2018.

Air and Water Temperature

Air and water temperatures were taken 115 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 34.0°C taken in July of 2017, and the lowest temperature of 4.5°C taken in March of 2015. The mean water temperature was 18.7°C and the water temperature ranged from a low of 7.0°C recorded in February of 2011 to a high of 29.5°C in July of 2017.

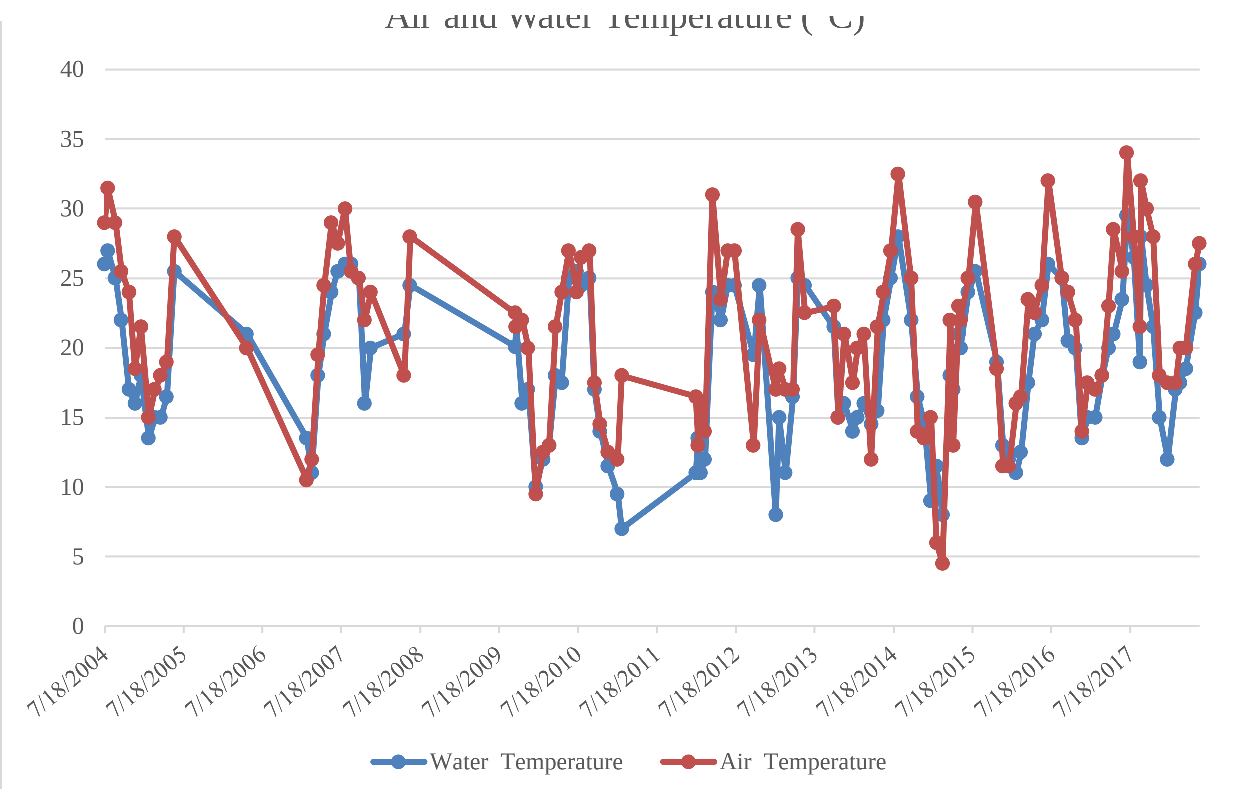

Figure 18: Air and water temperature at Site 80250

Total Dissolved Solids

Citizen scientists sampled TDS at this site 111 times between 7/18/2004 and 6/3/2018. The mean TDS concentration was 505 mg/L. The concentration of TDS ranged from a minimum of 247 mg/L in May of 2006 to a maximum of 793 mg/L in June of 2015.

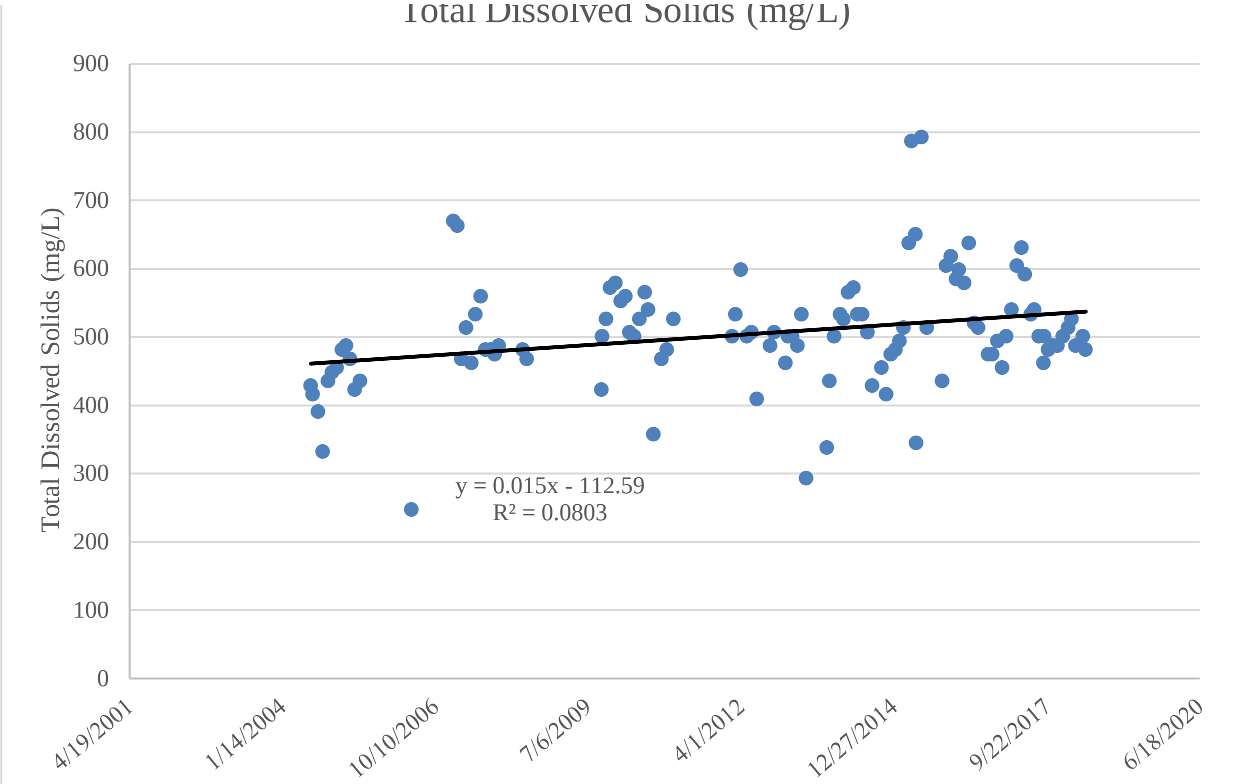

Figure 19: Total dissolved solids at Site 80250

Dissolved Oxygen

Citizen scientists took 113 DO samples at this site between 7/18/2004 and 6/3/2018. The mean DO concentration was 6.7 mg/L. DO concentrations ranged from a low of 2.7 mg/L in June of 2008 to a high of 10.1 mg/L in February of 2011.

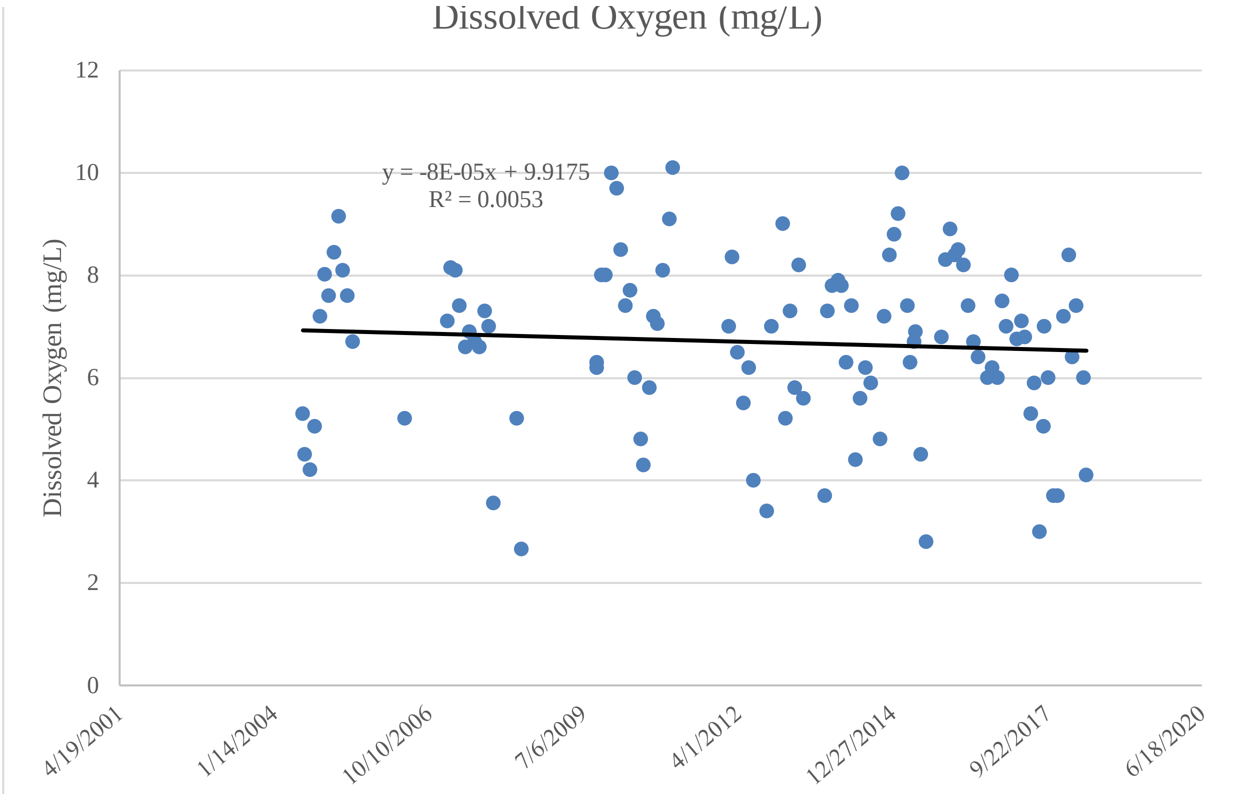

Figure 20: Dissolved oxygen at Site 80250

pH

There were 111 pH measurements taken at this site between 7/18/2004 and 6/3/2018. The mean pH was 8.0 and pH ranged from a low of 7.5 taken on multiple instances to a high of 9.0 taken in February of 2007.

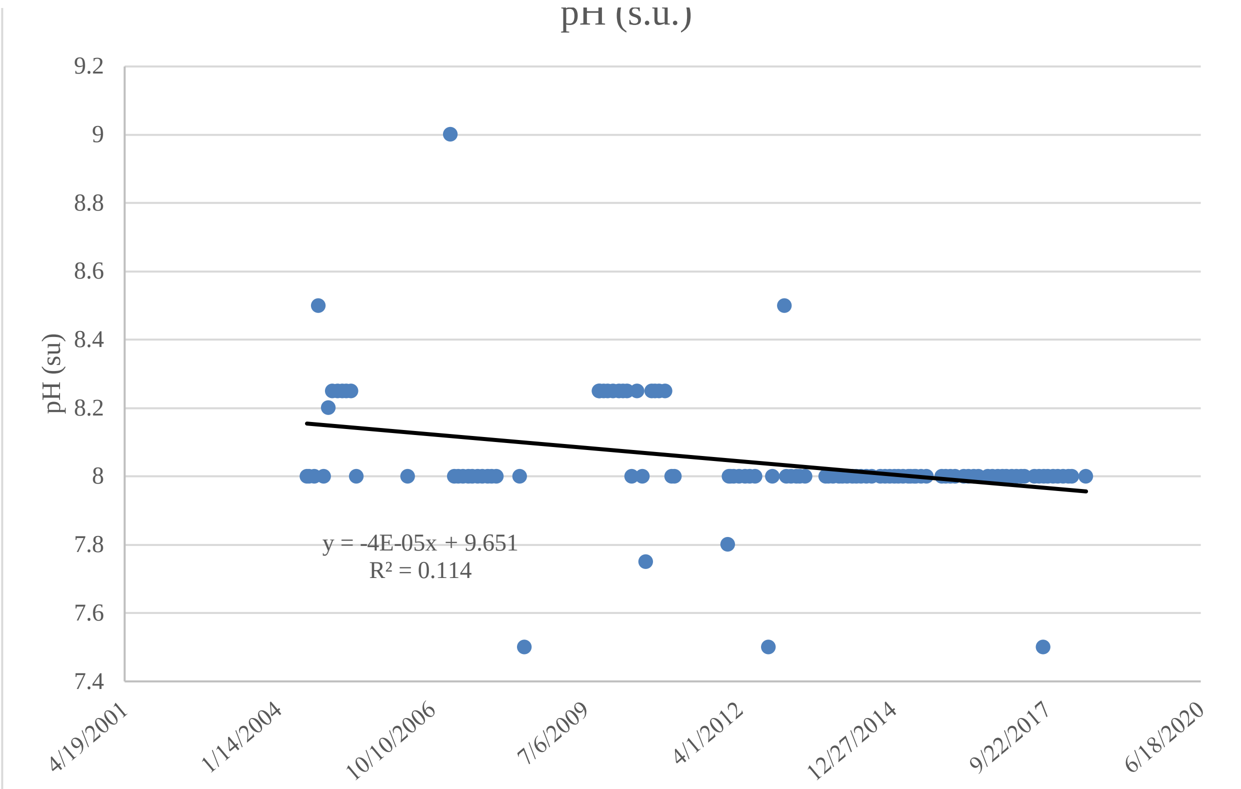

Figure 21: pH at Site 80250

E. coli

There was 1 *E. coli* measurement taken at this site on 8/31/2017 which resulted in a measurement of 749 CFU/100mL.

Nitrate-Nitrogen

There was 1 nitrate-nitrogen measurement taken at this site on 8/31/2017 which resulted in a measurement of 1.0 mg/L.

Site 81480 – Rocky Creek @ Shield Ranch

Site Description

This site is located on a private conservation easement approximately 1,070 meters upstream of Crumley Ranch Rd in Travis County. The watershed of Rocky Creek is mostly undeveloped rangeland and woodland; however, the extreme uplands of the watershed are experiencing an increasing amount of master-planned single-family, low-impact development. The creek is seasonal in terms of its flow.

Sampling Information

This site was sampled 85 times between 7/23/2007 and 8/30/2018. The time of sampling for this site ranged from 8:30 to 18:55. Throughout its study period, Rocky Creek @ Shield Ranch has been monitored monthly on a near-consistent basis. Notable lapses in the data between June 2008 and September 2009 are due to no flow in the stream.

Table 9: Descriptive parameters for Site 81480

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	83	456 ± 42	338	598
Water Temperature (°C)	84	20.3 ± 5.1	10	29
Dissolved Oxygen (mg/L)	85	5.7 ± 1.9	1.8	9.7
pH (su)	83	7.2 ± 2.0	7.0	7.5
E. coli (CFU/100ml)	69	50 ± 89	1	516
Nitrate-Nitrogen (mg/L)	77	1.0 ± 0.0	1.0	1.0

Site 81480 was sampled 85 times between 7/13/2007 and 8/30/2018.

Air and Water Temperature

Air and water temperatures were taken 84 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 40.0°C taken in July of 2011, and the lowest temperature of 4.5°C taken in January of 2008. The mean water temperature was 20.3°C and the water temperature ranged from a low of 10.0°C recorded on multiple instances to a high of 29.0°C on multiple instances.

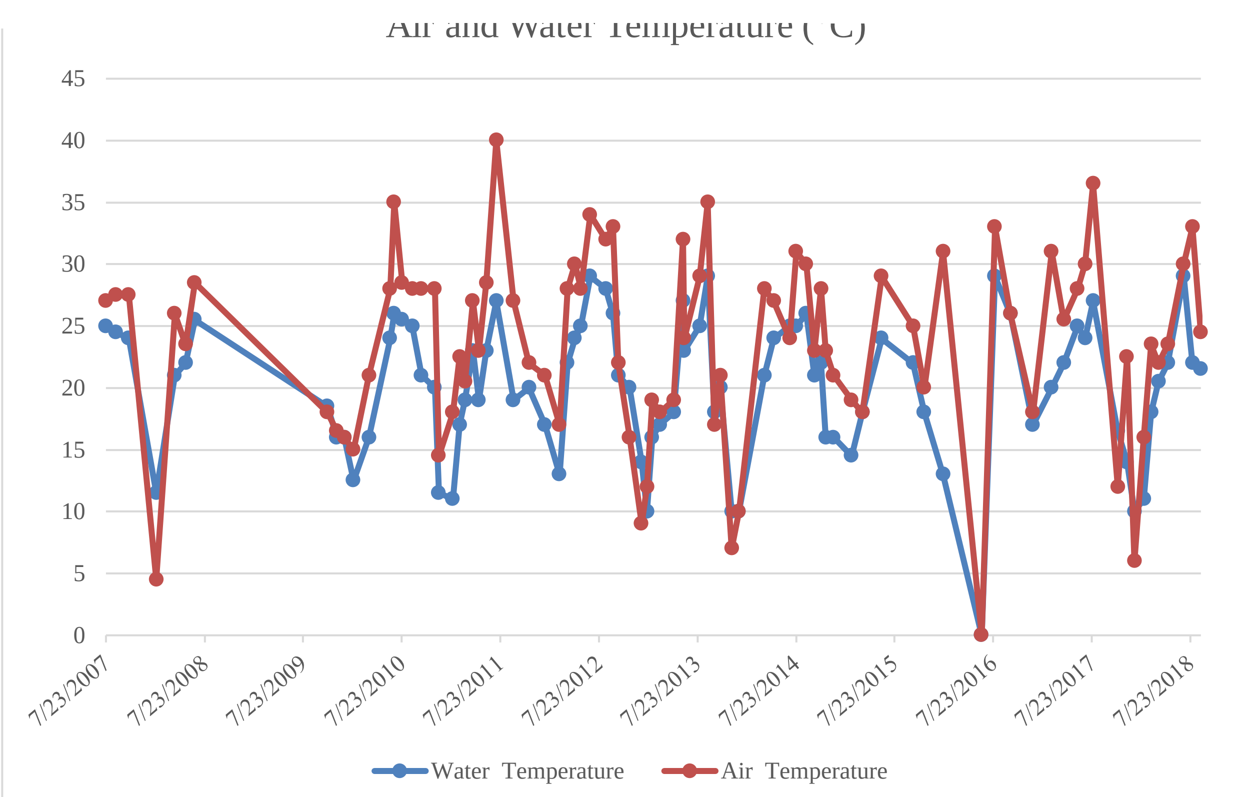

Figure 22: Air and water temperature at Site 81480

Total Dissolved Solids

Citizen scientists sampled TDS at this site 53 times between 7/13/2007 and 8/30/2018. The mean TDS concentration was 456 mg/L. The concentration of TDS ranged from a minimum of 338 mg/L in July of 2016 to a maximum of 598 mg/L in December of 2012.

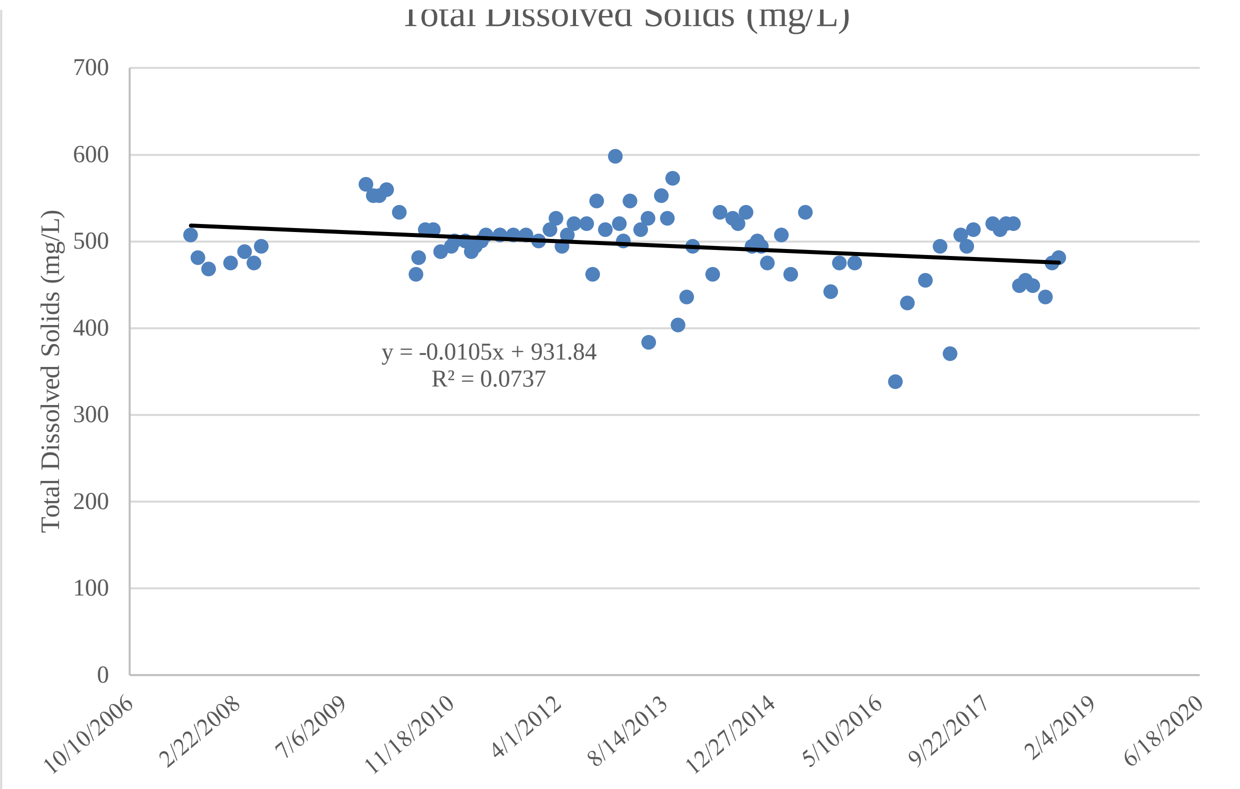

Figure 23: Total dissolved solids at Site 81480

Dissolved Oxygen

Citizen scientists took 85 DO samples at this site between 7/13/2007 and 8/30/2018. The mean DO concentration was 5.7 mg/L. DO concentrations ranged from a low of 1.8 mg/L in June of 2011 to a high of 9.7 mg/L in January of 2010.

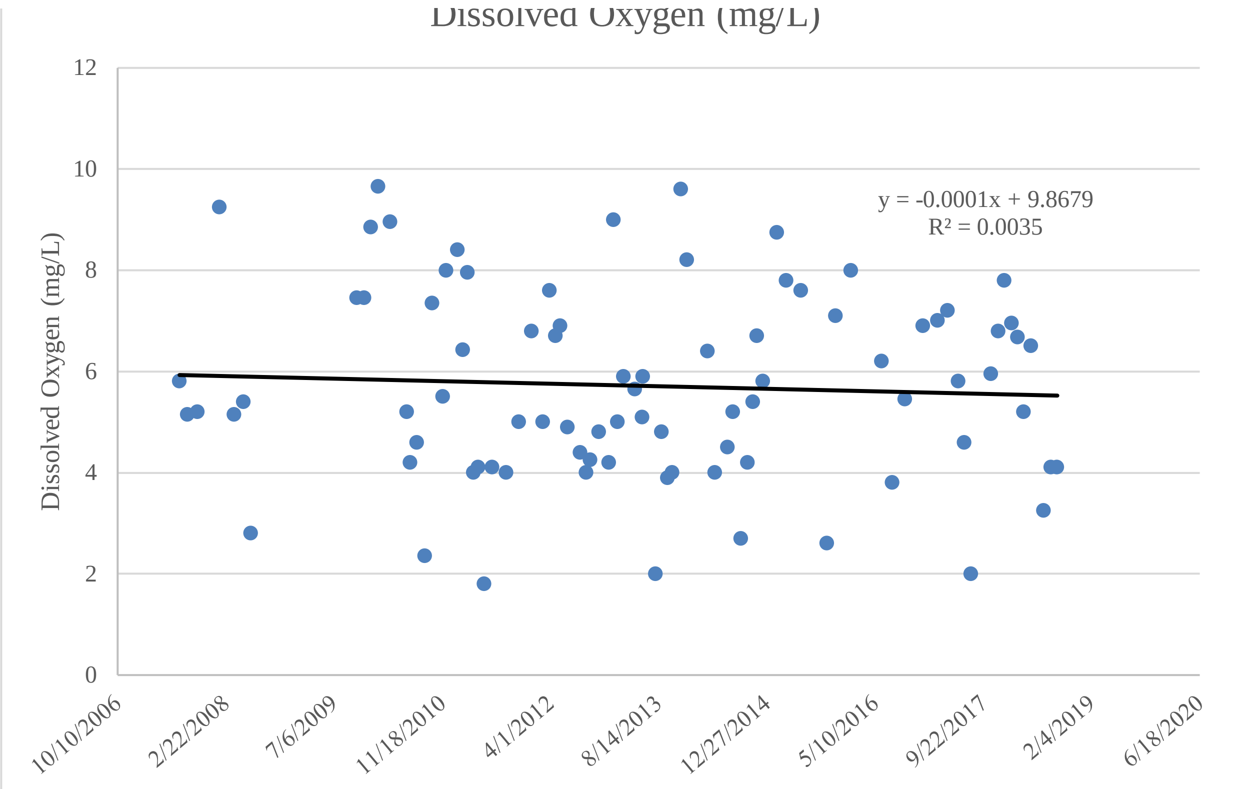

Figure 24: Dissolved oxygen at Site 81480

pH

There were 83 pH measurements taken at this site between 7/23/2007 and 8/30/2018. The mean pH was 7.2 and pH ranged from a low of 7.0 taken on multiple instances to a high of 7.5 taken on multiple instances.

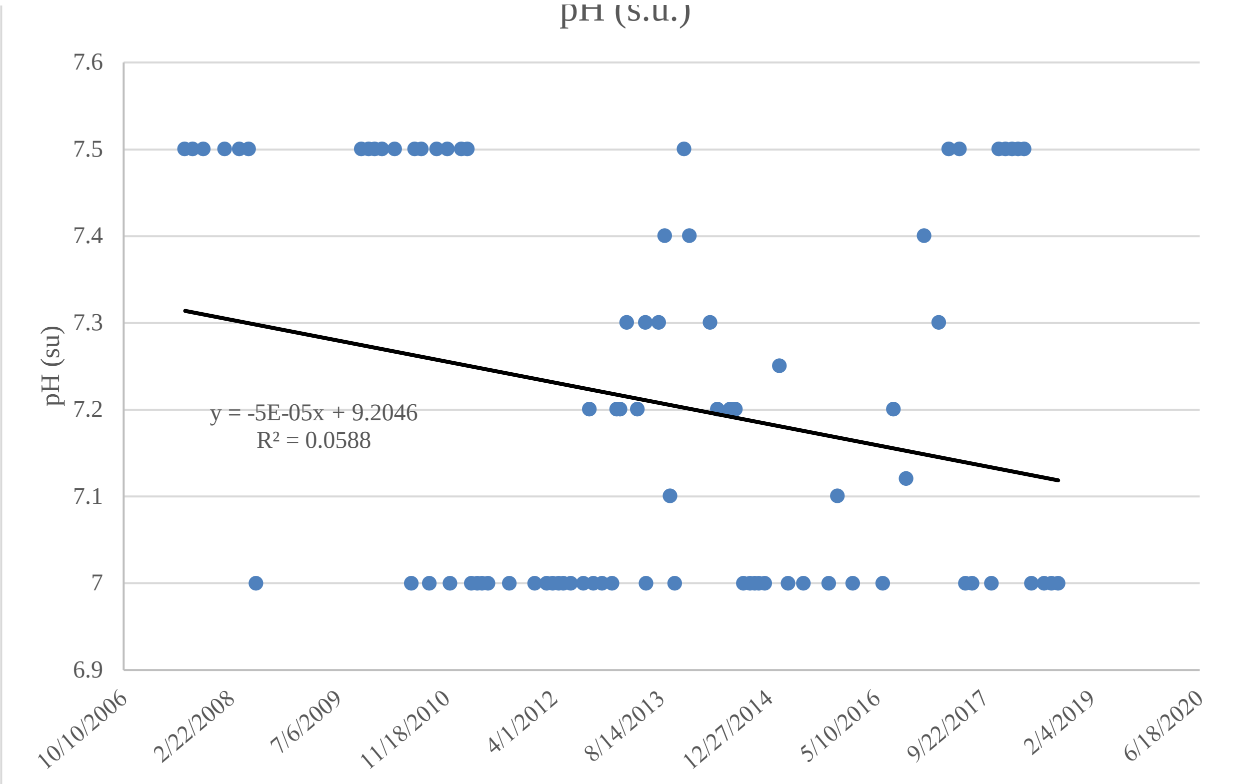

Figure 25: pH at Site 81480

E. coli

There were 69 *E. coli* measurements taken at this site between 1/25/2008 and 8/30/2018. The observed geomean was 50 CFU/100mL and ranged from 1 CFU/100mL taken on multiple instances to a high of 561 CFU/100mL taken in November of 2017.

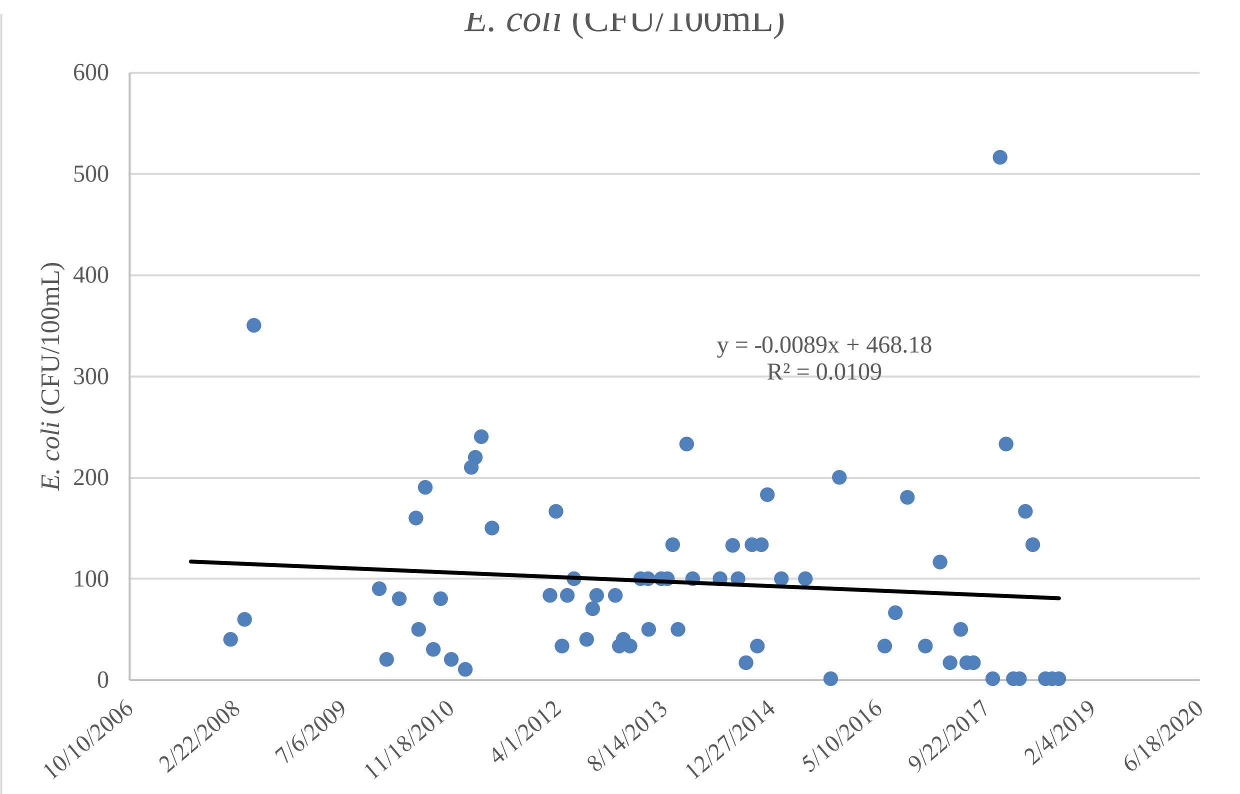

Figure 26: *E. coli* at Site 81480

Nitrate-Nitrogen

There were 77 nitrate-nitrogen measurements taken at this site between 7/23/2007 and 8/30/2018 all producing results of 1 mg/L.

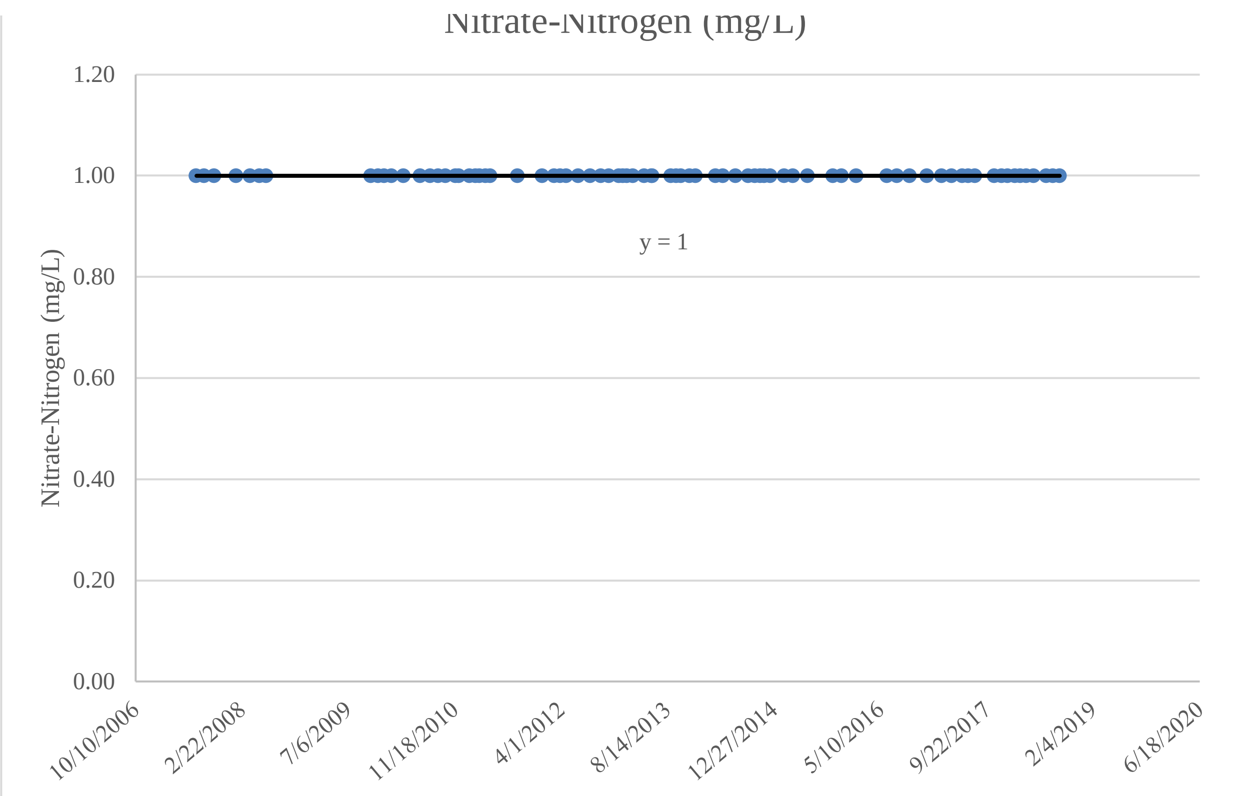

Figure 27: Nitrate-nitrogen at Site 81480

Site 81479 – Barton Creek @ Twin Boulders

Site Description

This site is located on private property approximately 600 meters downstream of the confluence of Rocky Creek and Barton Creek. The site Is located on a fairly deep pool on the creek, flanked to the south by a tall bluff. This location on Barton Creek often exhibits a disconnected pool during times of drought.

Sampling Information

This site was sampled 90 times between 7/13/2007 and 8/30/2018. The time of sampling for this site ranged from 7:10 to 19:20. The site was sampled somewhat sporadically throughout the study period, with monitoring events occurring 2 to 7 times a year.

Table 7: Descriptive parameters for Site 81479

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	89	447 ± 48	371	585
Water Temperature (°C)	90	21.2 ± 5.9	371	585
Dissolved Oxygen (mg/L)	90	6.1 ± 1.6	3.0	9.7
pH (su)	88	7.3 ± 0.3	6.9	8.1
E. coli (CFU/100ml)	74	14 ± 405	1	3513
Nitrate-Nitrogen (mg/L)	84	1.0 ± 0.0	1.0	1.0

Site 81479 was sampled 90 times between 7/13/2007 and 8/30/2018.

Air and Water Temperature

Air and water temperatures were taken 90 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 40.0°C taken in July of both 2011 and 2017, and the lowest temperature of 6.0°C taken in December of 2017. The mean water temperature was 21.2°C and the water temperature ranged from a low of 9.0°C recorded in December of 2013 to a high of 32.0°C in August of 2015 and June of 2018.

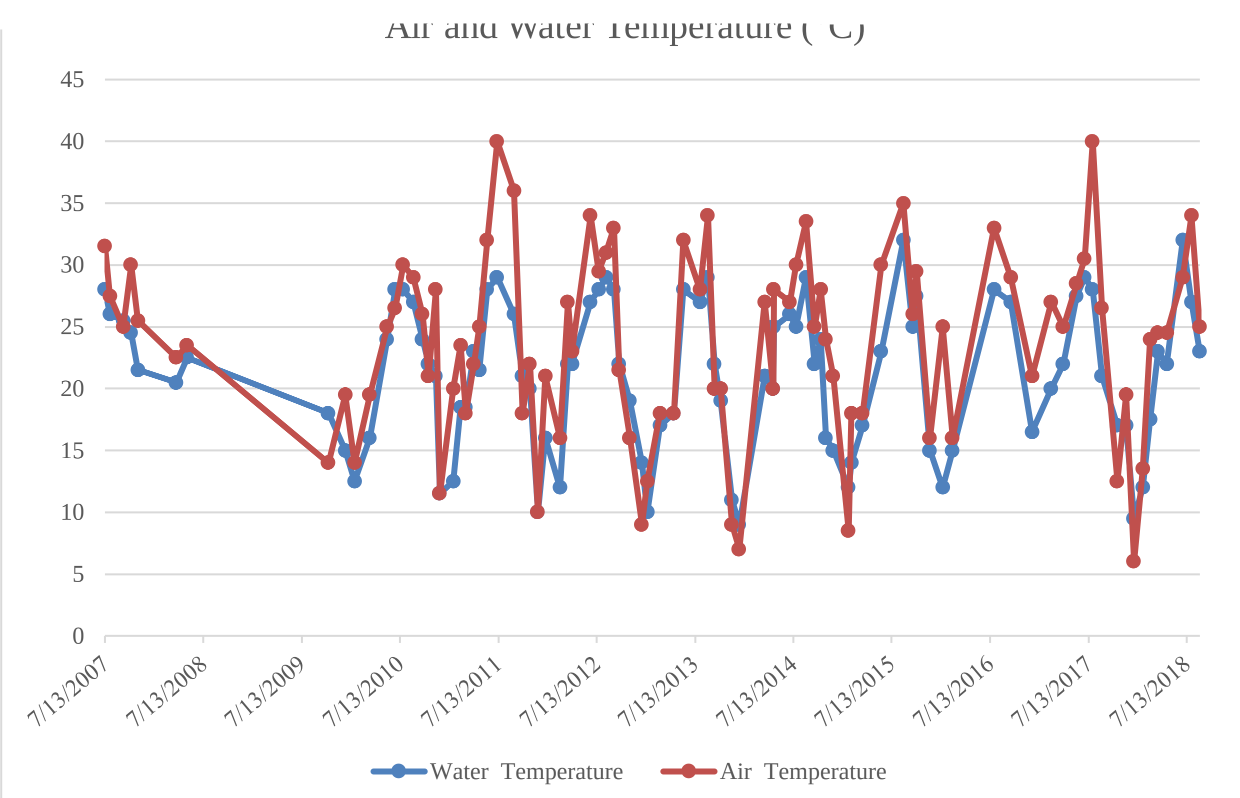

Figure 28: Air and water temperature at Site 81479

Total Dissolved Solids

Citizen scientists sampled TDS at this site 89 times between 7/13/2007 and 8/30/2018. The mean TDS concentration was 447 mg/L. The concentration of TDS ranged from a minimum of 371 mg/L in July of 2016 to a maximum of 585 mg/L in December of 2012.

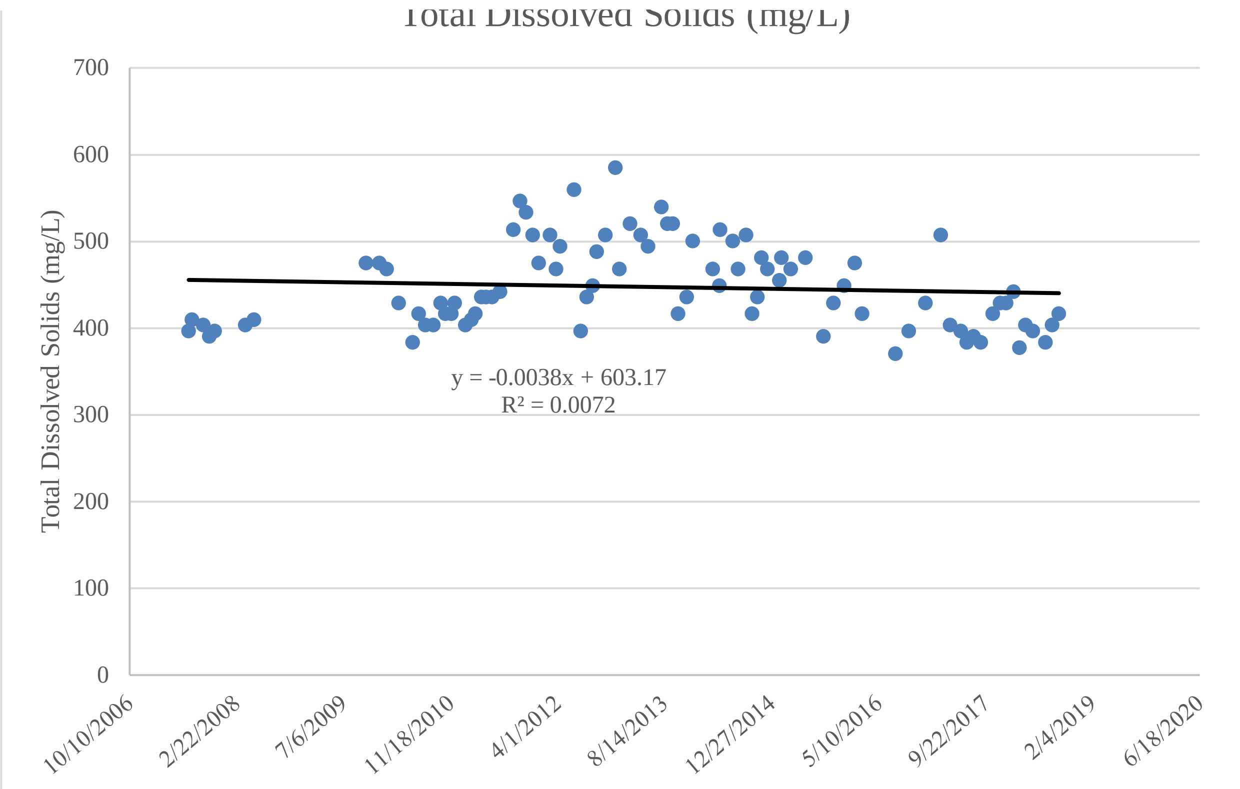

Figure 29: Total dissolved solids at Site 81479

Dissolved Oxygen

Citizen scientists took 90 DO samples at this site between 7/13/2007 and 8/30/2018. The mean DO concentration was 6.1 mg/L. DO concentrations ranged from a low of 3.0 mg/L in August of 2014 to a high of 9.7 mg/L in December of 2017.

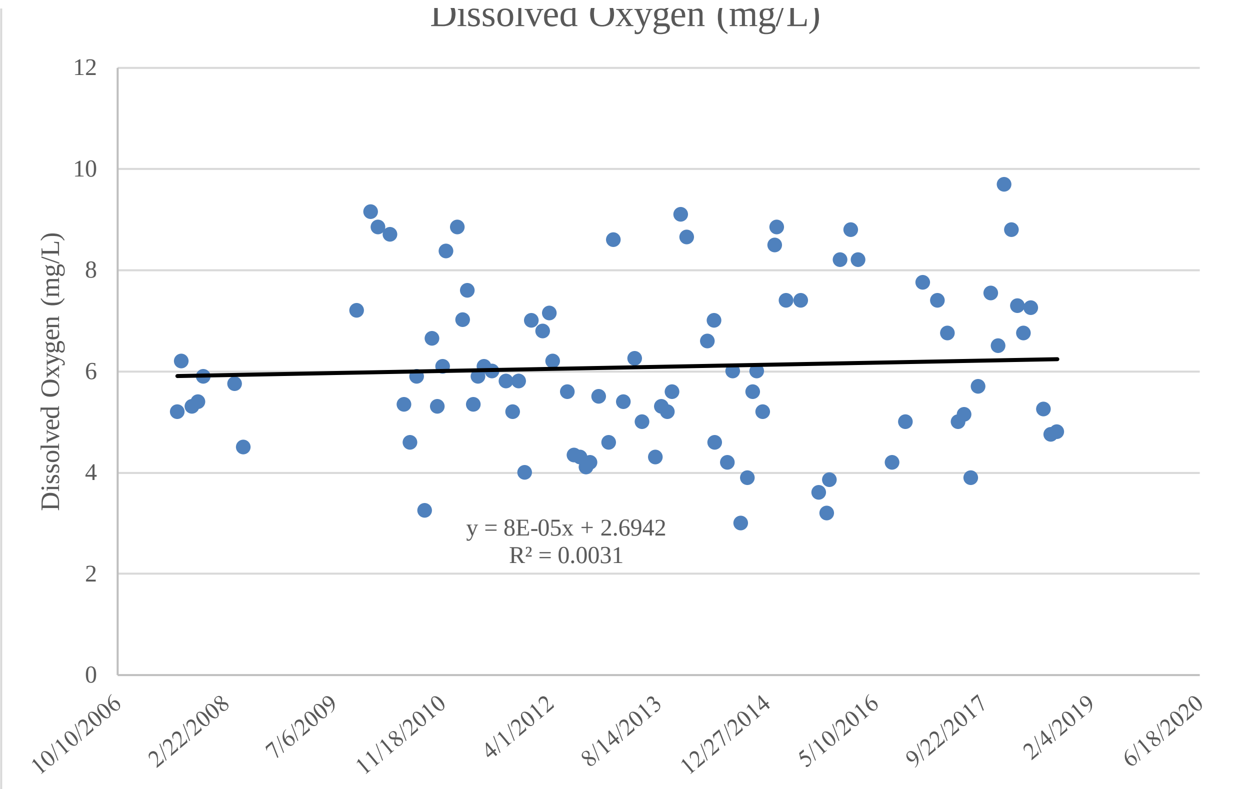

Figure 30: Dissolved oxygen at Site 81479

pH

There were 88 pH measurements taken at this site between 7/13/2007 and 8/30/2018. The mean pH was 7.3 and pH ranged from a low of 6.9 taken in July 2012 to a high of 8.1 taken in February of 2015.

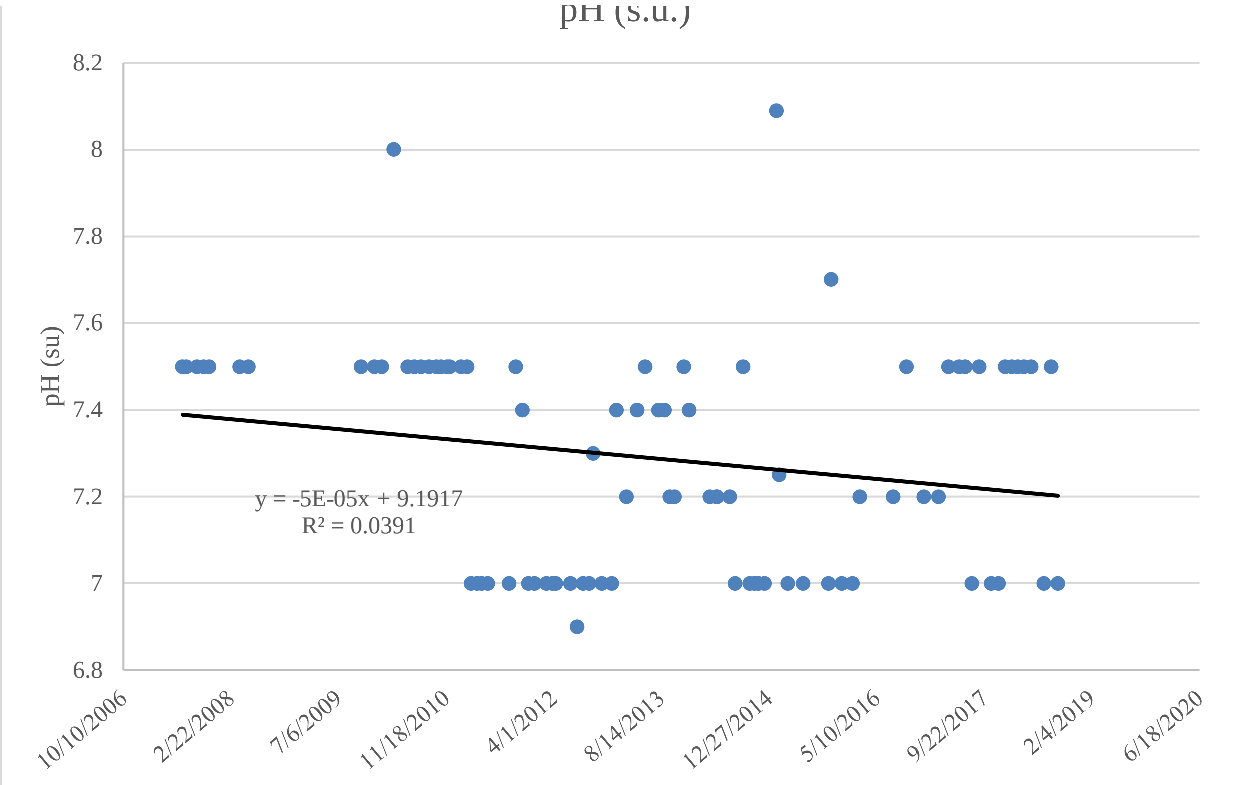

Figure 31: pH at Site 81479

E. coli

There were 74 *E. coli* measurements taken at this site between 11/12/2007 and 8/30/2018. The observed geomean was 14 CFU/100mL and ranged from 1 CFU/100mL taken on multiple instances to a high of 3513 CFU/100mL taken in October of 2011.

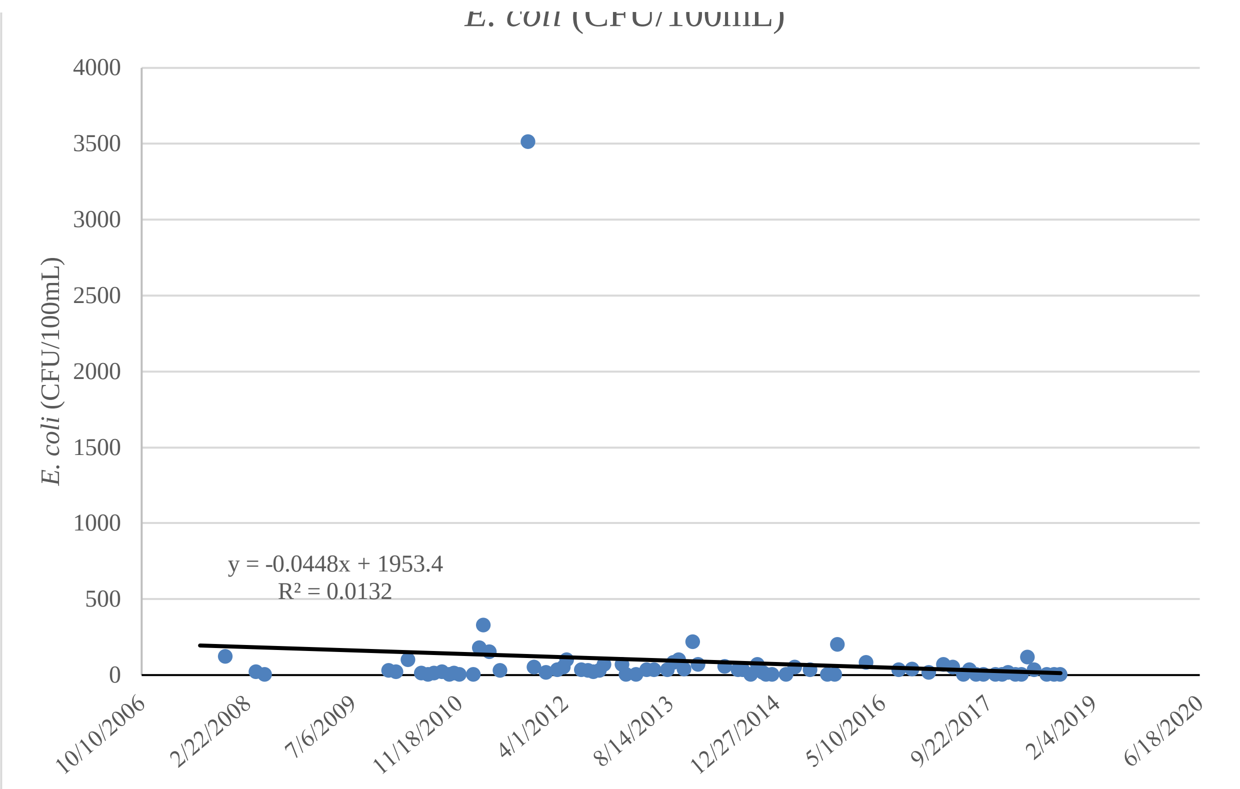

Figure 32: *E. coli* at Site 81479

Nitrate-Nitrogen

There were 84 nitrate-nitrogen measurements taken at this site between 7/13/2007 and 8/30/2018 all producing results of 1 mg/L.

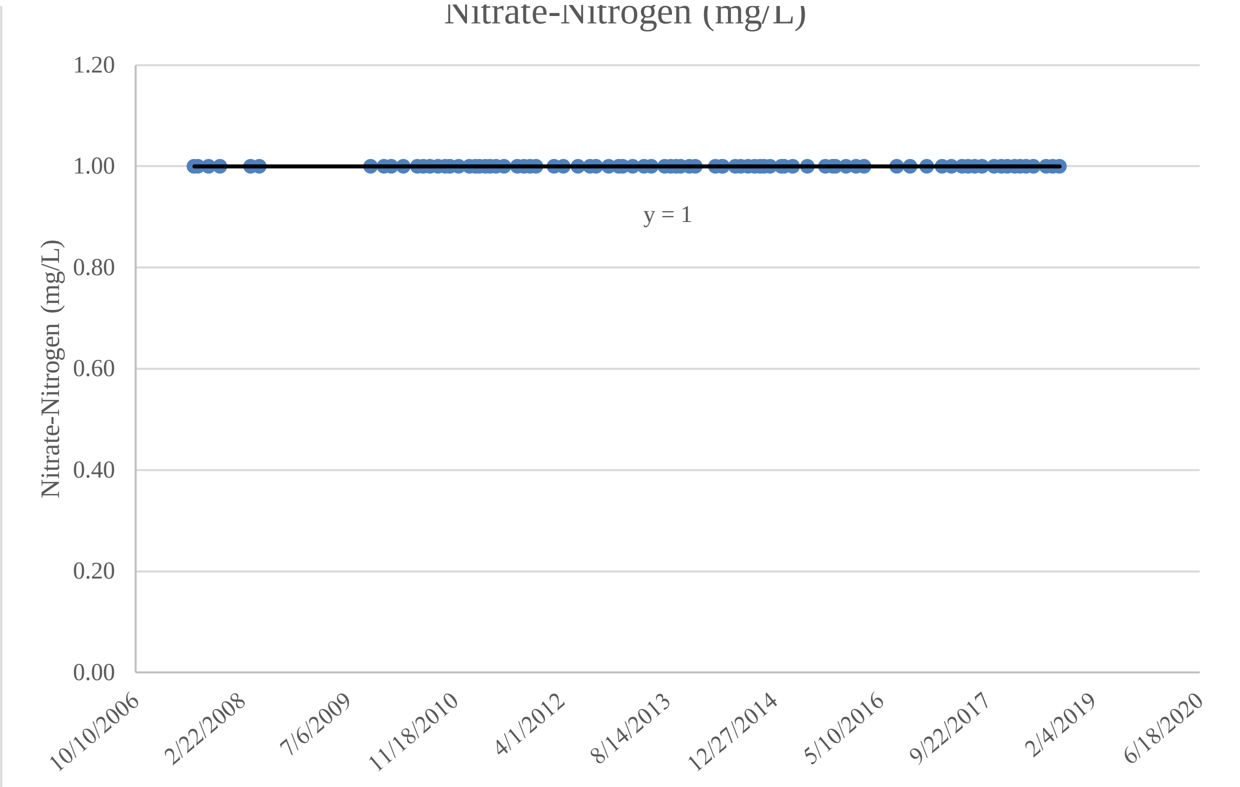

Figure 33: Nitrate-nitrogen at Site 81479

Site 15958 – Barton Creek below Barton Springs Pool

Site Description

This site is located immediately downstream of Barton Springs and the Barton Springs Pool, owned & operated by the City of Austin. The springs are home to the endangered Barton Springs Salamander. A perennial flow exists at this site, which is accessible by the Zilker Metropolitan Park and the Ann and Roy Butler Hike and Bike Trail at Barton Springs Rd. This is the most downstream location within this report.

Sampling Information

This site was sampled 228 times between 5/2/1999 and 8/31/2018. The time of sampling for this site ranged from 5:30 to 19:40. The site has experienced some fairly consistent monthly monitoring activity with some years having multiple sampling events per month. 2003, 2005, and 2006 had 2 to 7 monitoring events per year, making them the least-monitored years during the study period.

Table 8: Descriptive parameters for Site 15958

Parameter	Number of Samples	Mean ± Standard Deviation	Min	Max
Total Dissolved Solids (mg/L)	189	417 ± 49	169	702
Water Temperature (°C)	228	21.9 ± 2.6	10.5	32.0
Dissolved Oxygen (mg/L)	221	6.9 ± 1.1	2.5	10.3
pH (su)	220	7.2 ± 0.3	6.0	8.2
E. coli (CFU/100ml)	13	43 ± 820	1	2681
Nitrate-Nitrogen (mg/L)	213	1 ± 1	1	4

Site 15958 was sampled 228 times between 5/2/1999 and 8/31/2018.

Air and Water Temperature

Air and water temperatures were taken 228 times at this site. The air temperatures fluctuated in a seasonal pattern with the highest temperature of 45.0°C taken in May of 2017, and the lowest temperature of 4.0°C taken in March of 2014. The mean water temperature was 21.9°C and the water temperature ranged from a low of 10.5°C recorded in November of 2012 to a high of 32.0°C in October of 1999.

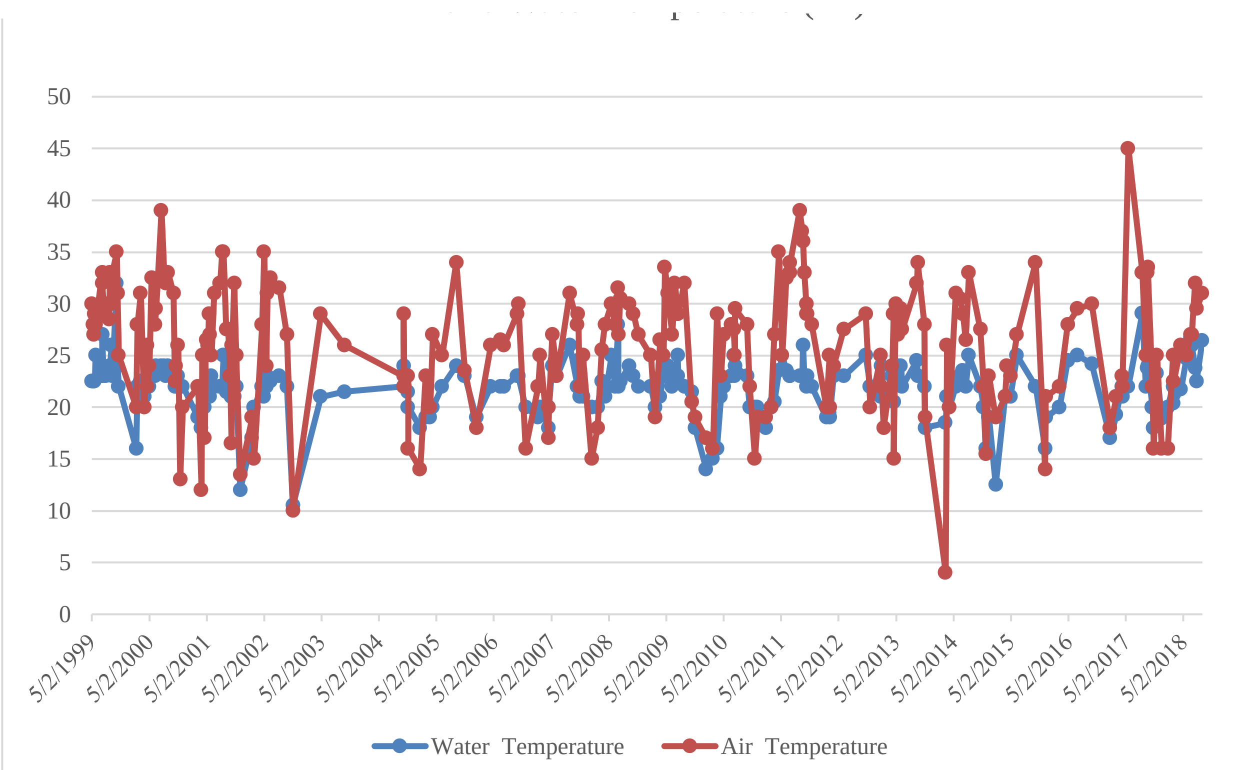

Figure 34: Air and water temperature at Site 15958

Total Dissolved Solids

Citizen scientists sampled TDS at this site 189 times between 10/3/2000 and 8/31/2018. The mean TDS concentration was 417 mg/L. The concentration of TDS ranged from a minimum of 169 mg/L in May of 2007 to a maximum of 702 mg/L in October of 2013.

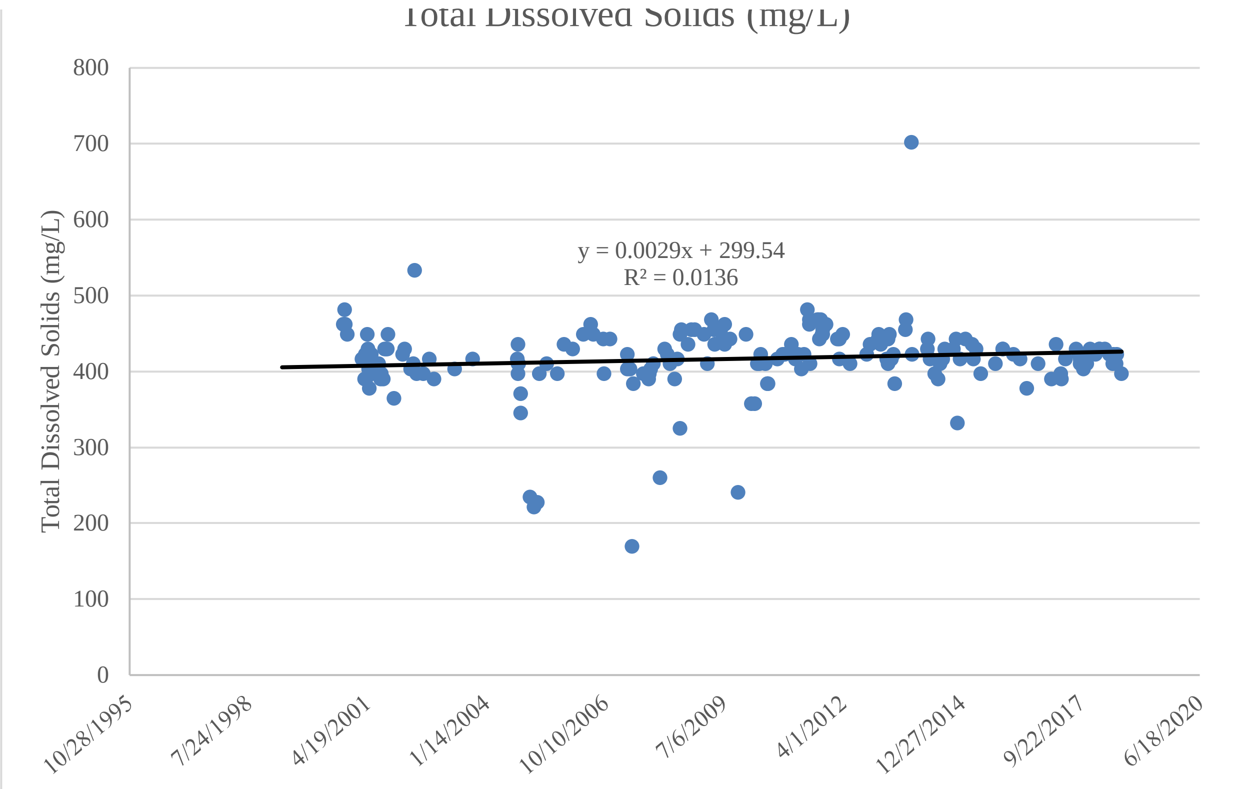

Figure 35: Total dissolved solids at Site 15958

Dissolved Oxygen

Citizen scientists took 221 DO samples at this site between 5/2/1999 and 8/31/2018. The mean DO concentration was 6.9 mg/L. DO concentrations ranged from a low of 2.5 mg/L in June of 2018 to a high of 10.3 mg/L in October of 1999.

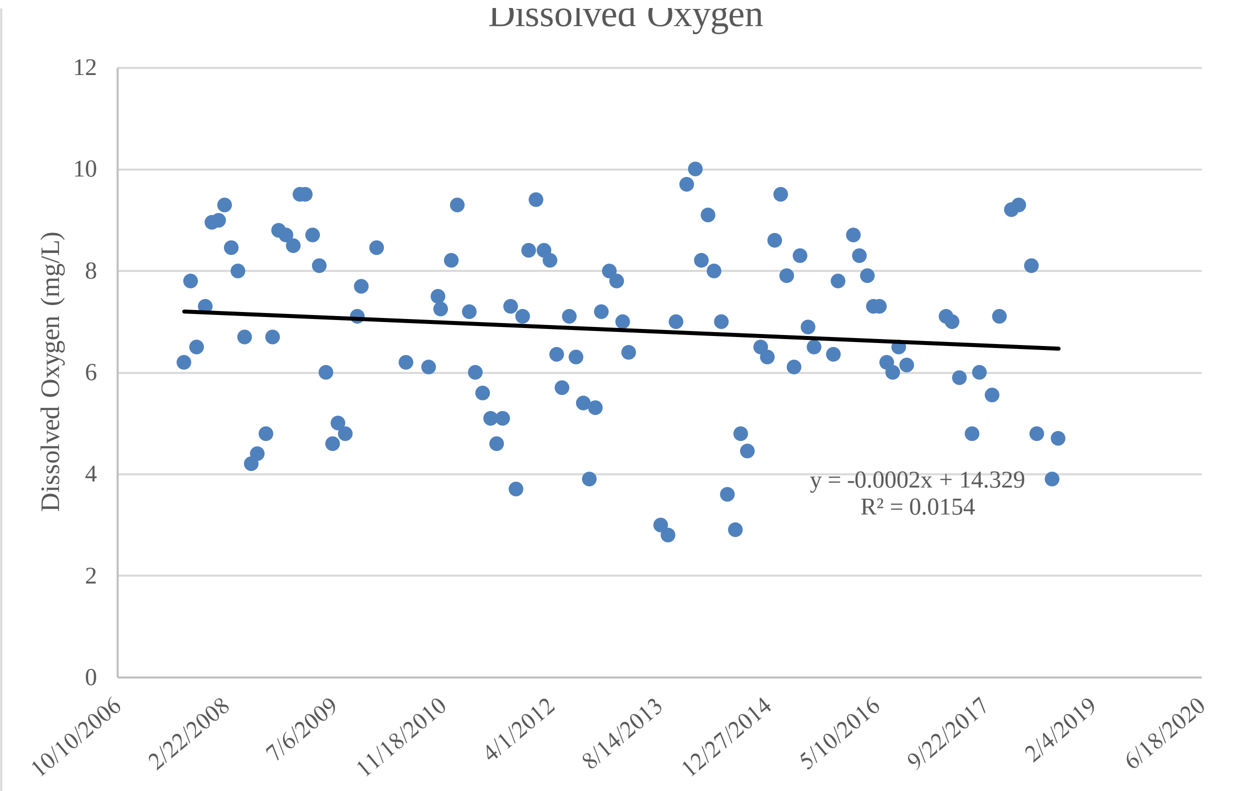

Figure 36: Dissolved oxygen at Site 15958

pH

There were 220 pH measurements taken at this site between 5/2/1999 and 8/31/2018. The mean pH was 7.2 and pH ranged from a low of 6.0 taken in August and October of 2017 to a high of 8.2 taken in February of 2000 and April 2007.

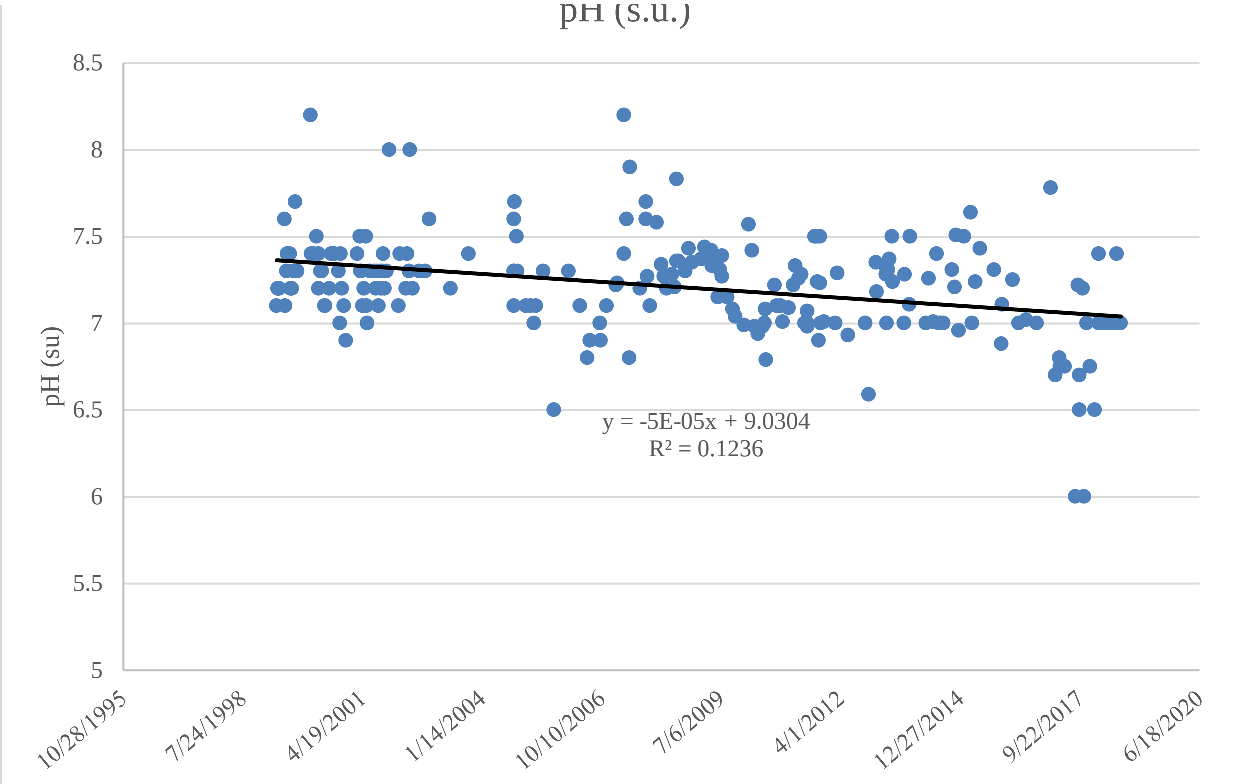

Figure 37: pH at Site 15958

E. coli

There were 13 *E. coli* measurements taken at this site between 10/6/2001 and 8/31/2018. The observed geomean was 43 CFU/100mL and ranged from 1 CFU/100mL taken on multiple instances to a high of 2681 CFU/100mL taken in August of 2018.

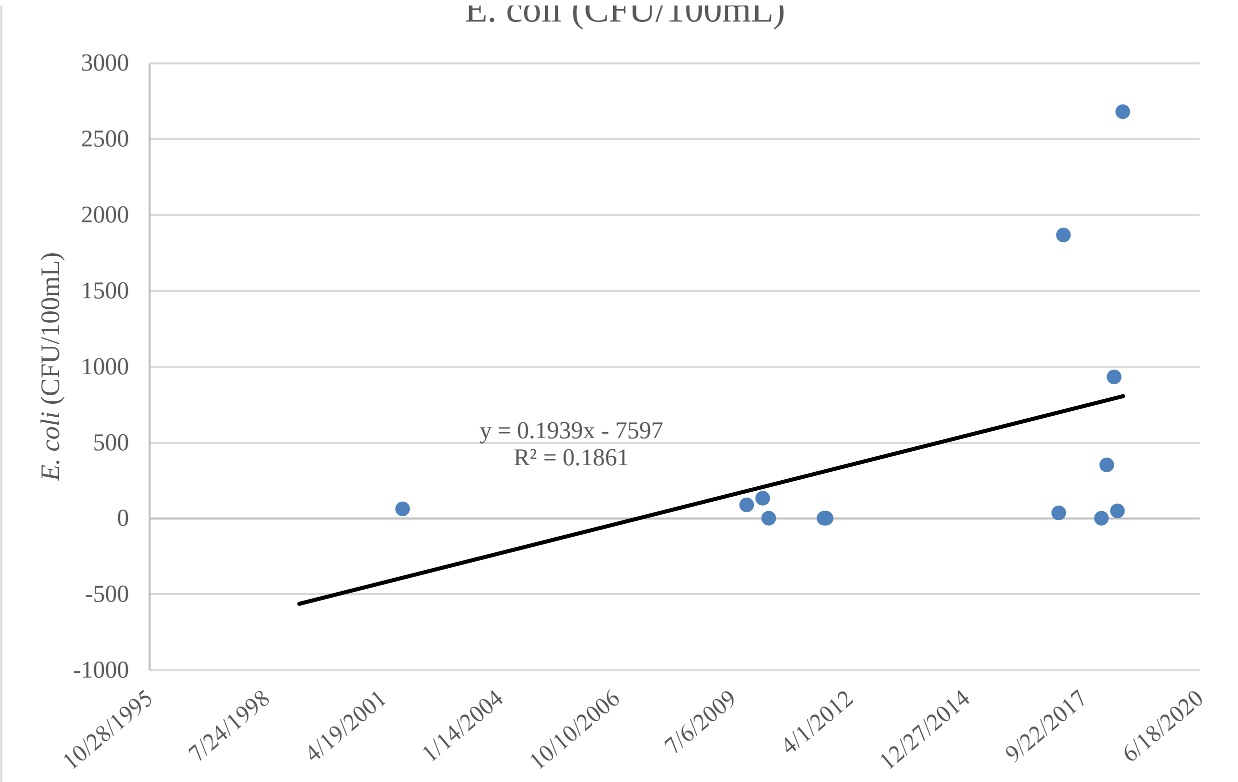

Figure 38: *E. coli* at Site 15958

Nitrate-Nitrogen

There were 241 nitrate-nitrogen measurements taken at this site between 5/2/1999 and 7/25/2018. The mean nitrate-nitrogen was 1.0 mg/L and nitrate-nitrogen ranged from a low of 1.0 mg/L taken on multiple instances to a high of 4.0 mg/L taken on multiple instances.

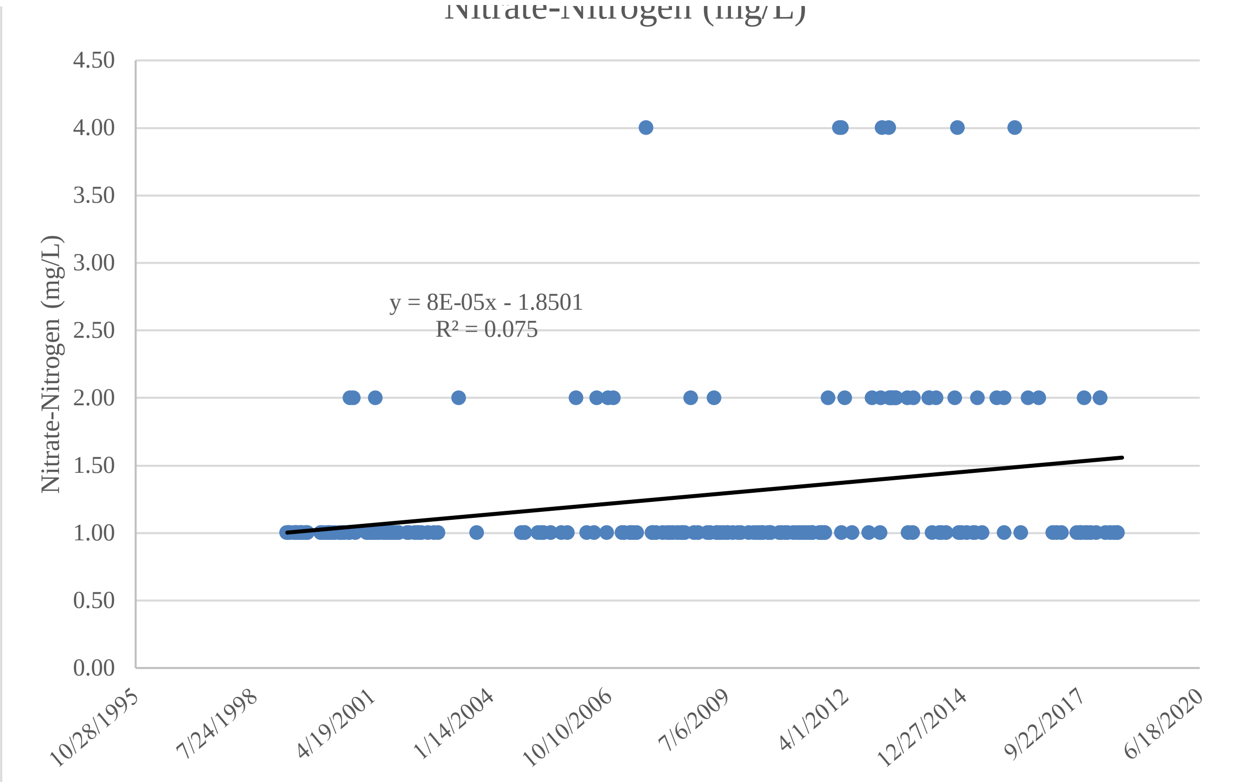

Figure 39: Nitrate-nitrogen at Site 15958

BARTON CREEK WATERSHED SUMMARY

TST citizen scientists monitored several water quality parameters from eighteen different sites in the Barton Creek watershed from 1998 to 2018, including TDS, DO, pH levels, *E. coli*, and nitrate-nitrogen. Data from the five different monitoring sites was analyzed to find trends and extremes over the monitoring periods. There were very few sampling events with elevated *E. coli* levels reported above the standard for a single sample of 394 CFU/100 mL. Several sites experienced low DO concentrations which are a concern in the watershed especially during droughts and low flow. However, even during droughts, some disconnected pools that were monitored in the Barton Creek Watershed never exceeded the TCEQ optimal temperature of 32.2°C. The LCRA CRWN citizen scientist monitoring group will continue to monitor the water quality of the Barton Creek watershed. Future work will consist of Riparian Bull's-Eye Evaluations and Rapid Benthic Macroinvertebrate Bioassessments at sites where there are concerns and interests. LCRA will continue to support existing TST citizen scientists with core supplies for local citizen scientists to collect and test samples for water quality. Additionally, the LCRA CRWN will continue to create new TST monitoring sites and activate existing sites.

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 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 Clean Rivers Program partner for your river basin at: https://www.tceq.texas.gov/waterquality/clean-rivers/partners.html. Currently, TST 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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