Surface Water Quality Monitoring to Support the Implementation of the Geronimo and Alligator Creeks Watershed Protection Plan

FINAL REPORT
TSSWCB PROJECT #14-09

Guadalupe-Blanco River Authority

FUNDING PROVIDED THROUGH A CLEAN WATER ACT §319(h) NONPOINT SOURCE GRANT FROM THE TEXAS STATE SOIL AND WATER CONSERVATION BOARD AND THE U.S. ENVIRONMENTAL PROTECTION AGENCY

Introduction

In 2007, the Texas State Soil and Water Conservation Board (TSSWCB) Regional Watershed Coordination Steering Committee, using established criteria, ranked Geronimo Creek in the top 3 watersheds for selection of Watershed Protection Plan (WPP) development. In 2008, the TSSWCB, the Guadalupe-Blanco River Authority (GBRA) and the Texas A&M AgriLife Extension (Extension) initiated an effort to develop a WPP for the Geronimo and Alligator Creeks Watershed (TSSWCB project 08-06). The project included water quality monitoring, water quality modeling and WPP development. The development of the WPP for Geronimo and Alligator Creeks was a stakeholder driven process lead by Extension with support from GBRA. The Geronimo and Alligator Creeks Watershed Partnership (the Partnership) Steering Committee includes local officials, land and business owners and citizens and is supported by state and federal agency partners. With technical assistance from project staff, the Steering Committee has identified issues that are of particular importance to the surrounding communities, and has contributed information on land uses and activities that has been helpful in identifying the sources of nutrient and bacterial impairments, and in guiding the development of the WPP.

Historical data identified the impairment for bacteria and a concern for nutrients. The historical data was collected at one site (12576) by GBRA through the Clean Rivers Program (CRP). Through TSSWCB project 08-06, GBRA conducted an eighteen month water quality monitoring task that included an additional seven monthly routine ambient and six targeted stream sites on Geronimo Creek, Alligator Creek and three tributaries, and quarterly monitoring of two springs, three wells, and the single point source in the watershed. Through TSSWCB project 11-06, "*Water Quality Monitoring in the Geronimo Creek Watershed and Facilitation of the Geronimo and Alligator Creeks Watershed Partnership*," an effective monitoring program provided critical water quality data that can be used to judge the effectiveness of WPP implementation efforts and can serve as a tool to quantitatively measure water quality restoration. In 2014, the TSSWCB project 14-09, "*Surface Water Quality Monitoring to Support the Implementation of the Geronimo and Alligator Creeks Watershed Protection Plan*," extended the implementation monitoring and facilitation of the Geronimo and Alligator Creek WPP that began with the previous TSSWCB project 11-06. The original 08-06 water quality monitoring program attempted to fill gaps in the historical data but was severely hampered by unrepresentative drought conditions. The data collection in the 11-06 and 14-09 projects verified that periodic elevations of *E. coli* levels continue to exist. These projects also tracked temporal changes in water quality as a result of WPP implementation activities and increased urbanization of the watershed.

Project Overview

In addition to water quality monitoring, the 14-09 project continued stakeholder engagement through semi-annual newsletters, maintenance of the project website, and hosting Partnership Steering Committee and work group meetings. The Geronimo Creek WPP was accepted by the EPA in September 2012. Continuing these efforts was critical to effectively bridging the gap between projects that developed the Geronimo Creek WPP and beginning WPP implementation efforts.

Through TSSWCB project 14-08 "***Coordinating Implementation of the Geronimo and Alligator Creeks Watershed Protection Plan***", TSSWCB contracted with Texas A&M AgriLife Extension to fund the watershed coordinator who facilitated and coordinated education and

outreach activities in the watershed in order to promote public participation and implementation of the WPP. Extension included active use of local media outlets to communicate project planning efforts and activities, contributions to the project website, development and/or dissemination of factsheets and other educational resources, and coordination of local meetings and educational events. GBRA's Public Communication and Education Department provided additional education and outreach in the watershed.

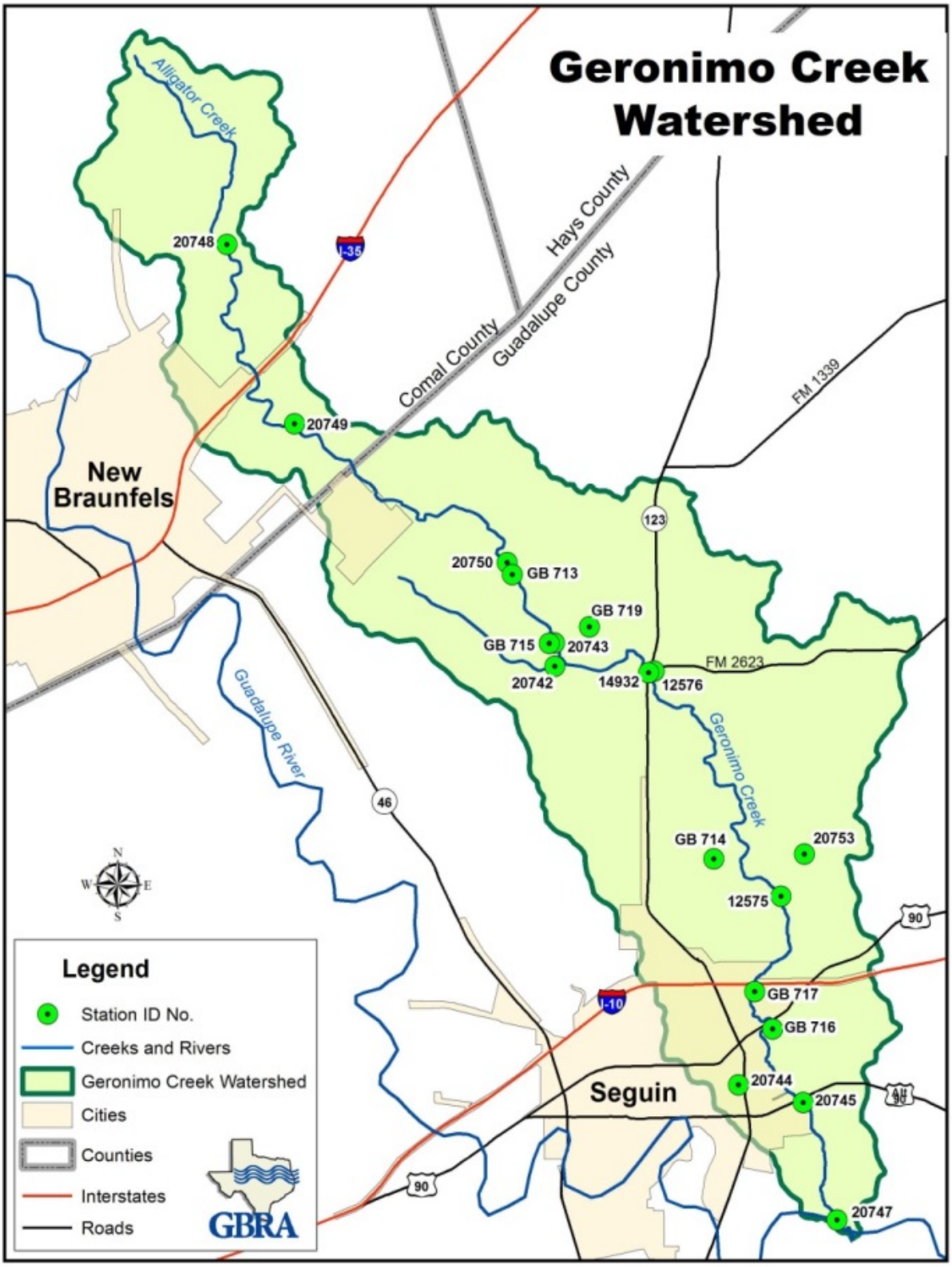

Figure 1. Map of watershed with sampling locations.

The routine and targeted water quality monitoring program was continued in this project by retaining seven routine monthly sites and fourteen targeted sites. GBRA also continued to monitor a historical monthly routine ambient monitoring location on the Geronimo Creek under the Texas Commission on Environmental Quality (TCEQ) Clean Rivers Program (CRP). During the previous 11-06 monitoring project, two new monitoring sites on the Geronimo Creek were added to replace two routine/targeted sites included in the TSSWCB project 08-06 that were determined to be ineffective due to lack of flow or proximity to other sites. One of the new sites was located at Geronimo Creek at IH10 in order to collect routine and targeted monitoring downstream of the Oak Village North Subdivision that has been known for failing septic systems and where the City of Seguin is expanding the city's wastewater collection system. The second site was added on Highway 90 near the Irma Lewis Seguin Outdoor Learning Center (ILSOLC), near several urban population centers. No changes were made in 14-09 project to the monitoring schedule from the previous 11-06 project.

A comprehensive watershed approach was used to focus on the most significant potential sources of agricultural nonpoint source (NPS) pollution contributing to the current impairments, while at the same time looking ahead at potential future sources of pollution from urban and suburban growth. The outcomes of the TSSWCB project 08-06 included data in the form of load allocations and watershed models developed in partnerships with local stakeholders and have benefited the local governmental entities as they formulate master plans and storm water management strategies. Recommended best management practices (BMPs) that were identified by the steering committee, work groups and partner agencies were prioritized for implementation. An important outcome of this project was the identification of implementation strategies that get ahead of growth so that it can be directed in an environmentally-safe and community-accepted direction.

Project Highlights

Project Webpage

GBRA and Extension maintained the project webpage. Updates to the webpage over the project period include a photo gallery, monthly newsletters, meeting announcements and copies of meeting presentations. The quality assurance project plan (QAPP), along with the current water quality monitoring data tables have been posted on the Water Quality page of the GBRA website and are available for review by the public. One of the most useful additions to the website was an online registration tab for the annual watershed cleanup. Other tabs on the webpage covered feral hogs, septic tank maintenance and TSSWCB project 13-07 "*Investigation into Contributions of Nitrate-Nitrogen to Plum Creek, Geronimo Creek and the Underlying Leona Aquifer"*.

Web hits are monitored monthly. This is one method that is used to determine the effectiveness of several of the public outreach methods. Generally, hits average between 1400 and 1800 hits a month. These numbers are generally higher immediately prior to a scheduled partnership event such as the annual cleanup event in April.

In 2016, the project webpage underwent modification to make it more mobile-device friendly. This modification was performed by GBRA IT staff, in response to the growing use of mobile devices accessing the project webpage. This is supported by the project newsletter email service reporting that the newsletter was accessed 51% of the time from a mobile device. Also, many of the links in the newsletter were directly accessed with the mobile device that would then take the

viewer to the project webpage. Improvements are continuing to streamline the mobile device experience when viewing the project page, and will hopefully lead to greater use.

Facilitation and Implementation Activities

Extension was responsible for facilitation of The Partnership and for coordination of implementation of the WPP. Extension assisted entities in the watershed with opportunities for implementation of management measures identified in the WPP. Extension also coordinated meetings between the cities located in the watershed and TCEQ to discuss potential urban implementation projects. At these meetings several potential ideas were developed, including upgrades to the City of Seguin's storm water conveyance system in the Oak Village North subdivision and decommissioning of failing septic systems after they have connected to the city's new wastewater collection system being installed in the subdivision. As a continuation of these meetings, Extension continued to assist Seguin with the development of a grant proposal to the TCEQ Clean Water Act Section 319(h) NPS Program. The original proposal included both the stormwater upgrades (introduction of rain gardens and pervious pavement) and the decommissioning of failing septic systems in the Oak Village North subdivision. However, shortly before the submission deadline, Seguin chose to remove the stormwater upgrades, due to construction timeline constraints. Seguin received the grant award, and Extension continued to assist the City with reporting requirements to TCEQ.

The meetings with the City of New Braunfels did not lead directly to an implementation project because at the time the city was actively working through the development and implementation of their phase II storm water permit, and wanted to wait until that was more complete before exploring implementation in their portion of the watershed.

Extension assisted GBRA with the preparation of a grant application to TCEQ that partnered with the ILSOLC. The ILSOLC is located in the watershed and its mission is to provide outdoor and environmental education opportunities to students as well as adults in the area. The grant was awarded with the objective of the project to design and implement educational components of the WPP that will serve as tools that can be utilized with elementary through high school students, teachers, civic leaders, riparian landowners, and with the general public to enhance understanding of the health of a riparian and creek ecosystem in the Geronimo and Alligator Creeks watershed. Besides the educational modules that were developed through the grant, several Low Impact Development (LID) structures (Figures 2-5) were installed on the ILSOLC property (rain water harvesting system, pervious parking, rain garden, and vegetated swale). The plan was to utilize the learning center for future on-site workshops using the LID structures for "hands on" demonstrations.

Some of the other presentations made by Extension, with the goal to promote and facilitate implementation of the WPP, included:

- meetings with staff of the City of New Braunfels,
- meetings and calls to the staff of the City of Seguin, their Long Range Planning Committee, and City Planning Department to discuss the development of a pet waste Ordinance, and other grant funded projects,
- meeting with Guadalupe County Commissioners to discuss the status of the WPP and stream cleanup activities,

- had a booth at the annual Association of Conservation District Directors meeting, and
- the GBRA annual CRP Basin Steering Committee and Coordinated Monitoring Meetings held each year.

Public Communication and Outreach

Public communications and outreach responsibilities were shared by Extension and GBRA. Outreach included newspaper and radio ads produced and paid for by Extension. The ads were run in the two local papers, the Seguin Gazette and New Braunfels Herald-Zeitung, with a circulation of 17,000 weekly subscribers. For various workshops, these newspaper ads were developed and produced in print and online versions to further draw attention to these activities. The local radio station, KWED, was utilized several times to assist with advertising events, such as stream clean up events, homeowner maintenance of septic system classes, and rainwater harvesting classes. In addition to the news articles and ads, Extension produced a biannual electronic newsletter, aptly named by the Partnership, *The Geronimo Flow*. The distribution of the newsletter has grown to over 520 email addresses.

A critical part of the project has been to disseminate information on Geronimo and Alligator Creeks and this project to stakeholders and other interested parties throughout the state. GBRA summarized the results and activities of this project in GBRA's CRP Basin Highlights Report and Basin Summary Report. Additionally, the results and activities of this project were summarized in quarterly reports to the stakeholders and the Steering Committee.

GBRA Public Communication and Education division was very active in the watershed. For example, to educate and increase awareness of water quality issues in the watershed, GBRA began working with the Seguin High School, assisting the teachers in conducting project-based classes during summer terms. Students in the summer program conducted studies on Geronimo Creek, such as benthic macroinvertebrate sampling and identification, water quality monitoring, and stream cleanup activities.

Also, located in the middle of the watershed, Navarro High School was the recipient of a 2011 Healthy Habitats grant focusing on the Geronimo Creek watershed. In partnership with the GBRA, students researched the Geronimo Creek watershed from its headwaters to the confluence with the Guadalupe River and then selected a location to restore natural grasses, forbs, and trees along the banks of the creek to help filter water flow during rain events to help prevent pollution. Healthy Habitat grants are designed to support students doing service-learning projects to benefit wildlife and the environment.

GBRA's Public Communication and Education Department, worked with Seguin High School teachers to develop a two week, intensive project-based learning class that also used Geronimo Creek as the focus. While earning two class credits (speech and technology), the students made a press kit and spoke to the public about issues pertaining to the watershed. The students took a tour of the entire watershed, picked up trash along the creek and learned how water bugs can indicate the quality of water. The students made a presentation to the Seguin ISD School Board on the issues impacting the Geronimo Creek, including information on pet waste and feral hogs. GBRA staff helped with the production of Google fly-overs, maps and graphics. The class developed educational materials for the Geronimo Creek watershed. Students approached restaurants and businesses located in the watershed and secured agreements with them to distribute placemats and other educational items developed through the summer academy. GBRA took the student designs, made final edits, and with funding from Extension, produced

1,000 placemats, 500 brochures, and 500 magnets. The outreach materials were distributed to local restaurants and businesses for display and use on Water Monitoring Day.

Over the course of the project GBRA staff made presentations to classrooms in the Seguin ISD and Navarro ISD schools located in the watershed. Their presentations covered the water quality of Geronimo Creek, and included a water quality monitoring project using water collected from Geronimo Creek. GBRA Public Communication and Education staff prepared NPS activity kits for use with elementary classroom activities in the Geronimo and Alligator Creeks watersheds. Kits support activities from the GBRA "Don't be Clueless about Water Quality" curriculum. Additionally, GBRA staff made presentations on NPS pollution to area school children at the ILSOLC and the Big Red Barn (Guadalupe County Agriculture Heritage Center), educational centers located in the Geronimo Creek watershed.

In 2015, Extension and GBRA partnered with Seguin ISD on a grant from the Seguin Education Foundation to the ISD. The project partnered Seguin HS Agriculture Wildlife and Ag Mechanics classes with Seguin Fabricators, GBRA, and Extension. Extension provided educational training on feral hog biology and their impact on water quality. Students were allowed the opportunity to visit and experience how a real-world metal fabrication plant operated, and how an idea was taken through development and into production. Students combined their knowledge and skills, and produced feral hog traps that were then distributed to local ag producers to assist with their feral hog control efforts. This project is ongoing in Seguin ISD while expanding its scope, and will be piloted in the Navarro ISD in 2017.

Smart Growth Workshop & Irma Lewis Seguin Outdoor Learning Center LID Structures

In September of 2016, 31 people attended a Smart Growth Workshop at the ILSOLC located next to the Geronimo Creek. Dr. Fouad Jaber of Texas A&M University taught the attendees of this workshop ways to reduce stormwater runoff into the local watersheds and improve water quality through the use of LID construction techniques. The workshop demonstrated several innovations that have been made to the ILSOLC through funding by TCEQ with GBRA providing project management and construction oversight, including a one thousand square foot surface area rainwater collection system that stores surplus water in a five thousand gallon storage tank. This water is used on the grounds of the learning center to water a community garden, which has since been replaced by a grass demonstration plot. The ILSOLC also demonstrated an onsite rain garden, vegetated swale, and pervious parking lot to slow the release of rainwater runoff into the Geronimo Creek.

Figure 2. Rainwater harvesting system at the ILSOLC.

Figure 3. Pervious pavement at the ILSOLC.

Figure 4. Rain garden at the ILSOLC.

Figure 5. Vegetated swale at the ILSOLC.

Lone Star Healthy Streams Workshop

A Lone Star Healthy Streams Workshop (LSHS) was conducted in September 2016 in Seguin. The LSHS program, funded by TSSWCB project 15-06, "*Continued Statewide Delivery of the Lone Star Healthy Streams Program*", focuses on educating Texas farmers, ranchers, and landowners about proper grazing, feral hog management, and riparian area protection to reduce contamination in streams and rivers. Fifty-two attendees heard about practices and structures that can help them prevent runoff containing bacteria from entering surface waters.

Rainwater Harvesting Workshops

Rainwater Harvesting Workshops were held cooperatively by Extension, GBRA and The Partnership in the fall of 2015 and 2016 at the ILSOLC. These classes provided education on how to collect, store, and utilize rainwater for a variety of uses. Incorporating these practices into the watershed is intended to lessen the demand on existing water supplies and reduce contamination of surface water due to storm water runoff. An in-class demonstration of how to build a rain barrel was performed, and the industrial size rainwater collection system installed at the ILSOLC was used to aid the demonstration. A presentation of the Geronimo and Alligator Creek WPP to reduce bacteria and nitrates in these watersheds was also provided to attendees. Public interest in rainwater harvesting has remained steady as the area has exited an extended period of drought. A total of 42 people attended the workshop in 2015 and 36 people attended in 2016.

Texas Well Owner Network Program

Since its inaugural program in 2013, Texas Well Owner Network (TWON) has covered the State of Texas with its training events aimed at reaching the private water well owner. TWON is an educational training offered by Extension and is funded under TSSWCB project 13-08, "*Statewide Delivery of the Texas Well Owner Network*". TWON returned to the watershed in September 2015, and educated 53 private water well owners. Well owners learned about Texas' groundwater sources, water quality, water treatment, and well maintenance issues. One class module covers septic system operation and maintenance, and informs attendees of signs and symptoms of potential failures. The goal is to train Texans regarding water quality and BMPs for protecting their wells and surface waters. This will avert off-site transport of contaminants to surface waters, prevent contamination of underlying aquifers, and safeguard the health of landowners and their families.

Soil Testing Campaign

In October and November of 2015 and 2016, The Partnership sponsored soil testing campaigns. The campaigns were advertised through The Partnership emails and press releases, and samples were collected by the local Comal and Guadalupe County Extension offices. A total of 169 soil samples were submitted in 2015 and 76 in 2016, to be analyzed by the Texas A&M Soil, Water and Forage Testing Laboratory. The results were distributed to the landowners at a December event in Seguin, where the Texas A&M Assistant Professor of Soil Nutrient & Water Resource

Management, Dr. Jake Mowrer, provided interpretations of the laboratory results and explanations how these results could inform nutrient enrichment practices on the land. The attendees of this seminar were taught about proper fertilizer applications in order to save money, time and increase watershed health during common crop, lawn and pasture maintenance.

Texas Watershed Stewards Water Quality Workshop

Extension and TSSWCB held a Texas Watershed Workshop in January of 2016 at the Guadalupe County Extension office in cooperation with the Geronimo and Alligator Creek Watershed Partnership. The workshop taught 43 attendees about the basic principles of water quality and watershed management in Texas, such as sources of water pollution and ways to improve and protect water quality. Particular focus was placed on local water quality issues including ways to protect the Alligator and Geronimo Creek Watersheds. A group discussion was held on community-driven watershed management and protection and each attendee received a copy of the Texas Watershed Steward Handbook and a certificate of completion. This program also offered continuing education credits certified engineers, teachers, pesticide license holders, architects, flood plain managers and crop advisors.

Homeowner Septic System Maintenance Workshops

Homeowners in the Alligator and Geronimo Creek watersheds were given the opportunity to attend septic system maintenance workshops in October of 2015 and 2016. These six hour workshops were held at the local Texas Agrilife Extension office and provided presentations to inform homeowners regarding the principles of conventional and aerobic septic system operation and maintenance. Some of the topics covered included treatment processes, health and safety considerations, and an overview of the septic inspection process. Common questions regarding proper frequency of pumping septic tanks and what types of items can go down the drain were answered. In Guadalupe county, aerobic septic tank owners must be certified in order to maintain an aerobic system or hire a certified maintenance contractor. Extension worked with the Guadalupe County Environmental Health office to design a class that would provide certification under County regulations that would allow homeowners to become certified to maintain their aerobic septic systems, without the County requirement of obtaining a maintenance provider contract. This all-day class allows homeowners the affordability and flexibility to maintain their own systems. Since this class was introduced, it has always functioned at capacity, due to its popularity and demand. Since its first introduction in 2013, 317 people have attended the class. In 2015, 68 homeowners attended the class and in 2016 50 more attended.

Figure 6. Homeowner Maintenance of Septic Systems workshops taught 317 homeowners about proper operation and maintenance of their septic systems.

Watershed Cleanup

The idea of a community cleanup was introduced to the partnership in the fall 2012 and was very well received (Figure 7). The first cleanup was so successful that it has been made an annual event. In addition to financial contributions from sponsors, area businesses and church groups sponsored cleanup areas in the watershed and provided time for workers to participate. The cities of Seguin and New Braunfels provided roll-off containers for the collection, disposal, and recycling of collected materials. Chapters of the National Honor Society and Interact groups from local high schools and middle schools provided volunteers. Parker Lumber, the New Braunfels Municipal Airport, and Navarro High School allowed registration booths to be set up in their parking lots.

The list of participating project sponsors has continued to grow each year, and the number of volunteers signed up to participate has remained stable for every year of the cleanup, while the amount of trash found along the roadsides of the watershed has continued to diminish each year. In the first cleanup 2,960 pounds of trash, 26 tires, and several large items such as a stove, air conditioner, car battery, and a toilet were collected. In the second event, volunteers collected 7,020 pounds of trash along 17 miles of roadway and creek banks, removing 45 tires, 2 cubic yards of scrap metal, and large items such as lumber and two toilets. In the April 2015 event 195 volunteers were able to pick up just over 2,000 pounds of trash, while in the April 2016 event 191 volunteers found more than 1,500 pounds of trash along the 17 miles of roadway and creek banks covered.

Figure 7. Volunteers participate in the Annual Clean Up event.

Data Collection and Transmittal

Data collected through the monitoring tasks of the project is collected under the approved QAPP that is updated annually. The objective of the quality assurance task was to develop and implement data quality objectives and quality assurance/control activities in order to ensure data of known and acceptable quality are generated through this project.

On September 29, 2014 GBRA participated in an audit of the monitoring program by the TSSWCB. The audit included the quality system of the laboratory and the field monitoring protocols. At the exit interview, one recommendation was made to provide safety equipment to visitors of the laboratory. Equipment, including safety glasses, is now available outside the door to the laboratory.

GBRA updates the TCEQ's Coordinated Monitoring Schedule each year to include the sites that are being sampled under this project.

The data collected in this project is uploaded to the TCEQ Surface Water Quality Monitoring Information System (SWQMIS). A completed Data Summary was submitted with each data submittal. Corrective Action Reports were submitted by the GBRA field staff or the laboratory if there was a problem or deficiency encountered. If a problem occurred during a sampling event, every attempt was made to recollect the sample if the flow conditions remained the same so there was no loss in data. A secondary lab was included in the QAPP in order to perform analyses when there was an instrument failure in the GBRA laboratory. Only two data sets were incomplete from January 2015 through December 2016 due to GBRA error, requiring a Corrective Action Report. The deficiencies are listed in Table 1.

Table 1. Deficiencies resulting in a loss of data.

Date	Site Name	Deficiency	Explanation
July 2015	Routine station 21260 (Geronimo Creek at IH 10)	Nitrate Nitrogen not reported	Nitrate Nitrogen was not analyzed due to laboratory instrument error
October 2016	All routine, water wells, spring, and targeted monitoring stations	Total Suspended Solids (TSS) not reported	TSS samples were not analyzed within regulatory holding time due to laboratory analyst error

Highlights and Evaluation of Water Quality Monitoring Data

Routine Monitoring

The GBRA conducted routine ambient monitoring at 7 sites monthly, collecting field, conventional, flow and bacteria parameter groups. Routine ambient monitoring was conducted monthly at 1 station by the GBRA (Site no. 14932, Geronimo Creek at Haberle Road) through the TCEQ CRP. The objective of the routine monitoring was to provide water quality data to assess the effectiveness of implementing the Geronimo and Alligator Creeks WPP by enhancing current routine ambient monitoring regimes. The scheduling of routine water quality sampling was designed to complement existing routine ambient monitoring regimes such that routine water quality monitoring was conducted monthly at 8 sites in the watersheds. GBRA's Regional Laboratory conducted the sample analysis. Field parameters were pH, temperature, conductivity, and dissolved oxygen. Conventional parameters were total suspended solids, turbidity, sulfate, chloride, nitrate-nitrogen, ammonia-nitrogen, Total Kjeldahl Nitrogen, chlorophyll a, pheophytin, total hardness, and total phosphorus. Flow parameters were collected by electric, mechanical or Doppler, including severity. Bacteria parameter is *E. coli*.

Beginning in January 2015 through December 2016, 24 routine sampling events were conducted. All routine monitoring sites were flowing and sampled during all weather conditions, with one exception. The Geronimo Creek at Huber Road routine monitoring station is located upstream of the springs that feed the Geronimo Creek. This station routinely went dry and sampling was often limited to isolated pools of water, unless the creek was recently influenced by a significant rainfall event.

The following data tables compile the routine monitoring data collected from May of 2009 to December of 2016. The collection period for the Geronimo Creek at IH 10 and Geronimo Creek at HWY 90A monitoring stations begins in October of 2012 because monitoring of these stations began with the TSSWCB 11-06 implementation monitoring project. Table 2 compares the geometric mean of the *E. coli* data collected at each routine site to the geometric mean of the data collected under wet weather conditions. The data shows that storm water carries a significant load of bacteria into the stream. But even under dry conditions the geometric mean at five of the eight sites exceeded the stream standard for contact recreation (126 organisms per 100 milliliters).

Table 2. Concentrations of *E. coli* under dry and wet conditions at the routine & targeted monitoring sites.

Monitoring Station	E. coli Geomean 2008 - 2016**	Median Flow (cfs) 2008 - 2016	*E. coli* Geomean Wet**	No. of Samples (Wet)	Range - Wet	Median Flow (cfs) Wet	*E. coli* Geomean - Dry**	No. of Samples (Dry)	Range - Dry	Median Flow (cfs) - Dry	% Change Between Dry and Wet**
Alligator Creek at FM 1102	222	0	746	8	60 - 6,100	0	18	4	10 - 58	0	97.36%
Alligator Creek at FM 1101	157	0	326	10	10 - 10,000	<0.01	36	5	7 - 1,000	0	88.84%
Alligator Creek at Barbarossa Road	391	0	519	8	30 - 17,000	0	126	2	20 - 790	0	75.78%
Alligator Creek at Huber Road	62	<0.01	96	35	2 - >24,000	<0.01	44	43	<1 - >2,400	0	51.75%
Geronimo Creek at Huber Road	154	0	215	22	3 - 8,700	0	105	19	2 - >24,000	0	51.27%
Geronimo Creek at SH 123	430	2.9	496	35	72 - 11,600	3.6	383	43	110 - 7,700	2.5	22.85%
Geronimo Creek at Haberle Road	209	4.8	283	38	51 - 16,000	5.4	175	65	54 - 3,080	4.2	38.29%
Unnamed Tributary at Laubach Road	265	0	534	9	4 - 14,0000	0	149	11	2 - 5,500	0	72.06%
Geronimo Creek at FM 20	218	5.8	292	18	35 - 13,000	6.4	160	17	60 - 4,350	5.8	45.37%
Geronimo Creek at IH 10	234	5.4	359	21	71 - 8,600	7.6	178	33	55 - 630	4.6	50.36%
Geronimo Creek at HWY 90A	176	6.5	208	35	20 - 8,200	6.9	153	43	21 - 1,860	6	13.04%
Bear Creek at Walnut Street	128	0	137	21	0.04 - 12,000	0	114	14	4 - 1,660	0	16.88%
Geronimo Creek at HWY 90	178	6	271	22	60 - 8,200	7.5	134	33	38 - 440	5.4	50.57%
Geronimo Creek at Hollub Road	181	7.2	241	35	41 - 11,000	8	143	43	24 - 2,720	6.4	40.54%

* Positive change indicates an increase in pollutant load with rainfall. Negative change indicates that rainfall is diluting the base flow pollutant concentration.

Highlighted values indicate an** *E. coli* geometric mean greater than the water quality standard of 126 MPN/100 mL.

Table 3 is the mean of the concentrations of total phosphorus at the routine sites. Although at no time, or under any flow conditions, did the mean exceed the screening concentration of 0.69 milligrams per liter there was an increase in total phosphorus during wet weather conditions.

Table 3. Concentrations of total phosphorus under dry and wet conditions at the routine and targeted monitoring sites. At no time, or under any flow conditions, did the mean exceed the screening concentration of 0.69 milligrams per liter.

Monitoring Station	Total P Mean 2008 - 2016**	Median Flow (cfs) 2008 - 2016	Total P Mean Wet**	No. of Samples (Wet)	Range - Wet	Median Flow (cfs) Wet	Total P Mean Dry**	No. of Samples (Dry)	Range - Dry	Median Flow (cfs) - Dry	% Change Between Dry and Wet**
Alligator Creek at FM 1102	0.32	0	0.4	8	0.19 - 0.65	0	0.18	4	0.14 - 0.23	0	53.80%
Alligator Creek at FM 1101	0.13	0	0.13	10	0.09 - 0.27	<0.01	0.17	5	0.03 - 0.07	0	74.71%
Alligator Creek at Barbarossa Road	0.31	0	0.3	8	0.17 - 0.63	0	0.36	2	0.09 - 0.64	0	-22.18%
Alligator Creek at Huber Road	0.08	<0.01	0.1	34	<0.02 - 0.26	<0.01	0.06	44	<0.02 - 0.27	0	37.15%
Geronimo Creek at Huber Road	0.33	0	0.32	22	0.04 - 0.62	0	0.35	19	<0.02 - 0.78	0	-12.12%
Geronimo Creek at SH 123	0.05	2.9	0.07	35	<0.02 - 0.34	3.6	0.03	43	<0.02 - 0.11	2.5	49.81%
Geronimo Creek at Haberle Road	0.05	4.8	0.08	37	<0.02 - 0.51	5.4	0.04	66	<0.02 - 0.22	4.2	50.89%
Unnamed Tributary at Laubach Road	0.3	0	0.32	9	0.16 - 053	0	0.29	11	<0.02 - 0.79	0	11.13%
Geronimo Creek at FM 20	0.05	5.8	0.08	18	<0.02 - 0.47	6.4	0.03	17	<0.02 - 0.17	5.8	58.26%
Geronimo Creek at IH 10	0.04	5.4	0.07	21	<0.02 - 0.31	7.6	0.03	33	<0.02 - 0.06	4.6	63.70%
Geronimo Creek at HWY 90A	0.06	6.5	0.08	35	<0.02 - 0.32	6.9	0.04	43	<0.02 - 0.21	6	50.68%
Bear Creek at Walnut Street	0.14	0	0.16	21	0.07 - 0.55	0	0.12	14	<0.05 - 0.34	0	24.77%
Geronimo Creek at HWY 90	0.04	6	0.07	22	<0.02 - 0.31	7.5	0.03	33	<0.02 - 0.07	5.4	57.94%
Geronimo Creek at Hollub Road	0.09	7.2	0.08	35	<0.02 - 0.35	8	0.1	43	<0.02 - 2.87	6.4	-29.00%

* Positive change indicates an increase in pollutant load with rainfall. Negative change indicates that rainfall is diluting the base flow pollutant concentration.

** All values were lower than the Total Phosphorus water quality screening criteria of 0.69 mg/L.

Table 4 is a compilation of the nitrate-nitrogen data collected from 2008 through August 2014. The Leona Aquifer is the source of the springs contributing to the base flow of the Geronimo Creek. Historically, the concentration of the nitrate-nitrogen found in the Leona is very high, exceeding the drinking water standard of 10.0 milligrams per liter. The impact of the Leona on the base flow can be seen in the mean concentrations of nitrate-nitrogen at all six Geronimo Creek sites. All six sites exceed the TCEQ screening concentration of 1.95 milligrams per liter. Under wet weather conditions, storm water dilutes the base flow and lowers the mean concentrations at all sites.

Table 4. Concentrations of nitrate-nitrogen under dry and wet conditions at the routine and targeted monitoring sites.

Monitoring Station	NO3-N Mean 2008 - 2016**	Median Flow (cfs) 2008 - 2016	NO3-N Mean Wet**	No. of Samples (Wet)	Range - Wet	Median Flow (cfs) Wet	NO3-N Mean Dry**	No. of Samples (Dry)	Range - Dry	Median Flow (cfs) - Dry	% Change Between Dry and Wet**
Alligator Creek at FM 1102	0.52	0	0.72	8	<0.05 - 2.77	0	0.1	4	<0.05 - 0.26	0	85.84%
Alligator Creek at FM 1101	0.49	0	0.31	10	<0.05 - 0.90	<0.01	0.85	5	<0.05 - 2.09	0	-171.80%
Alligator Creek at Barbarossa Road	0.66	0	0.77	8	<0.05 - 2.74	0	0.21	2	<0.05 - 0.36	0	73.38%
Alligator Creek at Huber Road	2.7	<0.01	2.63	35	<0.05 - 15.8	<0.01	2.75	43	<0.05 - 12.2	0	-4.84%
Geronimo Creek at Huber Road	1.08	0	1.83	22	<0.05 - 16.8	0	0.21	19	<0.05 - 2.49	0	88.27%
Geronimo Creek at SH 123	7.82	2.9	7.47	35	0.09 - 10.8	3.6	8.11	43	1.27 - 12.0	2.5	-8.57%
Geronimo Creek at Haberle Road	9.27	4.8	8.02	38	<0.05 - 14.2	5.4	10.02	63	2.23 - 14.0	4.2	-24.96%
Unnamed Tributary at Laubach Road	0.73	0	1.46	9	<0.05 - 5.8	0	0.13	11	<0.05 - 0.69	0	91.30%
Geronimo Creek at FM 20	10.45	5.8	9.65	18	0.9 - 13.7	6.4	11.29	17	5.56 - 17.3	5.8	-16.96%
Geronimo Creek at IH 10	9.7	5.4	8.03	21	1.0 - 13.1	7.6	10.76	33	6.6 - 16.5	4.6	-33.97%
Geronimo Creek at HWY 90A	8.51	6.5	7.14	35	<0.05 - 12.6	6.9	9.62	43	3.2 - 16.0	6	-34.86%
Bear Creek at Walnut Street	0.43	0	0.64	21	<0.05 - 8.36	0	0.12	14	<0.05 - 0.31	0	81.38%
Geronimo Creek at HWY 90	9.2	6	7.98	22	1.47 - 12.8	7.5	10.01	33	5.6 - 13.3	5.4	-25.40%
Geronimo Creek at Hollub Road	7.24	7.2	6.12	35	<0.05 - 11.8	8	8.15	43	2.6 - 13.7	6.4	-33.16%

* Positive change indicates an increase in pollutant load with rainfall. Negative change indicates that rainfall is diluting the base flow pollutant concentration.

**Highlighted values indicate an NO3-N mean greater than the water quality screening criteria of 1.95 mg/L.

Table 5 is a compilation of the data collected for ammonia-nitrogen. At no time, or under any flow conditions, did the mean of any of the routine stations exceed the screening concentration of 0.33 milligrams per liter. Two targeted stations showed exceedances under specific weather conditions, but the data at these stations was extremely limited due to drought conditions.

Table 5. Concentrations of ammonia-nitrogen under dry and wet conditions at the routine and targeted monitoring sites.

Monitoring Station	NH3-N Mean 2008 - 2016**	Median Flow (cfs) 2008 - 2016	NH3-N Mean Wet**	No. of Samples (Wet)	Range - Wet	Median Flow (cfs) Wet	NH3-N Mean Dry**	No. of Samples (Dry)	Range - Dry	Median Flow (cfs) - Dry	% Change Between Dry and Wet**
Alligator Creek at FM 1102	0.19	0	0.24	8	<0.1 - 0.97	0	<0.10	4	<0.1 - <0.1	0	58.33%
Alligator Creek at FM 1101	0.17	0	0.21	10	<0.1 - 0.64	<0.01	<0.10	5	<0.1 - <0.1	0	52.38%
Alligator Creek at Barbarossa Road	0.15	0	0.16	8	<0.1 - 0.30	0	0.12	2	<0.1 - 0.13	0	28.68%
Alligator Creek at Huber Road	0.28	<0.01	0.42	35	<0.1 - 8.12	<0.01	0.17	43	<0.1 - 0.7	0	59.78%
Geronimo Creek at Huber Road	0.18	0	0.2	22	<0.1 - 2.0	0	0.15	19	<0.1 - 0.39	0	26.10%
Geronimo Creek at SH 123	0.15	2.9	0.15	35	<0.1 - 0.45	3.6	0.14	43	<0.1 - 0.36	2.5	6.04%
Geronimo Creek at Haberle Road	0.15	4.8	0.16	33	<0.1 - 1.13	5.4	0.14	54	<0.1 - 1.13	4.2	12.57%
Unnamed Tributary at Laubach Road	0.58	0	0.16	9	<0.1 - 0.26	0	0.93	11	<0.1 - 4.5	0	-474.98%
Geronimo Creek at FM 20	0.16	5.8	0.16	18	<0.1 - 0.34	6.4	0.15	17	<0.1 - 0.39	5.8	5.15%
Geronimo Creek at IH 10	0.15	5.4	0.15	21	<0.1 - 0.38	7.6	0.15	33	<0.1 - 0.36	4.6	1.08%
Geronimo Creek at HWY 90A	0.14	6.5	0.14	35	<0.1 - 0.45	6.9	0.14	43	<0.1 - 0.37	6	-2.15%
Bear Creek at Walnut Street	0.18	0	0.18	21	<0.1 - 0.43	0	0.18	14	<0.1 - 0.41	0	-3.35%
Geronimo Creek at HWY 90	0.16	6	0.17	22	<0.1 - 0.50	7.5	0.15	33	<0.1 - 0.33	5.4	11.23%
Geronimo Creek at Hollub Road	0.16	7.2	0.14	35	<0.1 - 0.45	8	0.17	43	<0.1 - 0.77	6.4	-22.34%

* Positive change indicates an increase in pollutant load with rainfall. Negative change indicates that rainfall is diluting the base flow pollutant concentration.

**Highlighted values indicate an Ammonia-Nitrogen mean greater than the water quality screening criteria of 0.69 mg/L.

Analysis of Routine Data for Trends

The Geronimo and Alligator Creeks monitoring stations were analyzed for statistically significant correlations between concentrations for ammonia-nitrogen, nitrate-nitrogen, total phosphorus and *E. coli* versus time and stream flow. Relationships were also explored for background water quality parameters such as total suspended solids (TSS), chlorides, sulfates, chlorophyll A, total kjeldahl nitrogen (TKN), temperature, dissolved oxygen, specific conductance and pH. Multiple t-tests were conducted to determine significance. If the absolute value of the t-statistic was greater than 2 and the p value was less than or equal to a 0.05 significance level, then the correlation between each of the dependent variables and either time or stream flow was considered to be significant. The p value is the statistical probability that a result will equal or exceed the actual observed value if there is no relation between the groups of variables being tested by the hypothesis. The dotted red lines on the accompanying charts represent nutrient screening values for concentration levels for concerns and solid red lines represent contact recreation limits for *E. coli*, if applicable.

The Geronimo Creek at Hollub Road monitoring station (20747) is located approximately 0.5 kilometers (km) upstream of the confluence with the Guadalupe River. During heavy flooding the Guadalupe River backs up and influences the water quality of this portion of the Geronimo Creek. Only two statistically significant correlations with time were found at this location. The chloride anion, which forms table salt along with sodium was found to be decreasing with time t(77)=-2.33, p=0.02, (Figure 8). The sulfate salt anion was also found to be decreasing with time; t(77)=-2.06, p=0.04 (Figure 9). These correlations were explained by changes in flow. A statistically significant correlation was found between chlorides and stream flow t(77)=-3.72, p=0.00 and sulfates with stream flow t(77)=-3.71, p=0.00. The water at this location appears to be becoming less saline as a result of increased flows. Observed increases in stream flow also significantly increased *E. coli* concentrations t(77)=14.56, p=0.00, but E. coli levels were not found to be significantly changing over time.

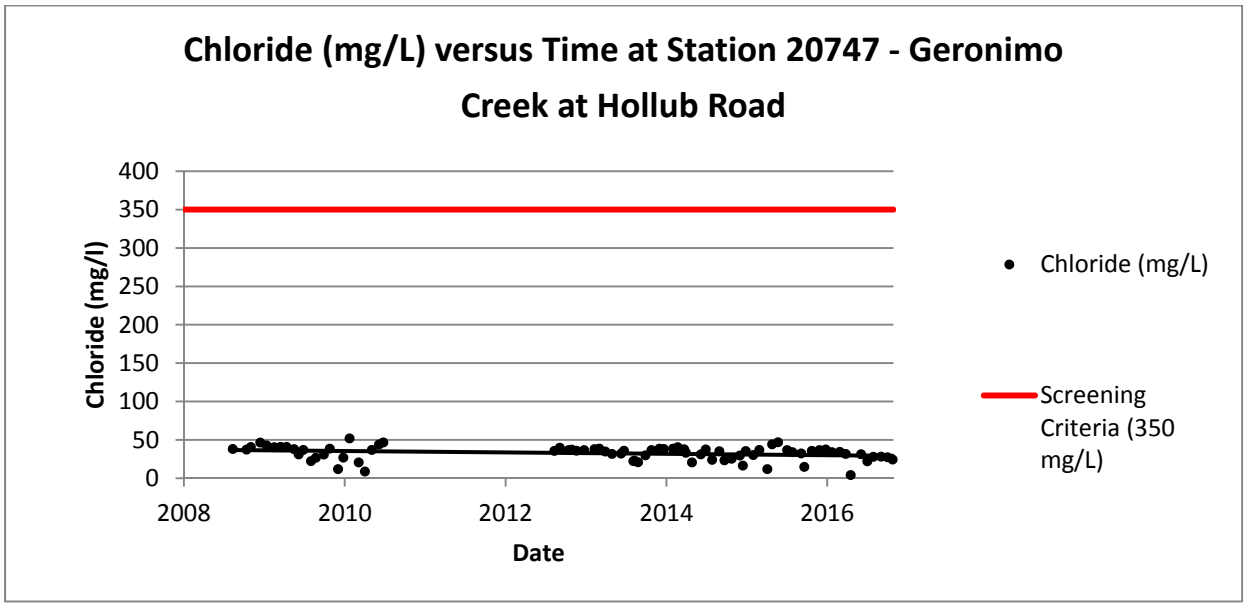

Figure 8. Chlorides (mg/L) versus Time at Station 20747 - Geronimo Creek at Hollub Road.

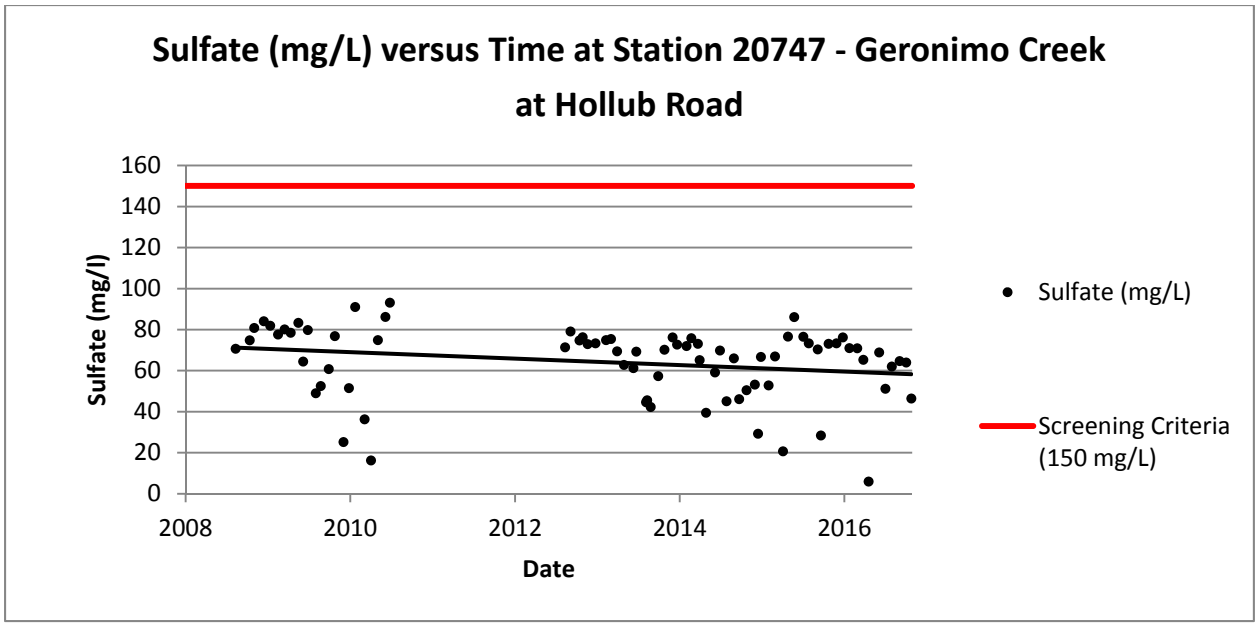

Figure 9. Sulfates (mg/L) versus Time at Station 20747 – Geronimo Creek at Hollub Road.

At the Geronimo Creek at Highway 90A station (20745) statistically significant correlations were found between several water quality parameters and time. Chlorides were decreasing with time; t(77)=-2.99, p=0.00 (Figure 10). Sulfates were also decreasing with time; t(77)=-2.31, p=0.02 (Figure 11). Several parameters also showed significant correlations with stream flow. Total phosphorus is increasing with stream flow t(77)=6.43, p=0.00 and *E. coli* is also increasing with stream flow t(77)=9.56, p=0.00. This station is located only about 4 kilometers upstream of the Geronimo Creek at Hollub Road station (20747) and 0.4 km upstream of the confluence of the Baer Creek tributary, but seems to be experiencing similar trending to the previous station downstream station.

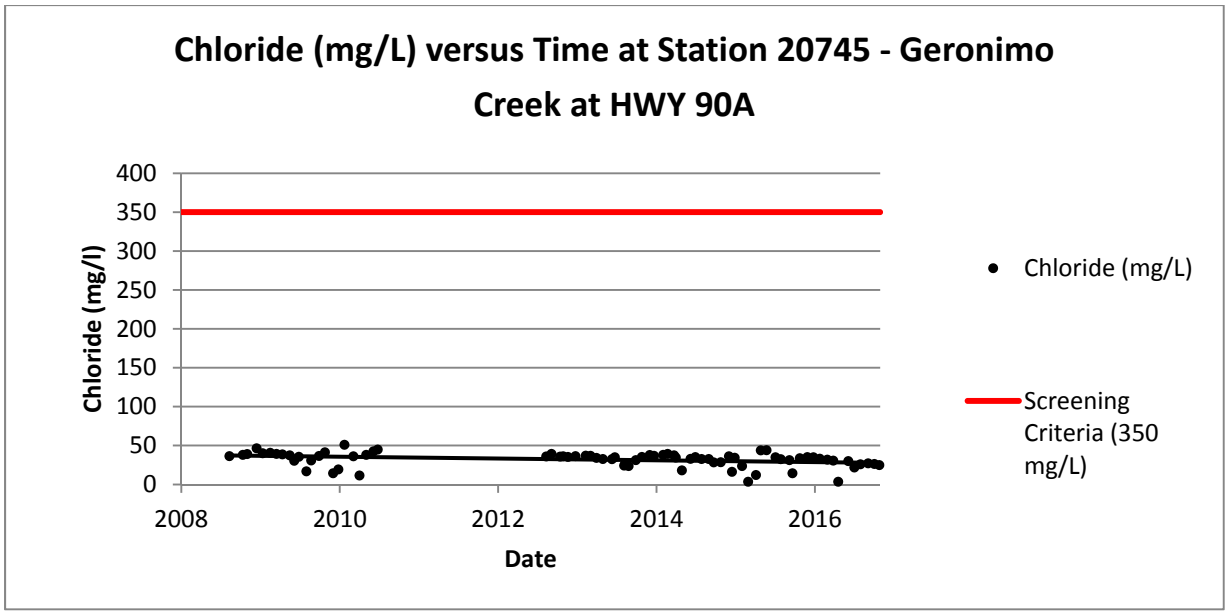

Figure 10. Chlorides (mg/L) versus Time at Station 20745 Geronimo Creek at Highway 90A.

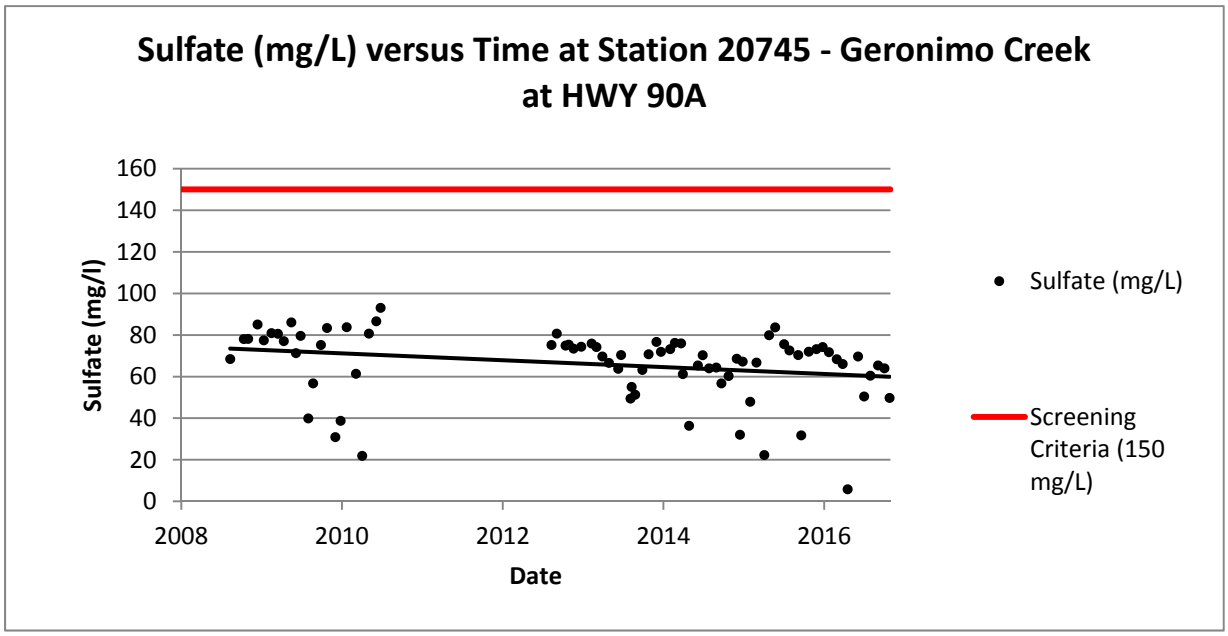

Figure 11. Sulfates (mg/L) versus Time at Station 20745 - Geronimo Creek at Highway 90A.

The Geronimo Creek at Highway 90 near the ILSOLC (21261) had four statistically significant correlations of water quality parameters with time. Ammonia-Nitrogen (mg/L); t(54)=-3.34, p=0.00, at this station is decreasing with time (Figure 12). Chlorides are decreasing over time; t(54)=-3.96, p=0.00 (Figure 13). Sulfates are also decreasing over time; t(54)=-2.86, p=0.01 (Figure 14). This station is only located about 2.1 kilometers upstream of the Geronimo Creek at Highway 90A station (20745), but water quality trends at this station are quite different. Station 21261 was added to the Geronimo Creek monitoring project in September of 2012 and has much less data available than many of the other monitoring stations on Geronimo Creek. The trends at this station may differ from other portions of the Geronimo Creek for this reason. The decrease in ammonia-nitrogen and salt anions concentrations at this location are generally indicators of better water quality conditions and are most likely due to a statistically significant increase in ambient stream flows at this station over the study period; t(54)=4.58, p=0.00. All four of the parameters that were changing over time, also showed statistically significant correlations with stream flow.

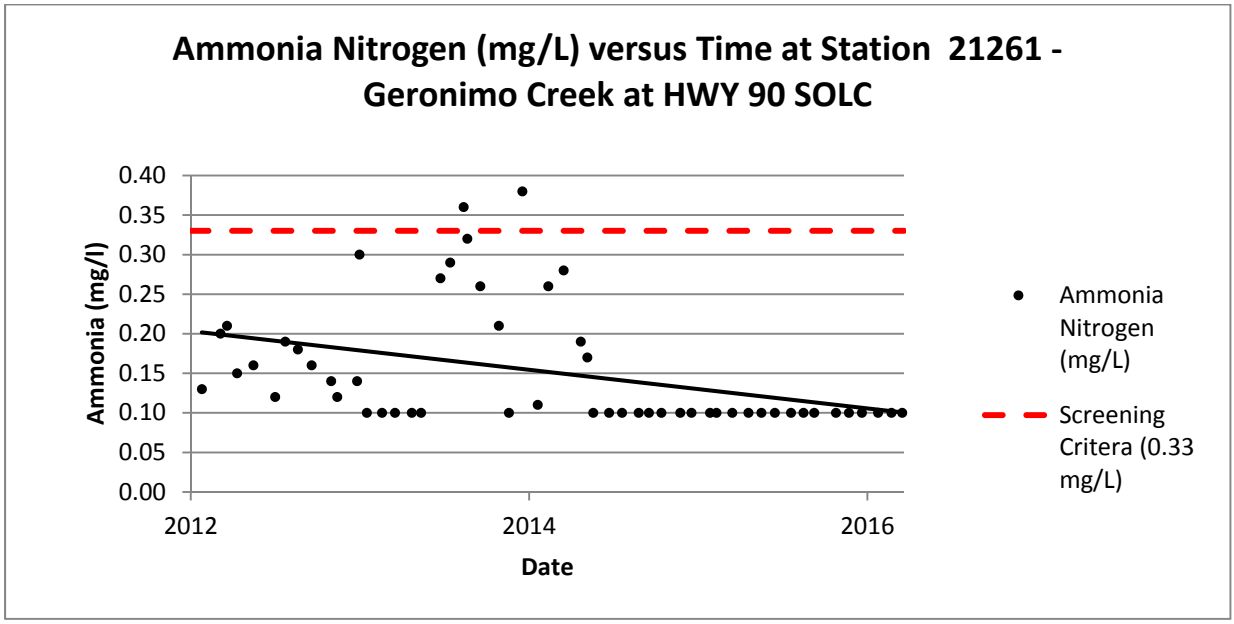

Figure 12. Ammonia-Nitrogen (mg/L) versus Time at Station 21261 - Geronimo Creek at Highway 90 near the Seguin Outdoor Learning Center.

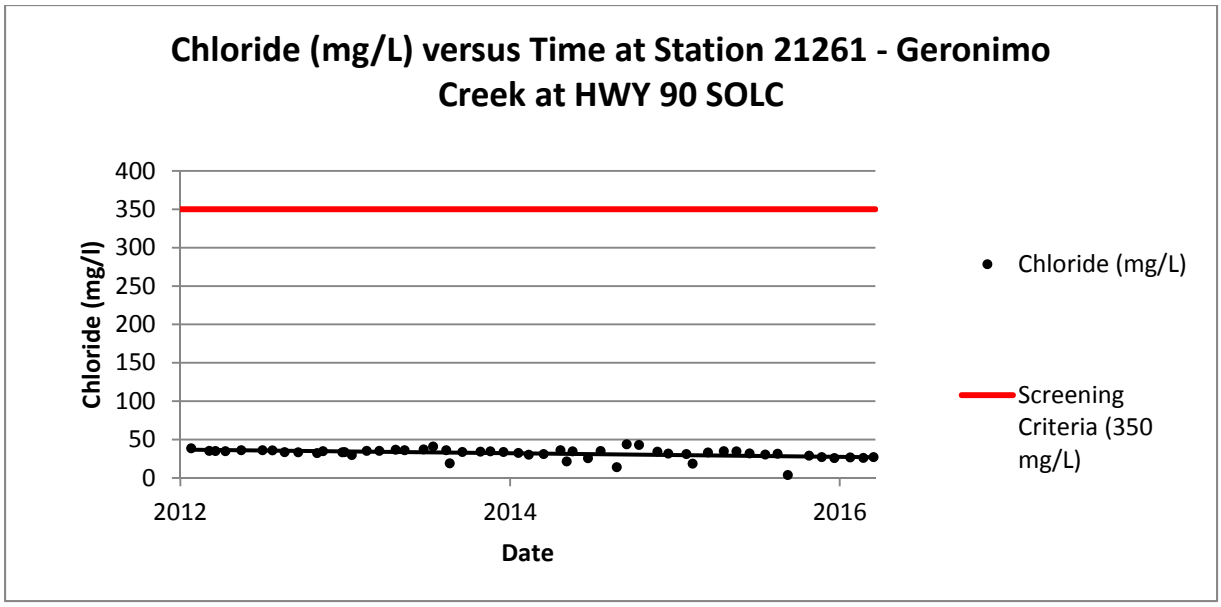

Figure 13. Chlorides (mg/L) versus Time at Station 21261 - Geronimo Creek at Highway 90 Near the ILSOLC.

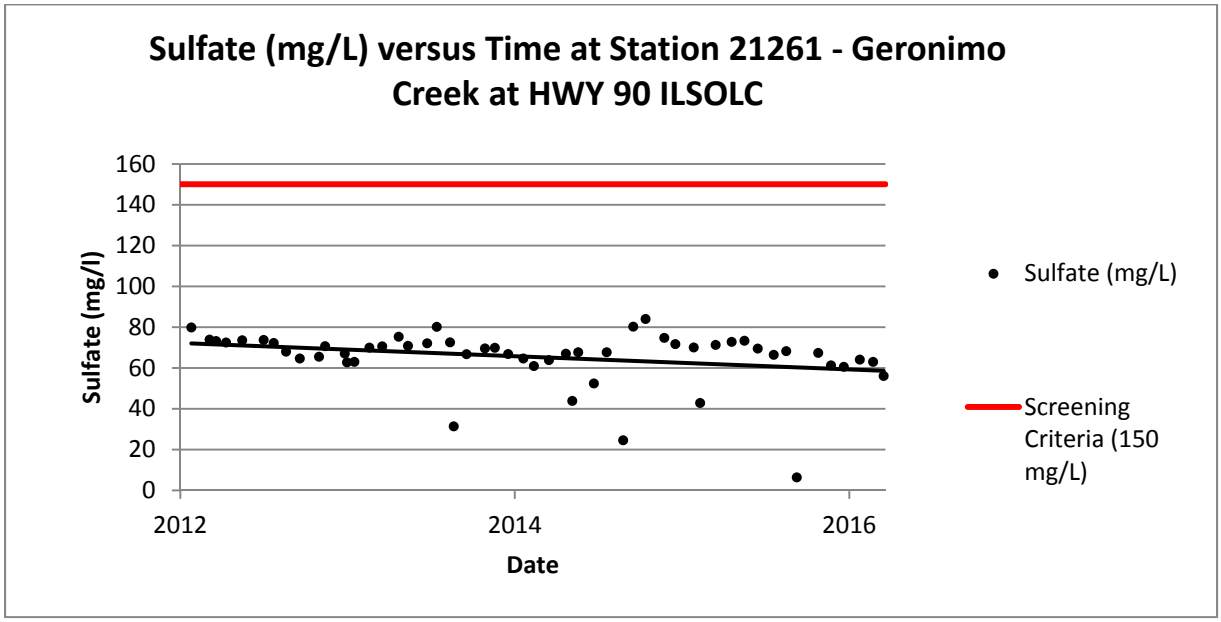

Figure 14. Sulfates (mg/L) versus Time at Station 21261 - Geronimo Creek at Highway 90 Near the ILSOLC.

The Geronimo Creek at IH 10 monitoring station (21260) was added to the Geronimo Creek and Alligator Creek Monitoring Project in September of 2012 along with the station at the ILSOLC. The water quality trends at this station were very similar to the trends at the Geronimo Creek at Highway 90 near the ILSOLC (21261). Ammonia-nitrogen; t(52)=-3.25,p=0.00 (Figure 15), chlorides t(53)=3.42, p=0.00 (Figure 16) and sulfates t(53)=-2.19, p=0.03 (Figure 17) are all decreasing with time. All three of these water quality parameters significantly decreased as stream flows increased. Stream flow at this station is significantly increasing with time t(51)=4.62, p=0.00 and *E. coli*; t(51)=12.33, p=0.00, significantly increased with higher stream flows, although overall *E. coli* concentrations do not appear to be changing with time. Station 21260 is located 1.25 km upstream of station 21261 and the close proximity of this station with station 21261 during the same truncated temporal monitoring interval may be the reason that these two stations showed such similar patterns.

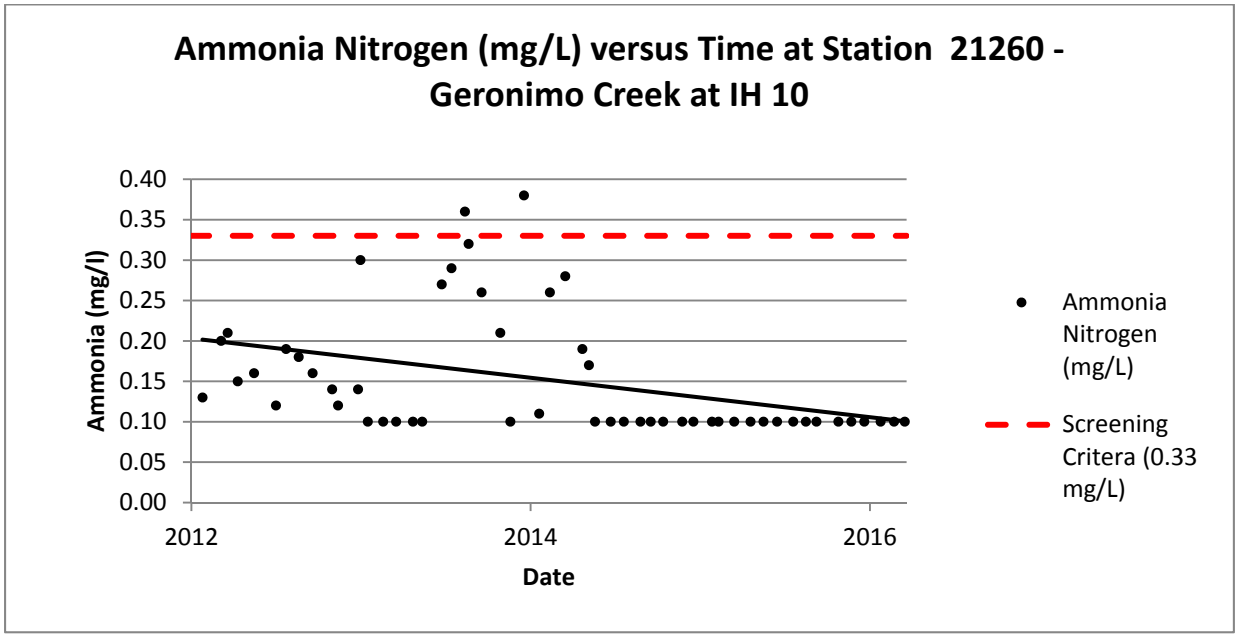

Figure 15. Ammonia-Nitrogen (mg/L) versus Time at Station 21260 - Geronimo Creek at IH-10.

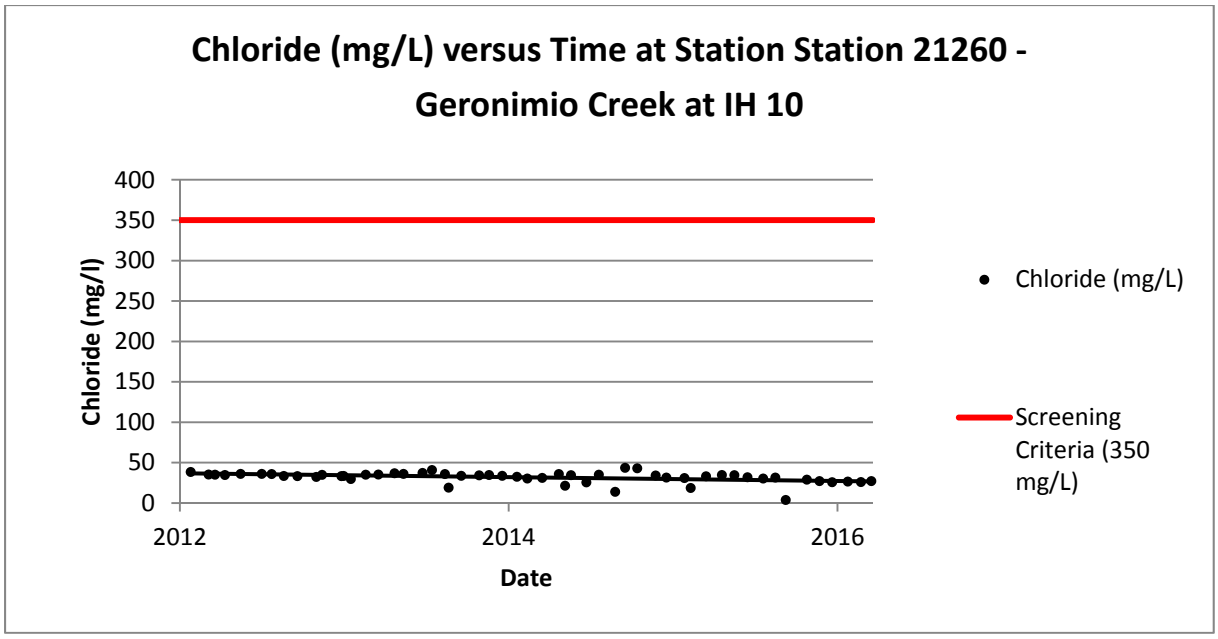

Figure 16. Chlorides (mg/L) versus Time at Station 21260 – Geronimo Creek at IH-10.

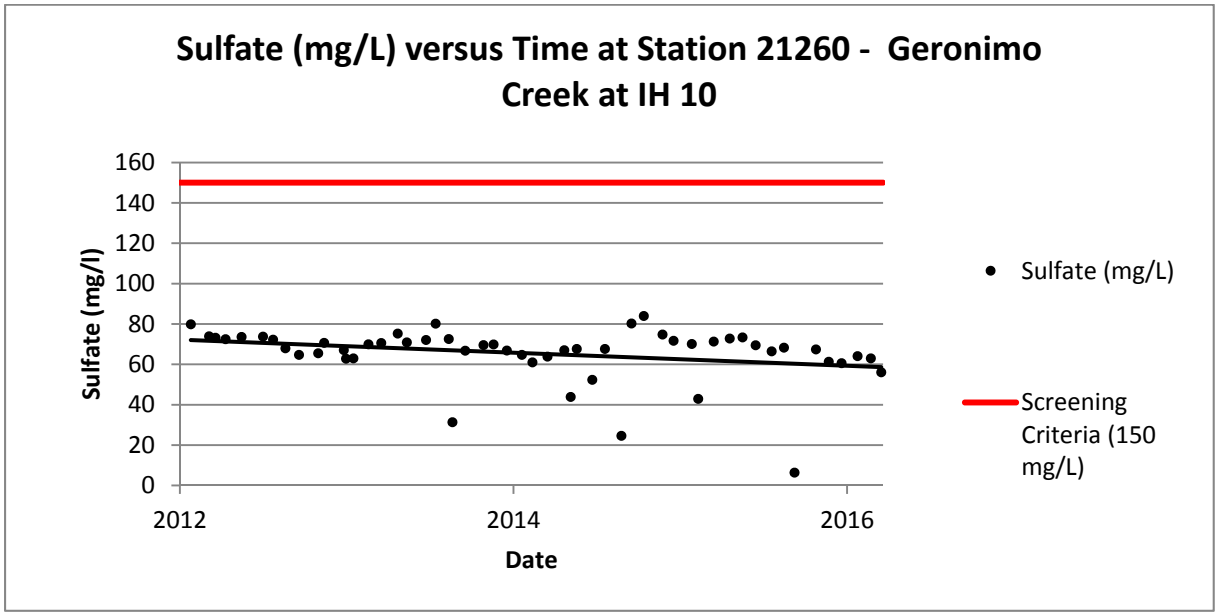

Figure 17. Sulfate s (mg/L) versus Time at Station 21260 – Geronimo Creek at IH-10.

The Geronimo Creek at Haberle Road station (12576) is the current TCEQ CRP monitoring station on the Geronimo Creek and is the station with the greatest amount of data available during the span of the monitoring project. This station is located 4.3 km upstream of the Geronimo Creek at IH 10 station (21260) and contributed much of the data to the original noncompliance listing for this stream. Station 12576 showed only two significant correlations with time. Ammonia-nitrogen; $t(61)=2.66, p=0.01$ is increasing over time (Figure 18) and sulfate is decreasing over time $t(77)=-2.32$, $p=0.02$ (Figure 19). This trend is consistent with the data from the Geronimo Creek at Highway 90A station (20745), which spanned the same temporal monitoring interval and showed similar correlations between ammonia-nitrogen and time. Station 12576 also showed significant correlations between nitrate nitrogen and stream flow; $t(75)=-3.51, p=0.00$, as well as *E. coli* and stream flow; $t(78)=3.61, p=0.00$. Nitrate nitrogen decreases as stream flow increases, while *E. coli* increases during higher stream flows.

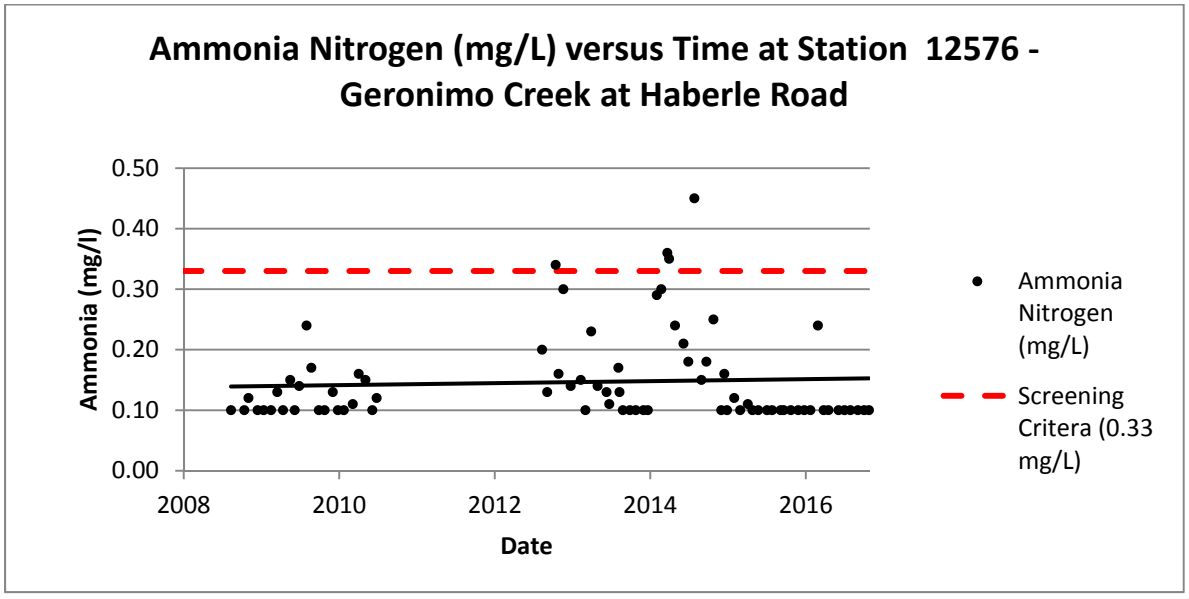

Figure 18. Ammonia-Nitrogen (mg/L) versus Time at Station 12576 - Geronimo Creek at Haberle Road.

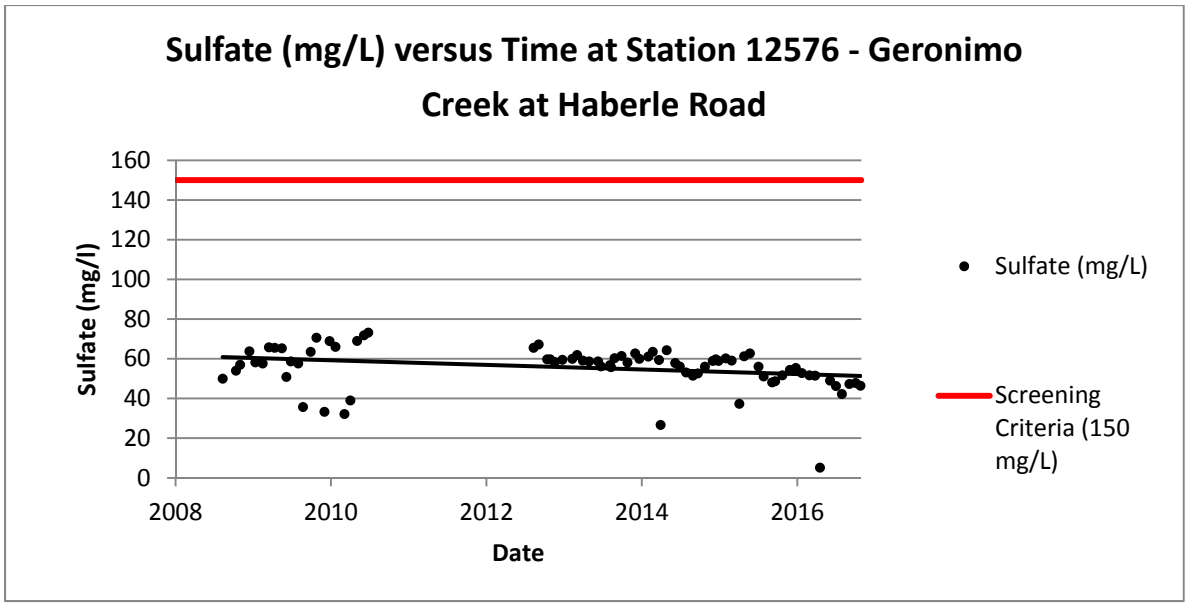

Figure 19. Sulfate (mg/L) versus Time at Station 12576 - Geronimo Creek at Haberle Road.

At the Geronimo Creek at SH 123 station (14932) a statistically significant correlation was found between increasing TSS; t(76)=-2.21,p=0.03 and time (Figure 20). This station also showed a significant correlation between decreasing chlorides; t(77)=-4.56,p=0.00 (Figure 21), and sulfates with time t(77)=-2.53, p=0.01 (Figure 22). This station is located immediately downstream of the headwater springs of the Geronimo Creek and approximately 4 km upstream of station 12576 (Geronimo Creek at Haberle Road). The trends at this station are generally similar to the trends at the other Geronimo Creek main stem stations such as 20747 (Geronimo Creek at Hollub Road) and 20745 (Geronimo Creek at Highway 90A), that were collected during the same temporal monitoring period. During base flow conditions, this portion of the stream is influenced by underground spring discharges more than any other Geronimo Creek main stem station, due to its close proximity to the headwater springs of the creek. The lack of significant correlations with any of the nutrient or bacteria parameters of interest at this station may be due to the consistent discharges from the Geronimo springs.

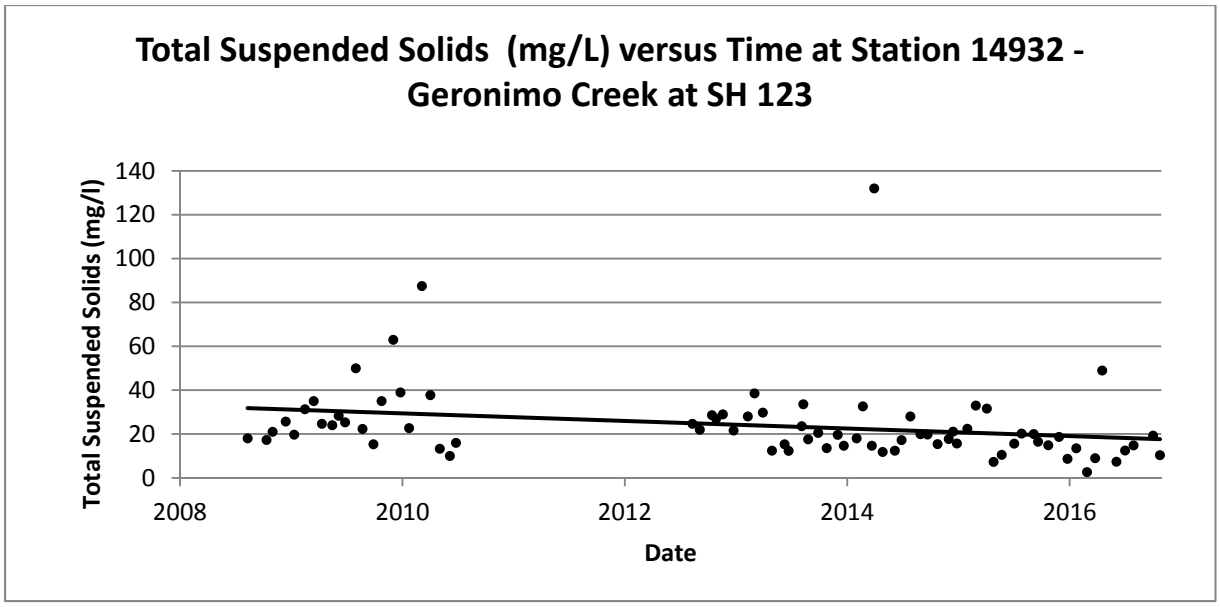

Figure 20. Total Suspended Solids (mg/L) versus Time at Station 14932 - Geronimo Creek at SH 123.

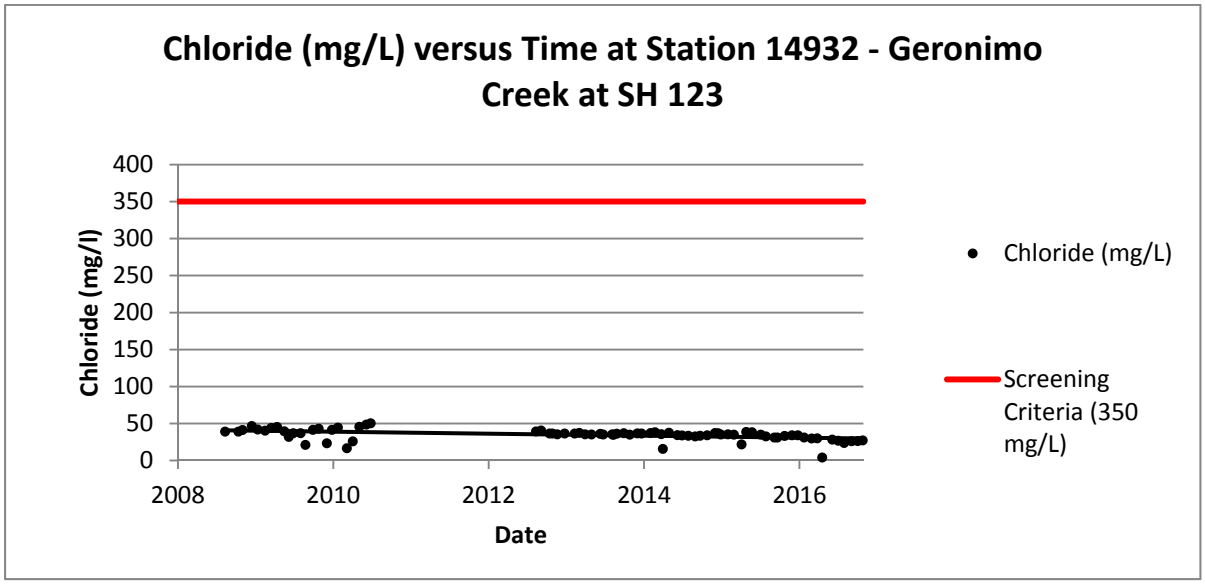

Figure 21. Chlorides (mg/L) versus Time at Station 14932 - Geronimo Creek at SH 123

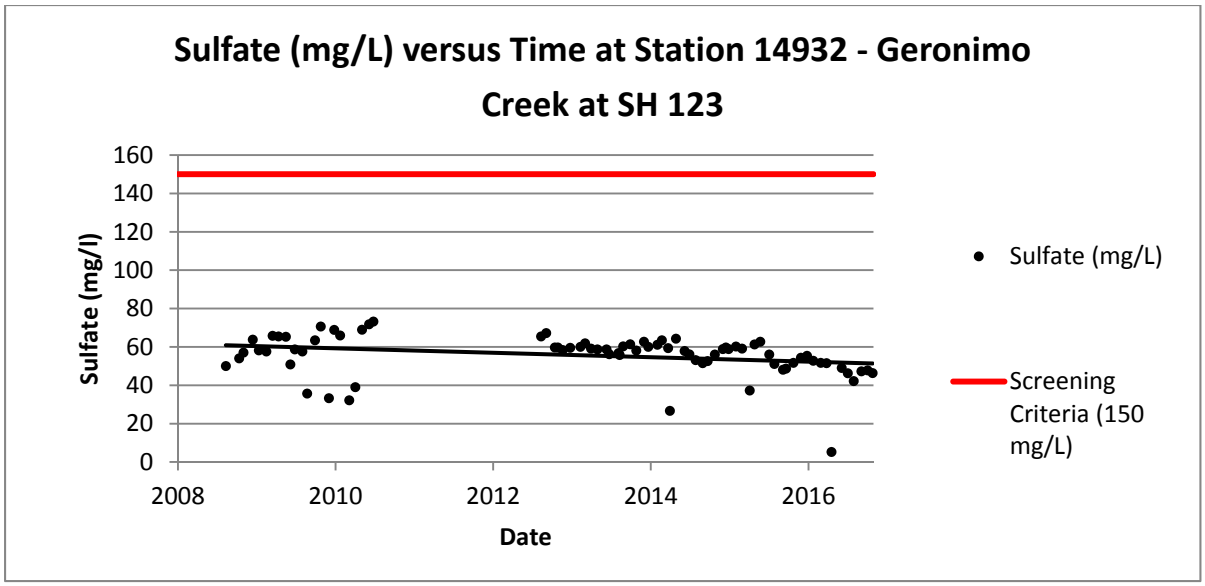

Figure 22. Sulfates (mg/L) versus Time at Station 14932 - Geronimo Creek at SH 123

The Geronimo Creek at Huber Road monitoring station (20742), showed only one statistically significant correlation between Chlorophyll A and time $t(39)=2.48$, $p=0.02$ (Figure 23). Chlorophyll A is a pigment found in plants that is measured in order to assess the effects of nutrient availability on plant and algae growth in a stream. The Geronimo Creek at Huber Road is located 3.3 km upstream of the SH 123 station and approximately 0.3 km upstream of the confluence with Alligator Creek. Station 20742 is the only routine monitoring station in the watershed that is not influenced by spring discharges. The Geronimo Creek at this location is dry during much of the year and almost all of the data points have been collected under wet weather conditions or from a small pond situated in the middle of the creek that retains water long periods after a rainfall runoff event. The water in this portion of the creek may have had a long enough retention time to build up significant algae growth between rainfall runoff events when the algae growth could be flushed downstream. The limited sample size and small flow variability during collection events probably contributed to the limited amount of statistically significant correlations at this station.

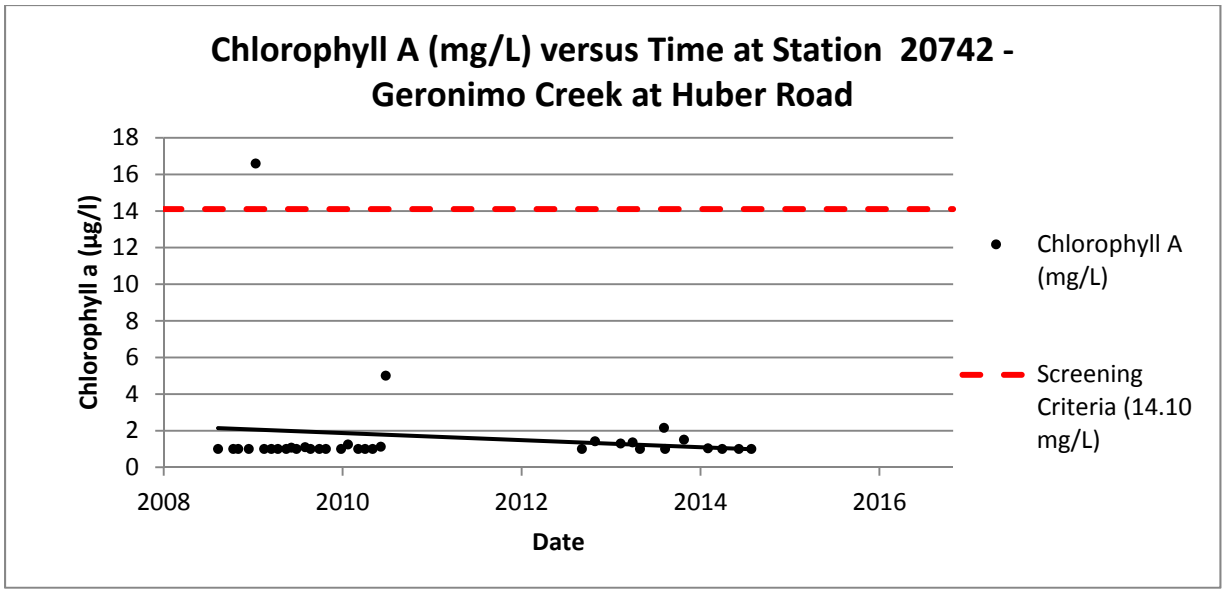

Figure 23. Chlorophyll A (ug/L) versus Time at Station 14932 - Geronimo Creek at SH 123

The Alligator Creek at Huber Road (20743) is the only routine monitoring station in the watershed located on the Alligator Creek tributary of Geronimo Creek. Station 20743 is located further upstream in the watershed than any other routine monitoring station and is 0.6 km upstream of the confluence with Geronimo Creek. This station is influenced by a groundwater seep and has never been dry during any sample collection events. The water at station 20743 becomes disconnected from downstream monitoring stations and does not flow during times of extreme drought. None of the water quality monitoring parameters of interest showed a clear correlation with time at this station. A significant correlation between stream flow and total phosphorus was found $t(77)=3.77$, $p=0.00$, which could indicate that phosphorus increases at this station as a result of major rainfall runoff from the surrounding agricultural land. No other significant relationships were found between any of the bacteria or nutrient parameters of concern and stream flow at this station. The ambient stream flows at this station were also not significantly changing over time.

Targeted Monitoring

The objective of the targeted watershed surface water quality monitoring task was to provide water quality data to assess the effectiveness of implementing the Geronimo and Alligator Creeks WPP during targeted flow conditions. GBRA attempted to conduct targeted watershed monitoring at 14 sites twice per season, once under dry weather conditions and once under wet weather conditions, collecting field, conventional, flow and bacteria parameter groups. Of these 14 sites, 8 sites were the same as the sites for routine ambient monitoring. Spatial, seasonal and meteorological variations were captured in these snapshots of watershed water quality. GBRA's Regional Laboratory conducted the sample analysis. Field parameters are pH, temperature, conductivity and dissolved oxygen. Conventional parameters are TSS, sulfate, chloride, nitrate-nitrogen, ammonia-nitrogen, TKN and total phosphorus. Flow is collected by mechanical or

acoustic Doppler flow measuring devices, and includes an evaluation of the flow severity. Bacteria parameters were *E. coli*.

The GBRA collected data from six targeted monitoring stations throughout the Geronimo and Alligator Creek watersheds twice per quarter between January of 2015 and December of 2016. With the exception of a station on the Geronimo Creek main stem at FM 20 (12575), these monitoring stations were dry for large portions of the monitoring project and consequently did not have enough data available to perform a trending evaluation. The only quarterly monitoring station with perennial flow was located on the Geronimo Creek at FM 20 (12575). This station was located just downstream of the TCEQ CRP monitoring station and upstream of Geronimo Creek at IH 10 (21260) monitoring station. This station had 35 data points available for trend analysis; however, none of the parameters evaluated showed any significant correlations with either time or stream flow. The Bear Creek tributary of the Geronimo Creek was listed as a concern for bacteria with an assessed mean of 251.20 MPN/100 mL over 13 data points assessed in the 2014 TCEQ Texas Integrated Report. The most recent data collected at the Bear Creek at Walnut Street (20744) monitoring station has shown that the geometric mean has declined to 127 MPN/100 mL since the publication of this assessment and a review of the data showed that past exceedances of the state recreational stream standard occurred after heavy rainfall events.

Groundwater Monitoring

The objective of the groundwater monitoring task was to provide water quality data to access the effectiveness of implementing the Geronimo and Alligator Creeks WPP through spring flow and groundwater monitoring. GBRA conducted groundwater monitoring at 2 wells and one spring once per season collecting field, conventional, flow and bacteria parameter groups. All sampling events were conducted.

GBRA's Regional Laboratory conducted the sample analysis. Field parameters are pH, temperature, conductivity and dissolved oxygen. Conventional parameters are TSS, sulfate, chloride, nitrate-nitrogen, ammonia-nitrogen, TKN and total phosphorus. Flow is collected by mechanical or Doppler, including severity. Bacteria parameters were *E. coli*. Data supports the source of the elevated nitrate-nitrogen concentrations from groundwater.

Table 6. Groundwater monitoring stations. GBRA began monitoring the two water wells in May of 2009 and Timmerman Springs was added to the monitoring schedule in November 2012.

Station	Median Flow (CFS)	Geometric Mean E. coli (MPN/100 mL)	Mean TSS (mg/L)	Mean pH (S.U.)	Mean Temperature (°C)	Mean Dissolved Oxygen (mg/L)	Mean Specific Conductance (uS/cm)	Mean Total Phosphorus (mg/L)	Mean Nitrate Nitrogen (*mg*/L)
Stream Screening Criteria	7Q2 = 2.3	126		6.5 to 9	32.2	5	1723	0.69	1.95
Huber Water Well	0.2	165	8.1	7.6	19.8	7.5	729	0.05	6.04
Timmerman Spring	0.9	261	8.9	7.7	20.8	8.8	774	0.04	6.10
Laubach Water Well	0.8	273	2.5	7.9	21.5	9.2	783	0.05	10.03

Conclusion

In summary, TSSWCB Project 14-09 titled *Water Quality Monitoring in the Geronimo Creek Watershed and Facilitation of the Geronimo and Alligator Creeks Watershed Partnership* has been completed and was essential to the continued water quality monitoring for the Geronimo and Alligator Creeks WPP. Water quality was monitored and updates were presented regularly to stakeholders. Furthermore, facilitation of The Partnership was maintained and stakeholders were engaged in implementation through a variety of educational workshops, meetings, and events. Outreach to the stakeholders was accomplished through a variety of methods including email, newsletters, press releases, newspaper and radio ads, and the project webpage.

Implementation of the Geronimo and Alligator Creeks WPP is continuing through TSSWCB Project 17-57 titled *Surface Water Quality Monitoring in the Geronimo and Alligator Creeks Watershed to Support the Implementation of the Geronimo and Alligator Creeks Watershed Protection Plan.* This work plan facilitates continued implementation of management measures contained in the WPP, while providing for regularly scheduled Partnership meetings. The work plan continues to support the watershed coordinator position, which will assist project partners in grant proposal development, coordinate outreach and education efforts, and will communicate water quality conditions to the public in order to support adaptive management.

The water quality monitoring that has been conducted in the Alligator and Geronimo Creeks watershed has shown that a significant change has not occurred in the concentrations of *E. coli* bacteria, nitrate-nitrogen or total phosphorus at any of the current routine monitoring stations. Reductions in the concentrations of these parameters as a result of implementation efforts may be lagging due to increased population growth and impermeable cover in the watershed during the same time period. The possibility of nitrate concentrations deriving from a natural source in the springs that feed the Geronimo is also being explored in an ongoing nitrate isotope study being conducted by the USGS. Ammonia-nitrogen concentrations have been significantly reduced at several routine monitoring stations since the acceptance of the Geronimo Creek WPP by the

EPA. The decline in ammonia-nitrogen may be a result of implementation efforts to reduce fertilizer runoff in the watershed. Chloride and sulfate concentrations have also been significantly reduced in the watershed. The decreasing salt concentrations may be the result of dilution from the increased rainfall and stream flows. The declining levels of these salts anions may also be a vanguard indicator of improving water quality in the watershed, as public education efforts and best management practices continue to be implemented.

List of Acronym's

BF……. Biased for Flow
BMP……. Best Management Practices
CFS…… Cubic Feet per Second
CFU……. Colony-Forming Unit
CRP…… Clean Rivers Program
CWA……. Clean Water Act
DO……. Dissolved Oxygen
DQOs…….. Data Quality Objectives
EPA…… Environmental Protection Agency
FY…… Fiscal Year
GBRA…… Guadalupe-Blanco River Authority
ILSOLC…… Irma Lewis Seguin Outdoor Learning Center
ISD…… Independent School District
MG/L…….. Milligrams/Liter
ML……. Milliliter
MPN……. Most Probable Number
NPS…… Non Point Source
NO3-N…… Nitrate as Nitrogen
NH3-N……. Ammonia Nitrogen
QAPP…….. Quality Assurance Protection Plan
QA/QC……. Quality Assurance/Quality Control
UMHOS/CM… Micromhos per Centimeter (Measurement unit for Specific Conductance)
UG/L……. Micrograms per Liter
RT…… Routine
SWCD……. Soil and Water Conservation District
SWQM…….Surface Water Quality Monitoring
TAG…… Technical Advisory Group
TCEQ…… Texas Commission on Environmental Quality
TKN……. Total Kjeldahl Nitrogen
Total P……. Total Phosphorus
TSS…… Total Suspended Solids
TSSWCB……. Texas State Soil and Water Conservation Board
USGS…….United States Geological Survey (agency)
WPP……..Watershed Protection Plan
WWTF……. Waste Water Treatment Facility