Surface Water Quality Monitoring to Support Implementation of the Plum Creek Watershed Protection Plan

FINAL REPORT
TSSWCB PROJECT #17-09

Guadalupe-Blanco River Authority

FUNDING PROVIDED THROUGH A STATE NONPOINT SOURCE GRANT FROM THE TEXAS STATE SOIL AND WATER CONSERVATION BOARD.

Introduction

Plum Creek rises in Hays County north of Kyle and runs south through Caldwell County, passing Lockhart and Luling, and eventually joins the San Marcos River at their confluence north of Gonzales County. Plum Creek is 52 miles in length and has a drainage area of 389 mi^2. According to the *2018 Texas Integrated Report for Surface Water Quality*, Plum Creek (Segment 1810) is impaired by elevated bacteria concentrations (category 4b) and exhibits nutrient enrichment concerns for, nitrate nitrogen (NO3-N) and total phosphorus (Total P).

The Texas State Soil and Water Conservation Board (TSSWCB) and Texas A&M AgriLife Extension (Extension)established the Plum Creek Watershed Partnership (PCWP) in April 2006. The PCWP Steering Committee completed the "Plum Creek Watershed Protection Plan (WPP)" in February 2008. Information about the PCWP is available at **https://www.gbra.org/plumcreek**. Sources of pollutants identified in the Plum Creek WPP include urban storm water runoff, pet waste, failing or inadequate on-site sewage facilities (septic systems), wastewater treatment facilities, livestock, wildlife, invasive species (feral hogs), and oil and gas production.

Through TSSWCB projects 03-19, *Surface Water Quality Monitoring to Support Plum Creek Watershed Protection Plan Development*, and 10-07, *Surface Water Quality Monitoring and Additional Data Collection Activities to Support the Implementation of the Plum Creek Watershed Protection Plan*, project 14-11, and project 17-58 of the same name. The Guadalupe-Blanco River Authority (GBRA) collected water quality data to fill data gaps. During these previous monitoring projects, sampling of water quality data impeded by drought conditions that persisted in the watershed through spring of 2015, causing the tributaries to run dry and the springs to slow to almost negligible flow.

Facilitated by a local watershed coordinator, implementation of the Plum Creek WPP is currently underway. TSSWCB projects provide technical and financial assistance through the local soil and water conservation districts (SWCD) to agricultural producers in developing and implementing water quality management plans (WQMPs). In order to reduce feral hog impacts on the stream, education and technical assistance is being provided by Extension to landowners in the watershed on strategies to reduce and manage feral hog populations. The cities of Kyle and Lockhart have completed projects with Clean Water Act (CWA) §319(h) funding from the Texas Commission on Environmental Quality (TCEQ), including a project to retrofit detention facilities to improve water quality, educate and stencil storm sewer inlets, map existing storm water facilities, implement a dog waste collection station program, and coordinate city "housekeeping" activities designed to improve water quality (street sweeping, creek cleanup days, etc.). Additionally, Lockhart evaluated their existing storm water system, identified and prioritized upgrades to the city's storm water management system including cleaning out and installing storm drain filters, and coordinated creek cleanup days, and household hazardous and electronic waste collection days. Stakeholders initiated an education and outreach campaign during the watershed planning process that

focused on educating watershed residents and landowners on the impacts of specific land use activities, illegal dumping, proper operation and maintenance of OSSFs and proper disposal of pet waste.

To demonstrate improvements in water quality, the Plum Creek WPP describes a water quality monitoring program designed to evaluate the effectiveness of best management practices (BMP) implemented across the watershed and their impacts on instream water quality. Water quality data will be used in the adaptive management of the WPP in order to evaluate progress in implementing the Plum Creek WPP and achieving water quality restoration.

The TSSWCB has historically funded implementation monitoring for the Plum Creek WPP through CWA Section 319 projects 03-19, 10-07, 14-11, and 17-58. The current 17-09 monitoring project described in this report is necessary to provide critical water quality data for stakeholders to judge the effectiveness of WPP implementation efforts and quantitatively measure water quality restoration. This effort will continue stakeholder engagement by providing technical assistance and sharing of water quality data by attendance at partnership meetings and maintenance of project website.

Project Overview

Throughout the 17-09 WPP implementation monitoring project, GBRA continued to collect surface water quality monitoring (SWQM) data to characterize the Plum Creek watershed, including the contributing wastewater effluents. Stakeholders will use monitoring data to assess and evaluate the effectiveness of the BMPs that have been proposed or implemented in the watershed as a part of the Plum Creek WPP. The sampling regime included diurnal, spring flow, and targeted monitoring under more elevated and typical base flow conditions over 23 months in 2018 and 2019. The monitoring regime attempted to provide a more complete and representative data set to characterize the Plum Creek watershed and document water quality improvements.

GBRA conducted much of the work under this project including technical and financial supervision, preparation of status reports, surface water quality monitoring sample collection and analysis, and data management. GBRA participated in the PCWP, Steering Committee, and Technical Advisory Group (TAG) in order to communicate project goals, activities and accomplishments to affected parties. The GBRA also worked with the Plum Creek Watershed Coordinator (WC) to assist local stakeholders with water quality concerns in the Plum Creek watershed.

GBRA collected data under an approved Quality Assurance Project Plan (QAPP) to ensure data of known and acceptable quality was generated in this project. The QAPP was consistent with *EPA Requirements for Quality Assurance Project Plans (QA/R-5)*, the *TSSWCB Environmental Data Quality Management Plan*, and TCEQ *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods, 2012 (RG-415)* and *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data, 2014(RG-416)*. GBRA revised the QAPP two times to change personnel and extend the sampling period of the project through December of 2019. Figure 1 is a map of the routine monitoring locations, identified by task. The list of sites and associated tasks is in Appendix A.

GBRA collected routine ambient water quality data monthly at three main stem stations (stations #17406, 12640 and 12647) through the Clean Rivers Program (CRP). Through this project, GBRA conducted routine ambient monitoring at an additional five sites monthly over a twenty-three-month period. Monitoring consisted of field, conventional, flow and bacteria parameter groups. The GBRA also collected supplemental bimonthly ammonia nitrogen and total kjeldahl nitrogen (TKN) at stations 17406, 12640 and 12647. This additional nutrient monitoring complemented the existing routine ambient monitoring regime

conducted by GBRA CRP, so that the same routine water quality monitoring parameters were collected monthly at eight sites in the Plum Creek watershed.

GBRA attempted to collect targeted watershed monitoring at thirty-seven sites twice per season, once under dry weather conditions and once under wet weather conditions, collecting field, conventional, flow and bacteria parameter groups. Spatial, seasonal and meteorological variations were captured in these snapshots of watershed water quality. Many of the tributary stations only held water during extreme runoff conditions, which often prevented their capture during dry weather.

GBRA conducted 24-hour Dissolved Oxygen (DO) monitoring at eight sites monthly during the index period, collecting field and flow parameter groups. These sites were the same as the sites for routine ambient monitoring. The GBRA maintains a continuous water quality monitoring probe station that collects the flow and field parameters every fifteen minutes. The sampling period extended over seven months during the index period of this project.

GBRA conducted effluent monitoring at seven wastewater treatment facilities (WWTFs) once per month collecting field, conventional, flow, bacteria and effluent parameter groups. Monitoring of the wastewater effluent was used to characterize the WWTF contributions to flow regime and pollutant loadings.

GBRA conducted spring flow monitoring at three springs over three seasons, collecting field, conventional, flow, and bacteria parameter groups. Monitoring captured spatial and seasonal variation in spring flow over the collection period. Stakeholders can use this monitoring component to characterize spring contributions to flow contributions and pollutant loadings.

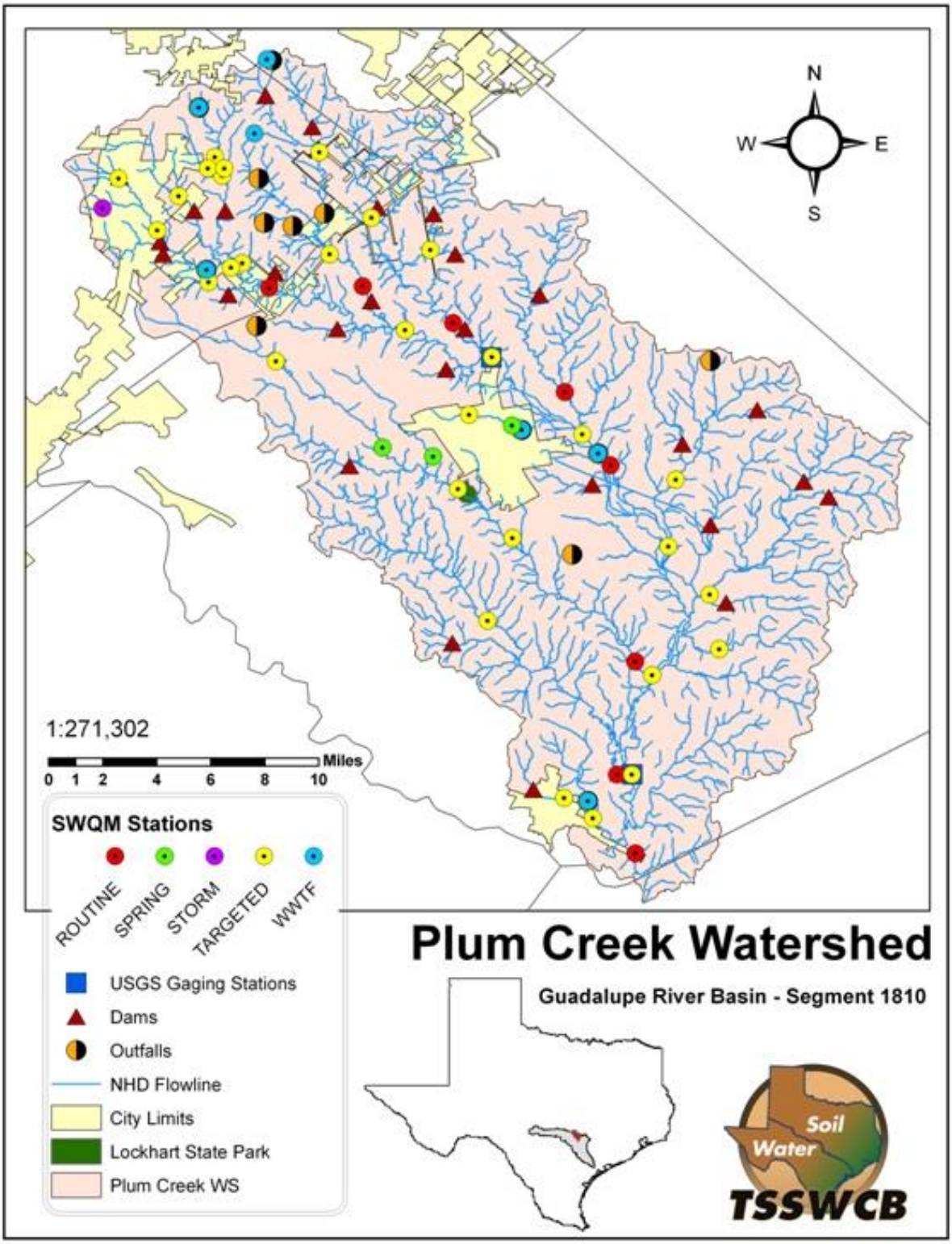

Figure 1. Map of sampling locations

Project Highlights

Outreach and education

The GBRA Education Department conducted outreach and education activities, including dissemination of information about the Plum Creek, the Partnership and related projects. Each school year, GBRA staff take a Watershed Model, highlighting Plum Creek, to local classrooms. 2,395 students from Hays Consolidated, and Lockhart Independent School Districts learned about the Plum Creek, its tributaries, and nonpoint source pollution from GBRA staff in 2018 and 2019. Students from selected classrooms had the opportunity to perform water quality analyses several times in the semester on water samples collected from the Plum Creek watershed or one of its tributaries. Some of the field parameters included dissolved oxygen, pH, and nitrate nitrogen.

Stream Clean Ups

The GBRA assisted with the Cities of Kyle and Lockhart annual stream clean-ups, including planning, sponsorship and participation in their environmental fair.

Data transmittal and information transfer

GBRA submitted monitoring data collected during this project to the TSSWCB and TCEQ for inclusion in the TCEQ Surface Water Quality Monitoring Information System (SWQMIS). GBRA submits a completed Data Summary with each data submittal. GBRA field and laboratory staff submitted corrective actions if there was a problem or deficiency encountered. Only one data set was incomplete through December of 2019 due to GBRA errors, requiring Corrective Action Report. If a problem occurred during a sampling event, every attempt was made to recollect the sample if the flow conditions remained, in order to prevent a loss in data. The GBRA laboratory serves as the primary analysis laboratory for most parameters. A secondary laboratory was included in the QAPP in order to perform the specific quality requirements of some parameters. The GBRA laboratory was unable to send samples to the secondary laboratory during December of 2019 due key personnel illness and inadequate staff training. Table 1 describes this deficiency in detail. Although this incident resulted in a data loss, it did not affect the SWQMIS database because GBRA does not submit WWTF data to TCEQ under this QAPP.

Table 1. Deficiencies resulting in a Corrective Action, Resampling, or Loss of Data.

Date	Tag No.	Site Name	Deficiency	Explanation
December 2019	No Tag Numbers established – WWTF grab data is not submitted to TCEQ SWQMIS	Kyle WWTF - Station 20486, Buda WWTF - 99923, Sunfield WWTF - Station 99937, Shadow Creek WWTF - Station 99936, Lockhart #1 WWTF - Station 20492), Lockhart #2 WWTF - 20494, Luling WWTF - 20499.	Chemical Oxygen Demand (COD) samples collected on 12-02-19 at the Plum Creek WWTFs were not shipped to Ana-lab Inc. laboratory by the GBRA laboratory within holding time.	The GBRA laboratory was shorthanded during the month of December of 2019 due to extended illness of personnel in charge of subcontracting and shipping COD samples for analysis. The GBRA laboratory performed extensive staff training following this incident in order to ensure that the subcontracting process occurs in the absence of key personnel.

A critical part of the project has been to disseminate information about Plum Creek and the project to stakeholders and other interested parties throughout the state. The GBRA summarized the results and activities of this project through inclusion in the GBRA's Clean Rivers Program *Basin Highlights Reports* and the biennial Plum Creek Watershed Protection Plan update.

The project's water quality monitoring schedule was included annually on the coordinated monitoring schedule maintained by TCEQ and stations were discussed in the annual Guadalupe river basin coordinated monitoring meeting. Following submittal to TCEQ, GBRA posted monitoring data to the project website for public access.

Highlights and Evaluation of Water Quality Monitoring Data

Quality Assurance Project Plan

GBRA collected water quality data under an approved QAPP. The objective of the quality assurance task was to develop and implement data quality objectives (DQOs) and quality assurance/control (QA/QC) activities in order to ensure data of known and acceptable quality are generated through this project. GBRA amended the QAPP as needed and recertified it annually. The QAPP received two revisions during this project. The first revision provided an annual recertification of the project, and the second revision extended the sample collection period from September of 2019 through December of 2019.

Routine Monitoring

GBRA conducted routine ambient monitoring at five sites monthly, collecting field, conventional, flow and bacteria parameter groups. Routine ambient monitoring occurred monthly at three stations by the GBRA (17406, 12640 and 12647) through the CRP and this project supplemented that effort with the collection of bimonthly Total Kjeldahl nitrogen (TKN) and ammonia nitrogen (NH3-N) data. The objective of the routine monitoring was to provide water quality data to assess the effectiveness of implementing the Plum Creek 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 the same routine water quality monitoring was conducted monthly at eight sites in the Plum Creek watershed. The 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. GBRA collected flow parameters by gage, electric, mechanical or Doppler, including severity. Bacteria parameters are *E. coli*.

For the period of February 2018 through December 2019, twenty-two routine sampling events occurred. GBRA did not collect samples under this monitoring project during the month of October 2019 due to administrative delays in extending the QAPP. All the Plum Creek main stem monitoring stations sampled under the CRP program were flowing and sampled during every month of the project. Of the five remaining routine stations, the Dry Creek at FM 672 (Site no. 20491) went dry six times (27%) This station only had water flowing or pools to sample for sixteen of the twenty-two events and GBRA has removed it from future monitoring projects. Of the other four routine plum creek tributaries Clear Fork at CR 128 (Site no. 12556), had flowing water to sample 100% of the time. The West Fork at Biggs Road (CR 131) (Site no. 20500) went dry two times (9.1%), the Elm Creek at CR 233 (Site no. 12558) went dry two times (9.1%) Brushy Creek at Rocky Road (Site no. 20488) went dry one time (4.5%). The data presented in Table 2 compiles the *E. coli* data collected from the beginning of watershed protection plan monitoring in 2008 through end of the 17-09 project in December of 2019. Concentrations of *E. coli* at all three main stem

stations remains elevated above the stream standard of 126 cfu/100 mL. All the routine tributary stations have bacteria concentrations greater than the stream standard. Exclusion of wet weather samples (runoff influenced) from the dataset, results in compliance for Brushy Creek at Rocky Road (20488), Elm Creek at CR 233 (12558) and Clear Fork at CR 128 (12556). This Dry creek at FM 672 (20491), does not fall within the stream standard with the removal of wet weather samples. This is most likely because samplers cannot collect water from this tributary during extremely dry periods of water availability in the stream.

Table 2. Concentrations of *E. coli* under dry and wet conditions at the routine monitoring sites. Measurements calculated in cfu/100ml.

Monitoring Station	*E. coli* Geomean 2008 - 2019*	Median Flow (cfs) 2008 - 2019	*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**
Plum Creek at Plum Creek Road	484	4.7	761	56	64 - >24,000	24	379	103	36 - >4,840	2.2	50.21%
Plum Creek at CR 202	319	10	654	60	36 - 35,000	54	210	99	16 - 3,600	6.3	68.01%
Plum Creek at CR 135	241	19	616	61	20 - 20,000	69	137	100	9 – 1,300	10	77.75%
Brushy Creek at Rocky Road	202	0.01	785	48	19 - >24,000	0.1	86	69	2 - 4,400	0	88.99%
Elm Creek at CR 233	150	0	645	47	5 - 40,000	0.5	50	60	<1 - 7,300	0	92.18%
Dry Creek at FM 672	551	0.2	1059	31	62 - 18,000	1.1	160	21	17 - 2,400	0	84.91%
Clear Fork at CR 128	252	2.9	629	54	41 - 22,000	6.6	144	87	3 - 3,400	1.5	77.09%
West Fork at Biggs Road	134	0.01	418	47	5 - >22,000	0.02	58	64	<1 - 3,800	0.01	86.02%

*Entire data set under all flow conditions through December of 2019.

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

Stations highlighted have a base flow geometric mean greater than the water quality standard of 126 organisms/100 mL under dry conditions.

Table 3 is a compilation of the Total Phosphorus data collected at the routine sites from 2008 through December of 2019. TCEQ uses a screening value of 0.69 mg/L to assess a concern for Total Phosphorus. All three of the Plum Creek main stem stations had a mean Total Phosphorus concentration greater than the screening criteria during dry conditions that were not influenced by rainfall runoff. The mean concentration was also higher than the screening criteria when all weather conditions were included at the main stem stations of Plum Creek at Plum Creek Road (17406), Plum Creek at CR 202 (12647), and Plum Creek at CR 135 (12640). The most downstream station Plum Creek at CR 135 (12640) was slightly above the screening criteria when all weather events were included. The Plum Creek at Plum Creek Road main stem station experienced the greatest change in concentrations between dry and wet conditions, as rainfall runoff diluted total phosphorus levels by more than 90% during high flows. All 5 routine tributary stations fell below the nutrient screening criteria during all subsets of weather conditions.

Table 3. Concentrations of total phosphorus under dry and wet conditions at the routine monitoring sites. Total phosphorus concentrations are reported in mg/L.

Monitoring Station	Total P Mean 2008 - 2019*	Median Flow (cfs) 2008 - 2019	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**
Plum Creek at Plum Creek Road	1.95	4.7	0.98	55	0.14 - 4.56	24	2.47	102	0.04 - 5.26	2.2	-151.32%
Plum Creek at CR 202	1.01	10	0.74	60	0.14 - 2.26	54	1.18	99	0.17 - 2.69	6.3	-59.34%
Plum Creek at CR 135	0.71	19	0.64	61	0.19 - 2.12	69	0.75	101	0.18 - 2.69	10	-17.29%
Brushy Creek at Rocky Road	0.12	0.01	0.14	48	0.03 - 0.37	0.04	0.1	69	0.03 - 0.37	0	25.02%
Elm Creek at CR 233	0.16	0	0.19	47	0.06 - 0.8	0.5	0.14	60	0.05 - 0.94	0	27.37%
Dry Creek at FM 672	0.29	0.2	0.31	31	0.11 - 0.69	1.1	0.26	21	0.08 - 0.47	0	17.18%
Clear Fork at CR 128	0.11	2.9	0.16	54	<0.02 - 0.9	6.6	0.07	87	<0.02 - 0.5	1.5	54.11%
West Fork at Biggs Road	0.41	0.01	0.36	48	0.07 - 0.85	0.02	0.44	64	0.06 - 2.14	0.01	-20.96%

*Entire data set under all flow conditions through December of 2019.

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

Stations highlighted have a base flow Total P mean greater than the water quality screening criteria of 0.69 mg/L under dry conditions.

Table 4 is a compilation of the nitrate nitrogen data collected from 2008 through December of 2019. TCEQ uses a screening value of 1.95 mg/L to assess a concern for Nitrate Nitrogen. The three main stem monitoring stations at Plum Creek at Plum Creek Road (17406), Plum Creek at CR 202 (12647), and Plum Creek at CR 135 (12640) had average concentrations of Nitrate Nitrogen greater than the screening criteria during dry conditions that were not influenced by rainfall runoff. The mean concentration at these stations was also higher than the screening criteria when all weather conditions were included. The most downstream station Plum Creek at CR 135 (12640) was slightly above the screening criteria when all weather events were included but experienced the least amount of change between wet and dry conditions. All 5 routine tributary stations fell below the nutrient screening criteria during all subsets of weather conditions.

Table 4. Concentrations of nitrate nitrogen under dry and wet conditions at the routine monitoring sites. Nitrate nitrogen concentrations are reported in mg/L.

Monitoring Station	NO3-N Mean 2008 - 2019*	Median Flow (cfs) 2008 - 2019	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**
Plum Creek at Plum Creek Road	9.71	4.7	4.87	55	0.37 - 29.3	24	12.31	102	0.6 - 34.8	2.2	-152.68%
Plum Creek at CR 202	5.35	10	3.42	60	0.22 - 14.6	54	6.51	99	0.58 - 16.3	6.3	-90.09%
Plum Creek at CR 135	2.36	19	2.31	61	0.07 - 9.48	69	2.40	101	<0.05 - 7.32	10	-3.69%
Brushy Creek at Rocky Road	0.30	0.01	0.44	47	<0.05 - 5.47	0.04	0.20	63	<0.05 –3.02	0	54.60%
Elm Creek at CR 233	0.23	0	0.38	47	<0.05 - 4.02	0.5	0.11	60	<0.05 - 0.48	0	71.89%
Dry Creek at FM 672	0.37	0.2	0.49	30	<0.05 - 3.78	1.1	0.16	21	<0.05 - 0.80	0	67.52%
Clear Fork at CR 128	1.51	2.9	1.57	54	<0.05 - 7.54	6.6	1.47	87	<0.05 –8.28	1.5	6.83%
West Fork at Biggs Road	0.27	0.01	0.26	47	<0.05 –1.36	0.02	0.28	63	<0.05 - 1.36	0.01	-5.66%

*Entire data set under all flow conditions through December of 2019.

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

Stations highlighted have a base flow Nitrate concentration greater than the water quality screening criteria of 1.95 mg/L under dry conditions.

Table 5 is a compilation of the ammonia-nitrogen data collected from 2008 to December of 2019. The TCEQ uses nutrient screening criteria of 0.33 mg/L. The only station that has an average ammonia nitrogen concentration above the screening criteria is Plum Creek at Plum Creek Road (17406). The average ammonia concentrations at this station are above the screening criteria during all subsets of weather conditions. This station is most impacted by wastewater influences because it is downstream of the discharges of two municipalities and receives very little influence from spring flow. All 7 other routine monitoring stations have average concentrations below the screening criteria during all weather conditions.

Table 5. Concentrations of ammonia-nitrogen under dry and wet conditions at the routine monitoring sites. Ammonia-nitrogen concentrations are reported in mg/L.

Monitoring Station	NH3-N Mean 2008 - 2019*	Median Flow (cfs) 2008 - 2019	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**
Plum Creek at Plum Creek Road	0.92	4.7	0.72	54	<0.1 - 21.2	24	1.02	101	<0.1 - 9.68	2.2	-41.69%
Plum Creek at CR 202	0.18	10	0.15	59	<0.1 - 0.71	54	0.20	94	<0.1 – 1.67	6.3	-32.41%
Plum Creek at CR 135	0.17	19	0.17	60	<0.1 - 0.66	69	0.17	97	<0.1 - 0.81	10	0.00%
Brushy Creek at Rocky Road	0.19	0.01	0.16	47	<0.1 - 0.37	0.04	0.21	69	<0.1 - 1.38	0	-35.49%
Elm Creek at CR 233	0.19	0	0.18	46	<0.1 - 1.04	0.5	0.20	60	<0.1 - 1.24	0	-11.52%
Dry Creek at FM 672	0.21	0.2	0.20	30	<0.1 - 0.76	1.1	0.24	20	<0.1 - 0.71	0	-23.69%
Clear Fork at CR 128	0.16	2.9	0.15	54	<0.1 - 0.36	6.6	0.17	73	<0.1 - 0.65	1.5	-14.83%
West Fork at Biggs Road	0.18	0.01	0.18	48	<0.1 - 1.91	0.02	0.18	64	<0.1 - 0.98	0.01	-4.96%

*Entire data set under all flow conditions through December of 2019.

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

Stations highlighted have a base flow ammonia-nitrogen mean of greater than the water quality screening criteria of 0.33 mg/L under dry conditions.

Statistical Analysis for Trends at Routine Sites

GBRA conducted regression analysis and multiple two tailed t-tests with an alpha of p=0.05 to determine the statistical significance of the correlations between concentrations for tested pollutants versus time and stream flow at the eight Plum Creek routine monitoring stations. 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 tested by the hypothesis. The routine testing parameters were ammonia-nitrogen, nitrate nitrogen, total phosphorus, total kjeldahl nitrogen (TKN), total dissolved solids (TDS), chlorides, sulfates, total suspended solids (TSS), chlorophyll *a*, dissolved oxygen, pH, temperature and *E. coli*. GBRA transformed the stream flow and *E. coli* parameters with base ten logarithms prior to analysis for correlations in order to control for outliers. A significant increasing trend in the concentrations of E. *coli* was present in the middle portion of the watershed between Lockhart and Luling, but significant changes in the concentrations of nutrients and other pollutants occurred at all locations.

At the Plum Creek at County Road 135 station (12640), a statistically significant correlation occurred between time and several water quality parameters. Nitrate nitrogen; r^2=0.16, t(163)=5.56, p=0.00, is increasing with time (Figure 2). Changes in stream flow do not significantly correlate with the increase in nitrate nitrogen at this station, which could be the result of increased wastewater treatment efficiency converting ammonia nitrogen into nitrate nitrogen. Total phosphorus; r^2=0.12, t(163)=-4.59, p=0.00, is decreasing with time at this station (Figure 3). Total phosphorus also shows a negative correlation with stream flow r^2=0.18, t(163)=-5.92, p=0.00. The decreasing phosphorus numbers are most likely a result of dilution of effluent water from spring flow and rainfall, as the watershed recovers from previous drought conditions. The chlorophyll *a* concentration; r^2=0.04, t(141)=2.44, p=0.02, is also increasing over time at this station (Figure 4). Chlorophyll *a* is a green pigment associated with plants and algae that serves as an indicator of nutrients available for biological organisms that are present in the water column. The increase in Chlorophyll *a* at this station is likely due to the increasing nitrate nitrogen concentrations available for algae growth. The Total dissolved solids (TDS); r^2=0.07, t(162)=-3.43, p=0.00 are also significantly decreasing over time at this station (Figure 5). TDS is a measurement of all of the salts and metals and minerals that are dissolved in the water and significantly decreases as stream flow rises; r^2=0.73, t(162)=-21.02, p=0.00. Additionally, the salt anion chloride, which contributes to TDS, also showed decreases over time; r^2=0.09, t(141)=-3.71, p=0.00, (Figures 6). Chloride anions also significantly decrease as stream flow increases; r^2=0.57, t(141)=-13.55, p=0.00. The overall decrease in total dissolved solids and strong negative correlation with stream flow is most likely explained by an overall increase in stream flow over time; r^2=0.14, t(163)=5.13, p=0.00, which is diluting the concentrations of these pollutants.

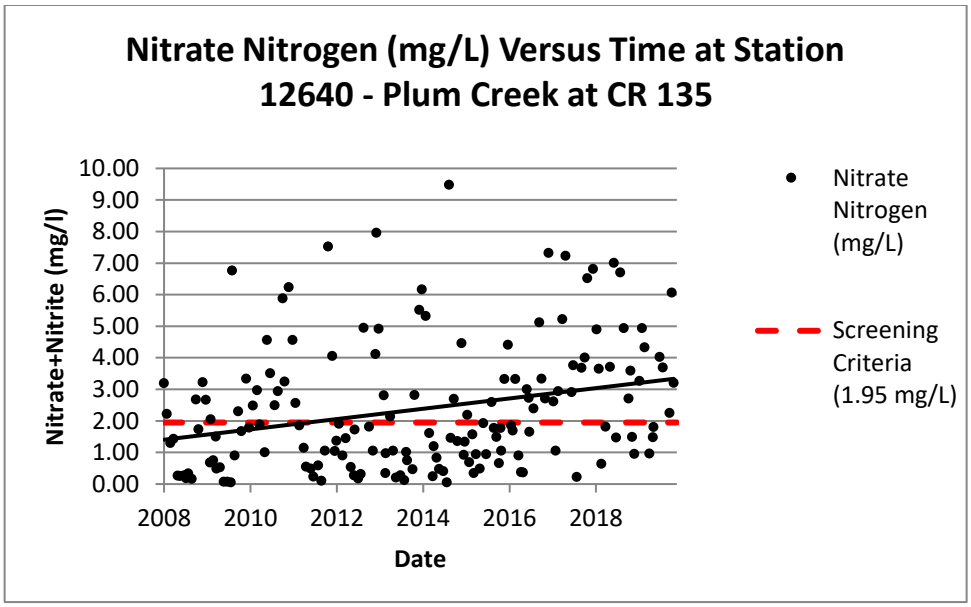

Figure 2. Nitrate nitrogen versus time at station 12640 – Plum Creek at CR 135. The red line is the screening concentration (1.95 mg/L) for concerns set by TCEQ. The black line is the trend line.

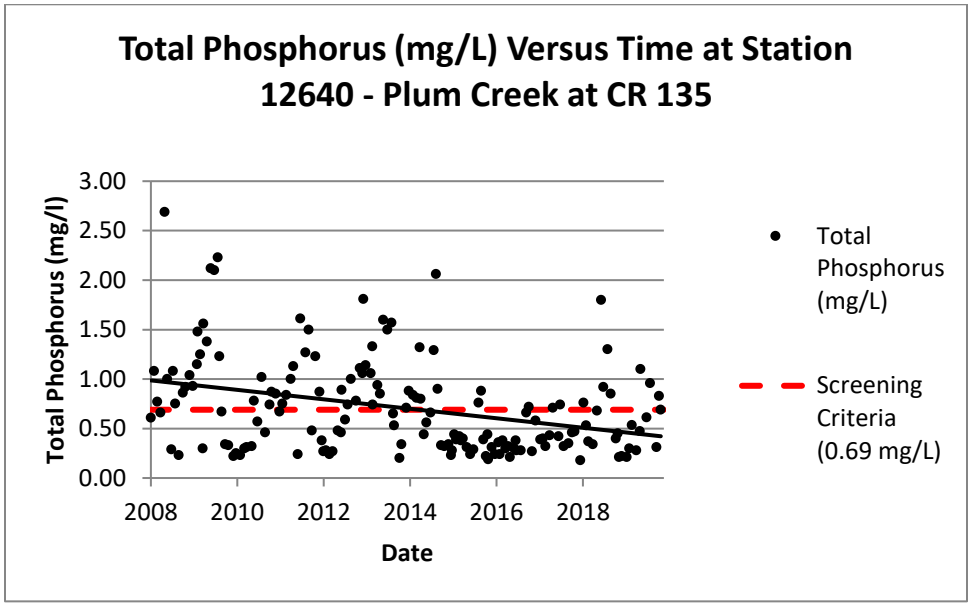

Figure 3. Total phosphorus versus time at station 12640 – Plum Creek at CR 135. The red line is the screening concentration (0.69 mg/L) for concerns set by TCEQ. The black line is the trend line.

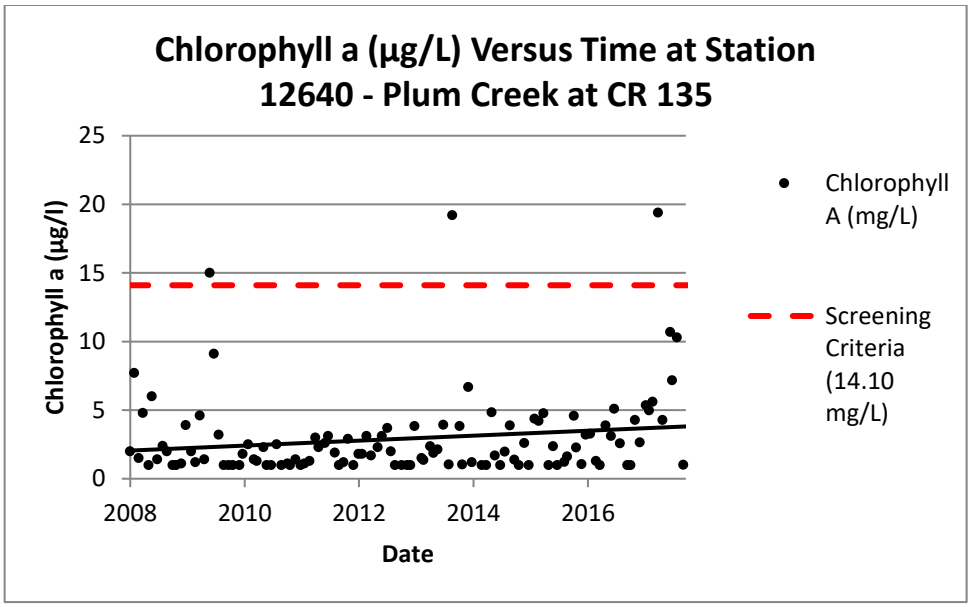

Figure 4. Chlorophyll *a* versus time at station 12640 – Plum Creek at CR 135. The red line is the screening concentration (14.1 µg/L) for concerns set by TCEQ. The black line is the trend line.

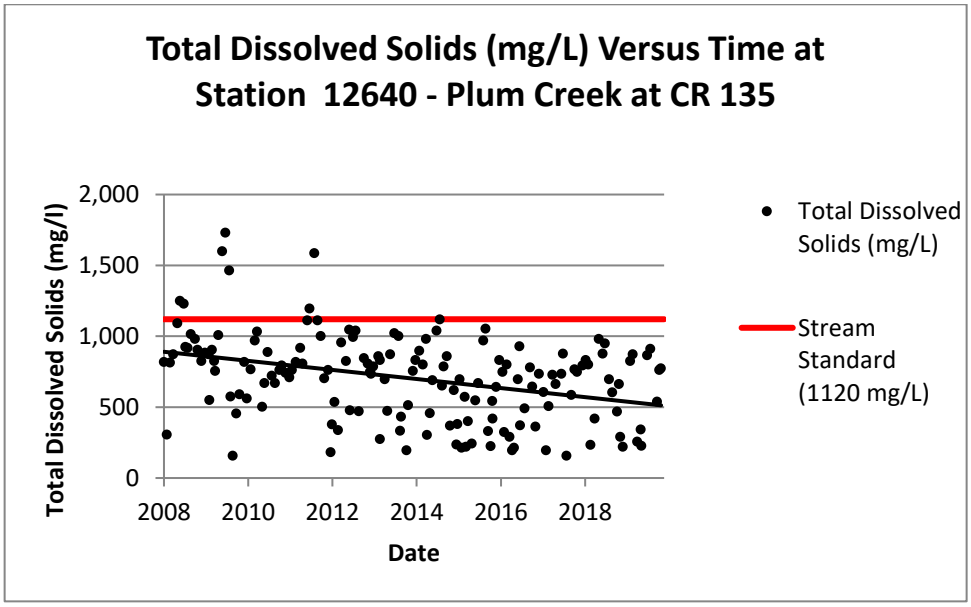

Figure 5. Total dissolved solids (TDS) versus time at station 12640 – Plum Creek at CR 135. The red line is the screening concentration (1120 mg/L) for concerns set by TCEQ. The black line is the trend line.

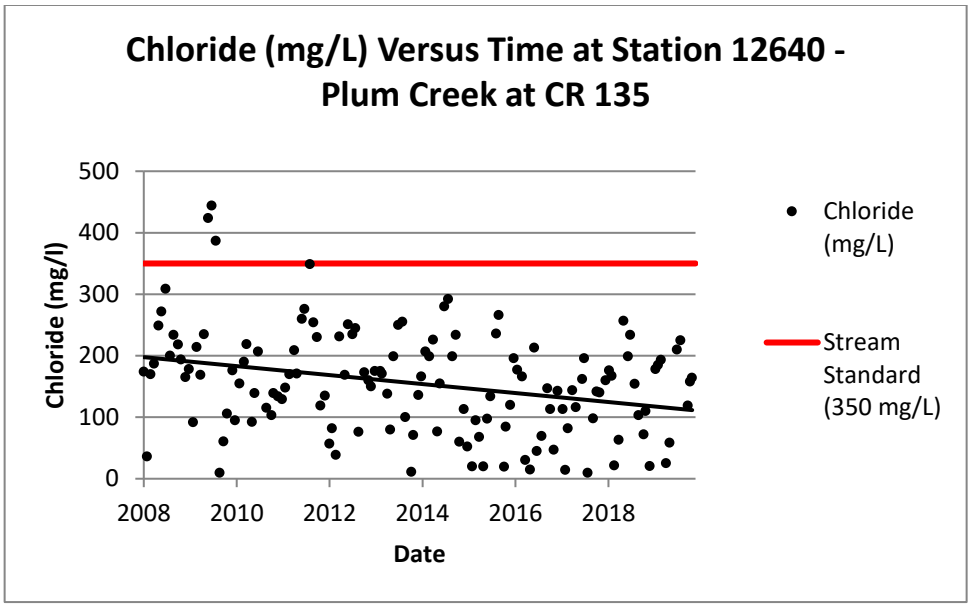

Figure 6. Chloride versus time at station 12640 – Plum Creek at CR 135. The red line is the screening concentration (350 mg/L) for concerns set by TCEQ. The black line is the trend line.

The Plum Creek at County Road 202 station (12647) is located ~20 miles upstream of the CR 135 station (12640). The only major WWTF discharge that occurs between these two stations comes from the City of Luling, and the West Fork and Clear Fork tributaries of Plum Creek contribute additional stream flow between these two stations. Water quality parameters at this station showed statistically significant correlations with time that were very similar to the CR 135 station downstream. Nitrate nitrogen; r^2=0.10, t(160)=4.19,p=0.00, is significantly increasing with time (Figure 7), total phosphorus; r^2=0.11, t(160)=-4.43, p=0.00,is significantly decreasing with time (Figure 8) and chlorophyll *a* is increasing with time (Figure 9); r^2=0.05, t(138)=2.67, p=0.01. The *E. coli* concentrations at this station are significantly increasing over time (Figure 10); r^2=0.03, t(160)=2.04, p=0.04 and do not show a statistically significant correlation with streamflow.

The nitrate nitrogen; r^2=0.29, t(160)=-8.00, p=0.00, and total phosphorus; r^2=0.44, t(160)=-11.17 p=0.00, showed a statistically significant negative correlation with stream flow. The relationship between stream flow and these nutrients does not fully explain the changes in these parameters over time. Nitrate nitrogen, and Total Phosphorus are common wastewater byproducts from point source discharges that may increase in stream concentrations as stream flows from ambient sources disappear, but the nitrate nitrogen is increasing over time, while the total phosphorus is decreasing. Nitrate Nitrogen levels are increasing over time despite the effect from stream flow conditions, which may be a result of increased influence from wastewater discharges. Chlorophyll *a*; r^2=0.18, t(138)=5.45, p=0.00, and *E. coli* t(160)=3.43, p=0.00, were both positively correlated with streamflow. Chlorophyll *a* is green color pigment that occurs in the cells of photosynthetic organisms. Increased chlorophyll *a* is usually an indicator of algae growth and associated nutrient use in the water column. The rise in chlorophyll *a* and *E. coli* bacteria with increased flows at this station indicates that these parameters may be the result of nonpoint source pollution during runoff events and the increase in these parameters over time is likely due to an overall increase in stream flow over time; r^2=0.13, t(160)=4.82, p=0.00.

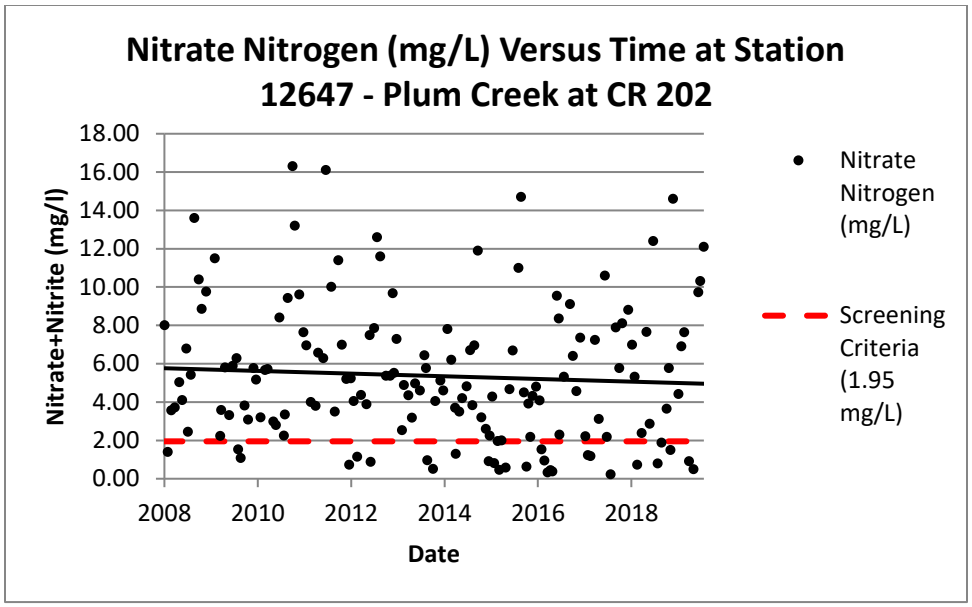

Figure 7. Nitrate nitrogen versus time at station 12647 - Plum Creek at CR 202. The red line is the screening concentration (1.95 mg/L) for concerns set by TCEQ. The black line is the trend line.

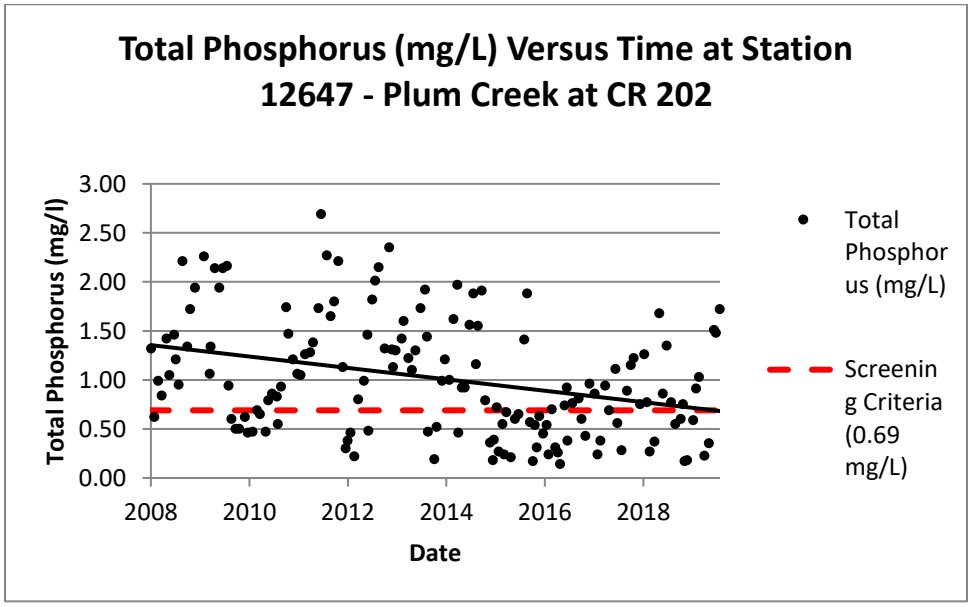

Figure 8. Total phosphorus versus time at station 12647 - Plum Creek at CR 202. The red line is the screening concentration (0.69 mg/L) for concerns set by TCEQ. The black line is the trend line.

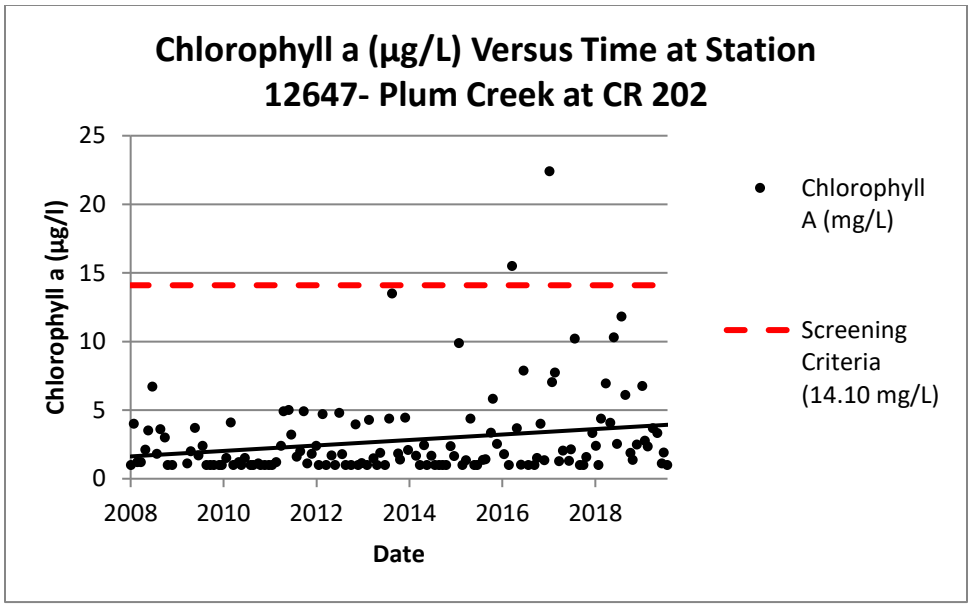

Figure 9. Chlorophyll *a* versus time at station 12647 - Plum Creek at CR 202. The red line is the screening concentration (14.1 µg/L) for concerns set by TCEQ. The black line is the trend line.

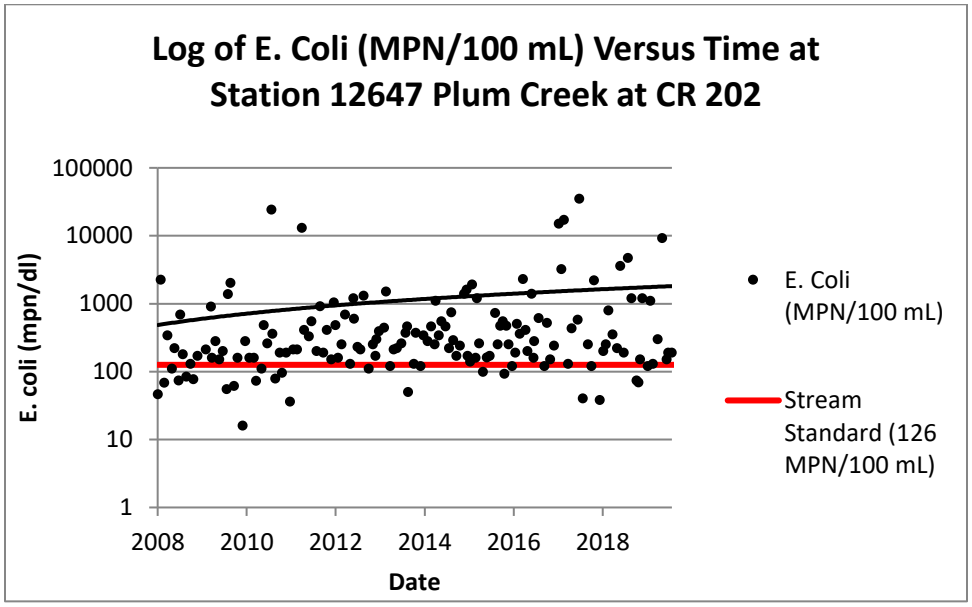

Figure 10. *E. coli* versus time at station 12647 - Plum Creek at CR 202. The red line is the contact recreation geometric mean (126 MPN/100 mL) designated use criteria set by TCEQ. The black line is the trend line.

Station 17406 (Plum Creek at Plum Creek Road) is located ~16 miles upstream of the CR 202 (12647) routine monitoring station. This station is located outside of the influence of most spring flows and downstream of two major municipal wastewater discharges. GBRA found statistically significant correlations between time and several water quality parameters at this station. Ammonia nitrogen (Figure 11); r^2=0.07, t(157)=3.38, p=0.00, and Total kjehldahl nitrogen (Figure 12); r^2=0.06, t(134)=2.88, p=0.00, are increasing with time. Total phosphorus; r^2=0.12, t(161)=-4.77, p=0.00, is decreasing with time (Figure 15). This station is located downstream of the point source discharges from the City of Buda and the City of Kyle. A wastewater treatment plant collects ammonia nitrogen and organically bound nitrogen from the incoming raw wastewater and converts it to nitrate nitrogen through nitrification. Total kjeldahl nitrogen is a measure of the combined ammonia nitrogen and organically bound nitrogen. The increase in ammonia nitrogen and TKN over time may be an indication of decreased efficiency in the WWTF nitrification process of upstream dischargers in this portion of the watershed. Several large outliers for these parameters corresponded with high concentrations of these parameters in the effluent collected at the wastewater treatment operations from the City of Kyle WWTF in July of 2013, August of 2017 and September of 2019.

The monitoring station near Uhland, in the upper portion of the watershed, is particularly susceptible to rainfall runoff. There is very little natural spring flow upstream of this area, although it does receive perennial effluent discharges from several major WWTF outfalls. GBRA found no correlation with stream flow for ammonia nitrogen and TKN. The total phosphorus at this station; t(161)=-17.47, p=0.00 showed a statistically significant negative correlation with stream flow. The increasing flow at this this station over time; r^2=0.66, r^2=0.16, t(162)=5.47, p=0.00, is likely responsible for the observed decrease in concentrations of this parameter.

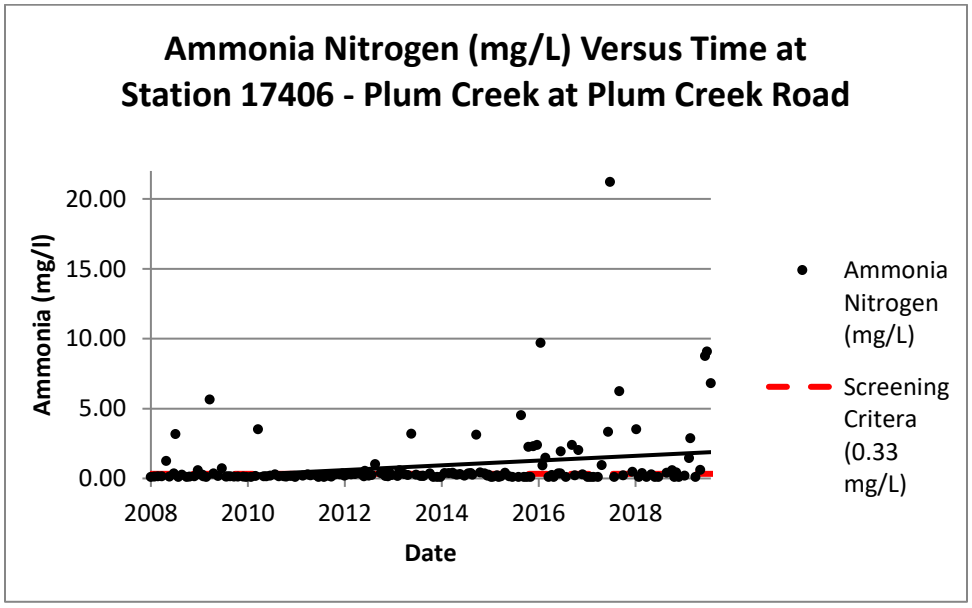

Figure 11. Ammonia nitrogen versus time at station 17406 - Plum Creek at Plum Creek Road. The red line is the screening concentration (0.33 mg/L) for concerns set by TCEQ. The black line is the trend line.

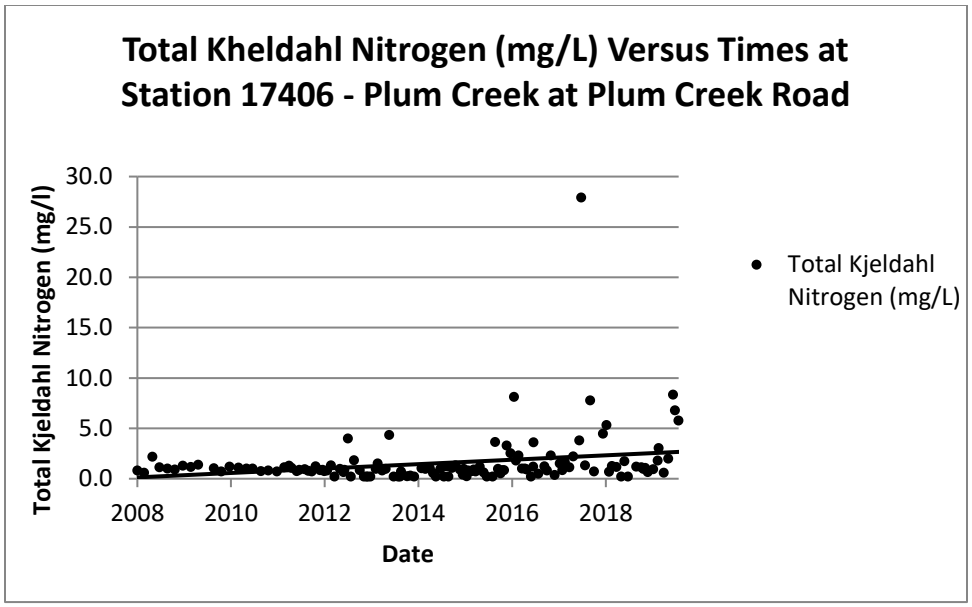

Figure 12. Total kjeldahl nitrogen (TKN) versus time at station 17406 - Plum Creek at Plum Creek Road. TCEQ has not set a screening criterion for concerns. The black line is the trend line.

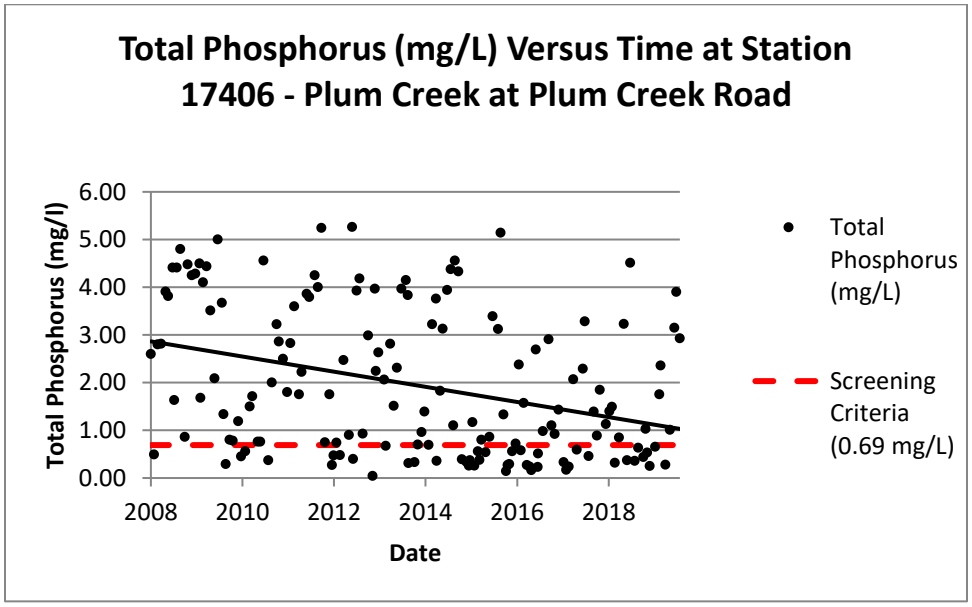

Figure 13. Total phosphorus versus time at station 17406-Plum Creek at Plum Creek Road. The red line is the screening concentration (0.69 mg/L) for concerns set by TCEQ. The black line is the trend line.

At station 12556 (Clear Fork at County Road 128), a statistically significant correlation was found between time and several water quality parameters. Nitrate nitrogen; r^2=0.42, t(144)=10.14, p=0.00, is increasing and *E. coli* ; r^2=0.07, t(144)=3.22, p=0.00, are increasing over time (Figures 14 & 15), while ammonia nitrogen; r^2=0.05, t(144)=-2.83, p=0.00, and TKN; r^2=0.08, t(108)=-3.14, p=0.00, are both decreasing with time (Figures 16 & 17). This station is located on a large tributary of Plum Creek that receives most of its flow from natural spring discharges, and nonpoint source runoff. The Clear Fork

Springs that discharge into this tributary have high nitrate nitrogen concentrations and low total phosphorus and ammonia nitrogen concentrations. The increase in nitrate nitrogen and decrease in ammonia nitrogen and TKN is likely the result of increased spring flows following previous drought conditions. TKN; r^2=0.15, t(104)=3.38, p=0.00, and *E. coli* ; r^2=0.06, t(140)=3.15, p=0.00, also showed statistically significant correlations with stream flow at this station. The reduction in TKN and increase in *E. coli* is likely a response to the overall increase in stream flow at this station over time; r^2=0.12, t(129)=4.21, p=0.00. Dilution of TKN occurs with additional inputs of water into the stream, but this nonpoint source runoff also carries *E. coli* from the surrounding landscape.

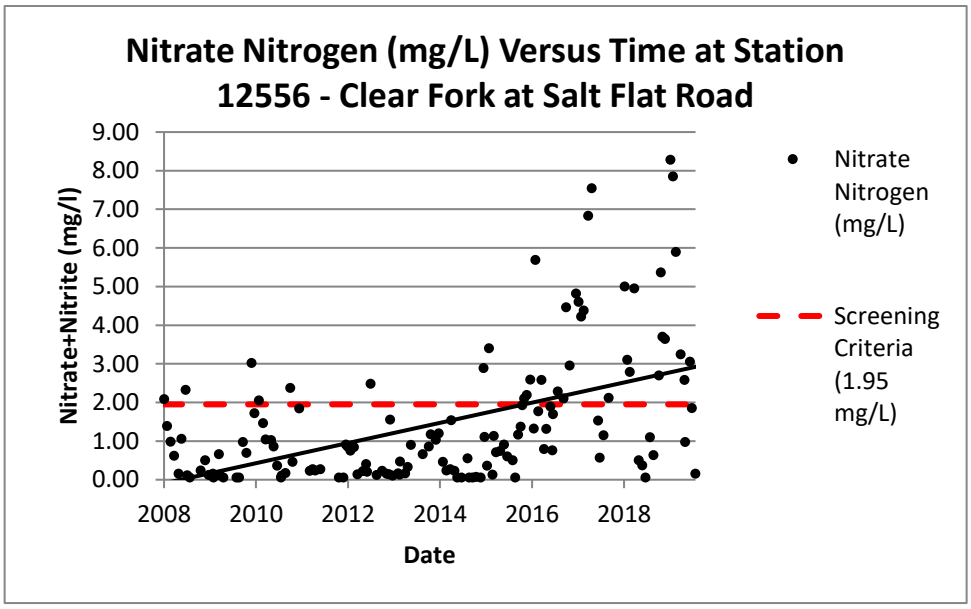

Figure 14. Nitrate nitrogen versus time at station 12556 – Clear Fork at Salt Flat Road. The red line is the screening concentration (1.95 mg/L) for concerns set by TCEQ. The black line is the trend line.

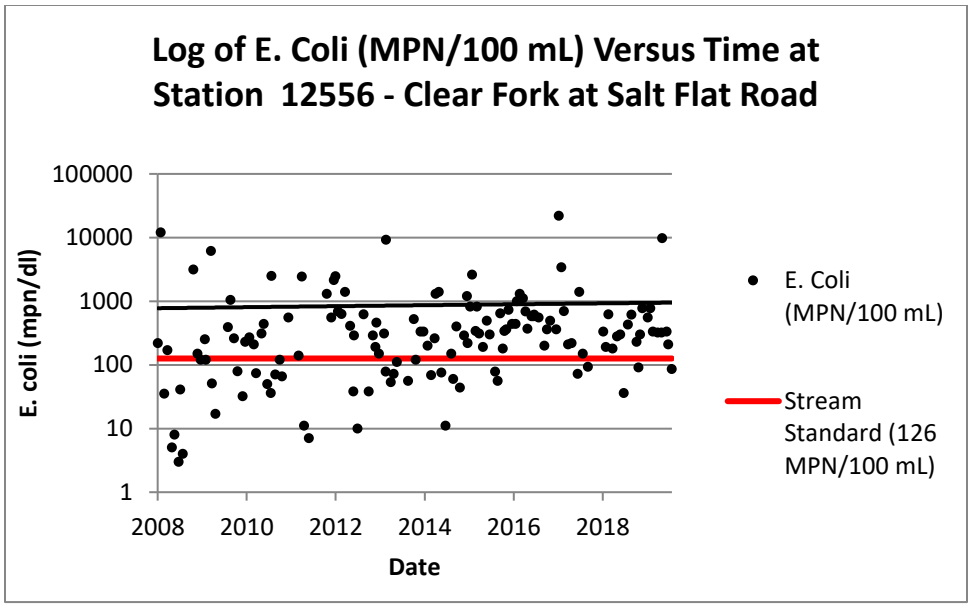

Figure 15. *E. coli* versus time at station 12556 – Clear Fork at Salt Flat Road. The red line is the contact recreation geometric mean (126 MPN/100 mL) designated use criteria set by TCEQ. The black line is the trend line.

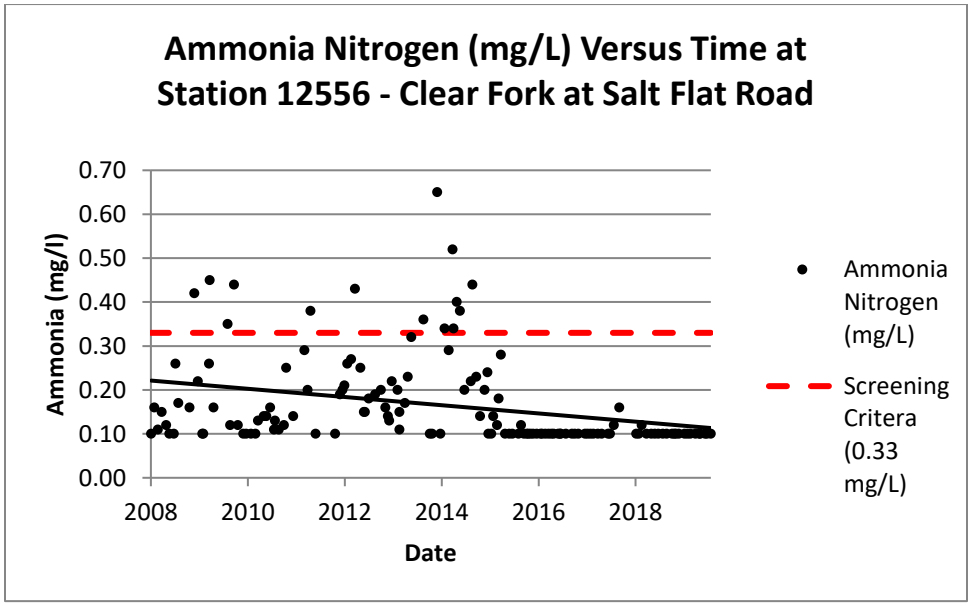

Figure 16. Ammonia nitrogen versus time at station 12556 – Clear Fork at Salt Flat Road. The red line is the screening concentration (0.33 mg/L) for concerns set by TCEQ. The black line is the trend line.

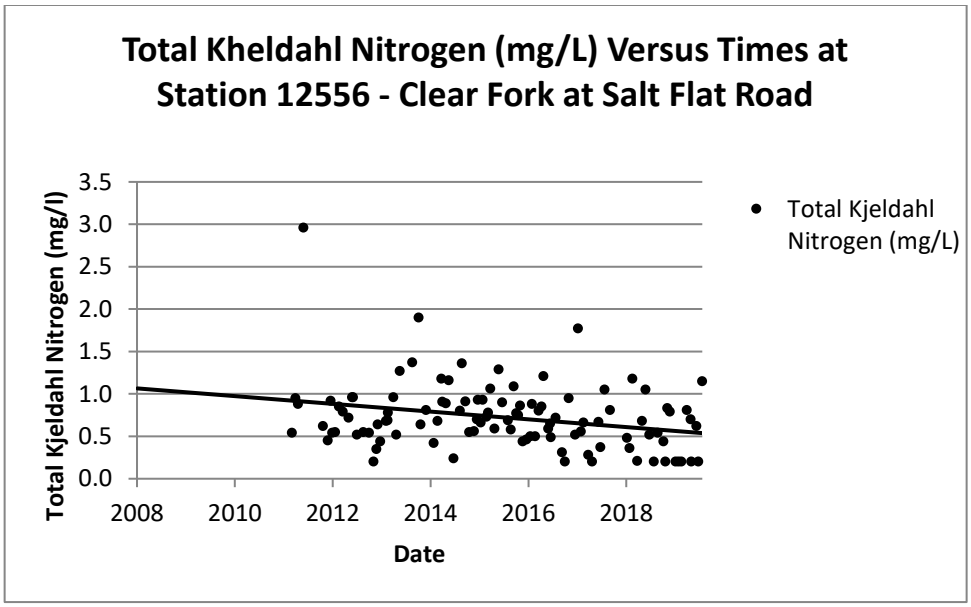

Figure 17. Total kjeldahl nitrogen (TKN) versus time at station 12556 – Clear Fork at Salt Flat Road. TCEQ has not set a screening criterion for concerns. The black line is the trend line.

At station 20500 (West Fork of Plum Creek at County Road 131), statistically significant correlations were found between nitrate nitrogen; r^2=0.04, t(110)=2.06, p=0.04, ammonia nitrogen ; r^2=0.04, t(112)=-2.21, p=0.03, and TKN; r^2=0.09, t(79)=-2.77, p=0.01, with time (Figures 18, 19 & 20). This tributary follows the same pattern as the clear fork with overall increases in nitrate nitrogen and decreases in ammonia nitrogen and TKN. Station 20500 is located on a large tributary of Plum Creek that is highly influenced by nonpoint source runoff. Heavy agricultural land use is also present in this sub-watershed, where nitrogen is applied to the surrounding fields.

The nitrate nitrogen; r^2=0.27, t(150)=7.43, p=0.00, and ammonia nitrogen; r^2=0.05, t(151)=2.94, p=0.00, showed a statistically significant correlation with stream flow. The West Fork frequently goes dry, and the majority of the samples have been collected during times of little or no stream flow. The stream flow at this station is not significantly changing with time. The correlation between nutrients and flow is consistent with nonpoint sources. Rainfall washes oxidized nitrogen from the surrounding agricultural fields into the stream as nitrate nitrogen.

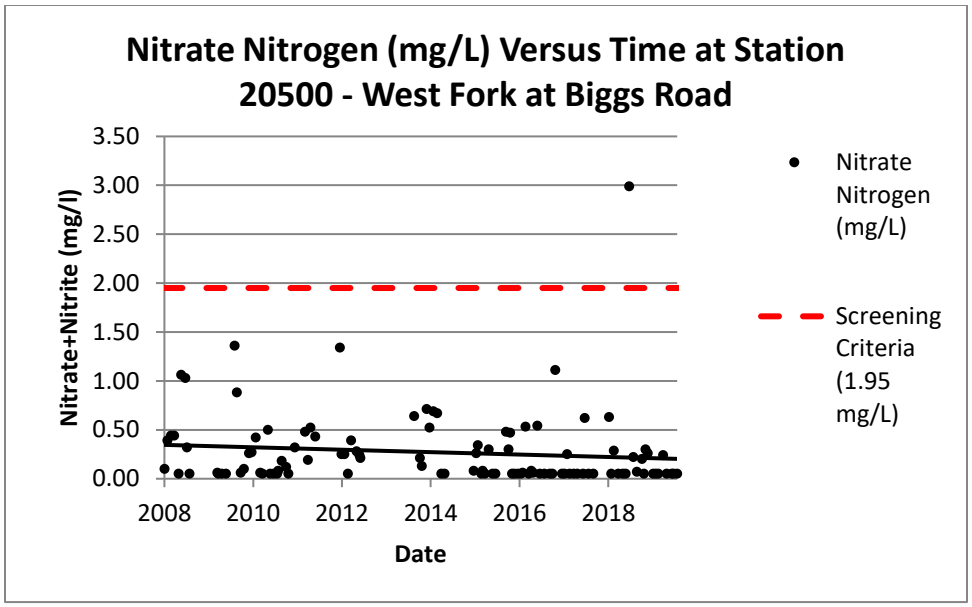

Figure 18. Nitrate nitrogen versus Time at Station 20500 – West Fork at Biggs Road. The red line is the screening concentration (1.95 mg/L) for concerns set by TCEQ. The black line is the trend line.

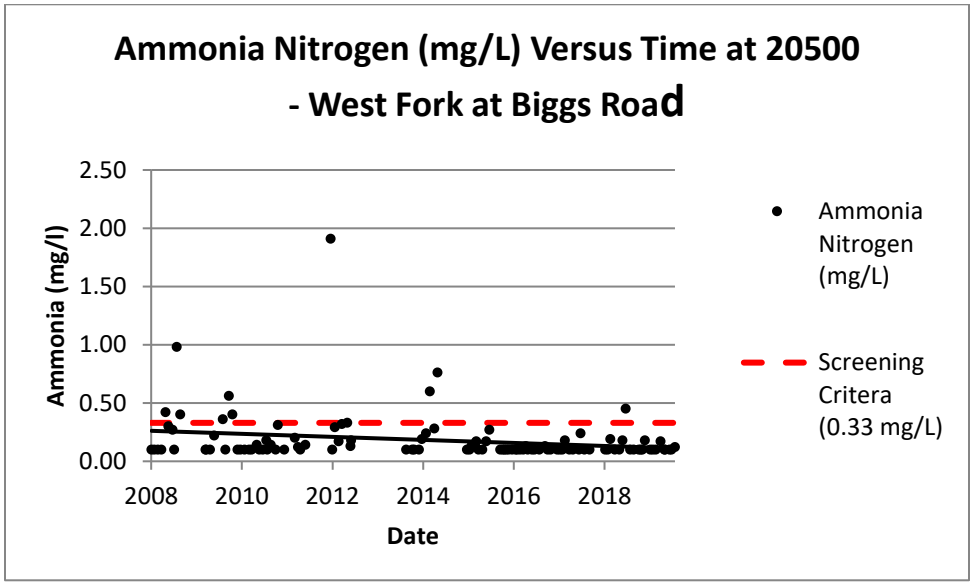

Figure 19. Ammonia nitrogen versus time at station 20500 – West Fork at Biggs Road. The red line is the screening concentration (0.33 mg/L) for concerns set by TCEQ. The black line is the trend line.

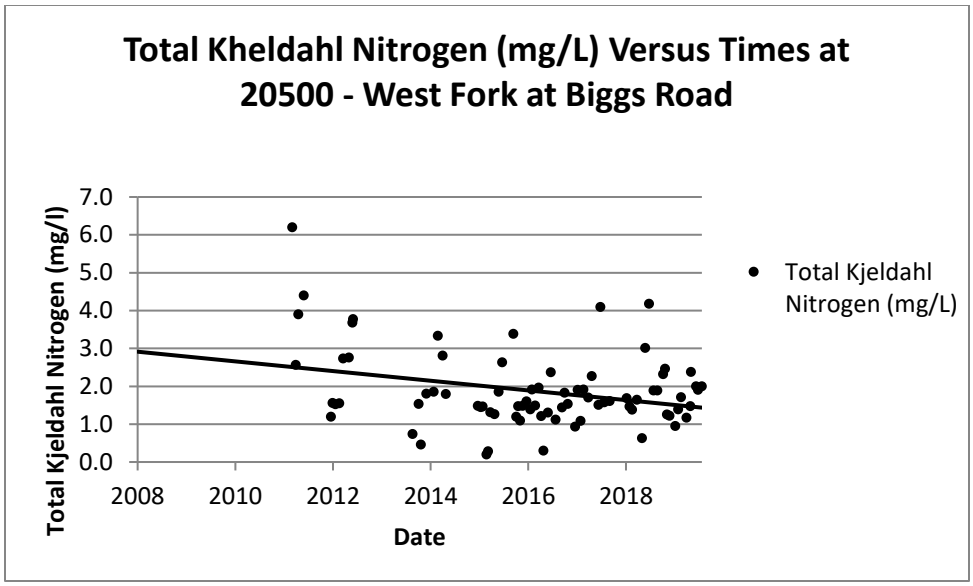

Figure 20. Total Kjeldahl nitrogen (TKN) versus time at station 20500 – West Fork at Biggs Road. TCEQ has not set a screening criterion for concerns. The black line is the trend line.

At station 20488 (Brushy Creek at Rocky Road) statistically significant correlations were found for two water quality parameters with time. Nitrate nitrogen is increasing with time; r^2=0.05, t(119)=2.60, p=0.01, while TKN is decreasing with time; r^2=0.06, t(95)=-2.36, p=0.02 (Figures 21 & 22). This station is located on a large tributary of Plum Creek with high agricultural production and heavy influence from nonpoint source runoff. This station is also the receiving stream for several treated wastewater discharges; however, the stream is heavily influenced by several on channel National Resource Conservation Service (NRCS) flood control structures. This location is often stagnant with no measurable stream flow, which may have limited the variability of the water quality parameters at this station. No parameters showed a statistically significant correlation with stream flow.

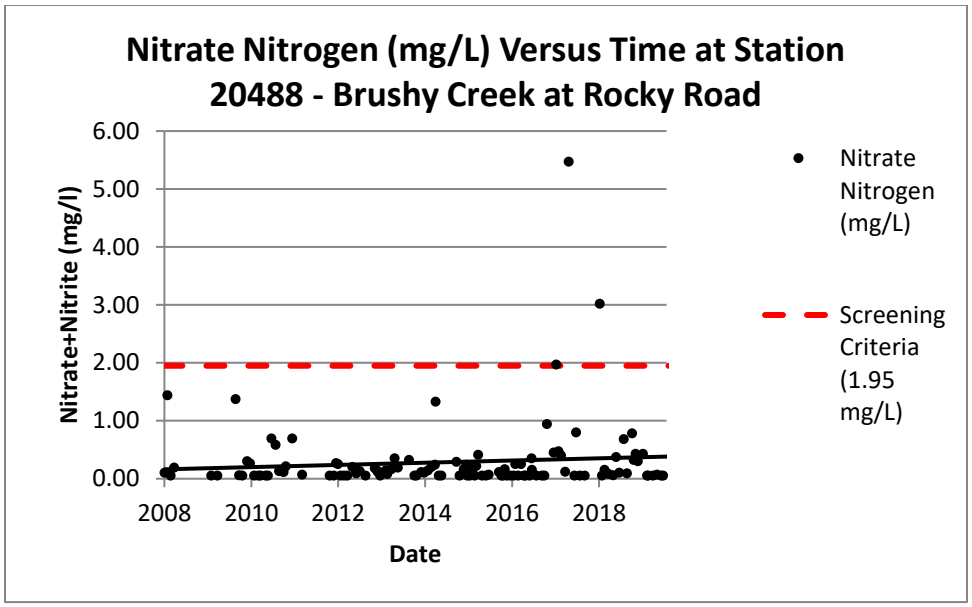

Figure 21. Nitrate nitrogen versus Time at Station 20488 – Brushy Creek at Rocky Road. The red line is the screening concentration (1.95 mg/L) for concerns set by TCEQ. The black line is the trend line.

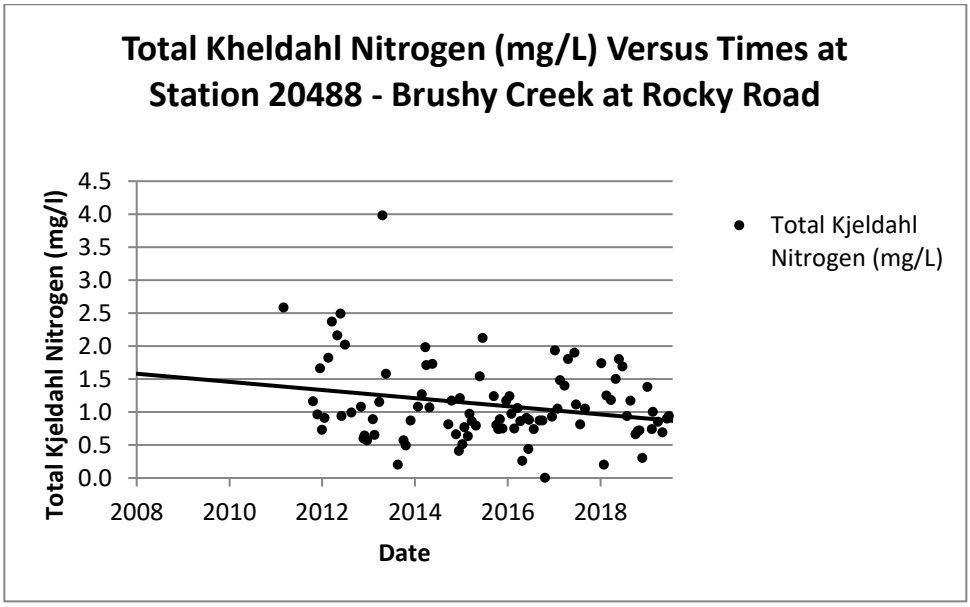

Figure 22. Total Kjeldahl nitrogen (TKN) versus time at station 20488 – Brushy Creek at Rocky Road. TCEQ has not set a screening criterion for concerns. The black line is the trend line.

At station 12558 (Elm Creek at County Road 233); statistically significant correlations were found between total suspended solids (TSS); r^2=0.08, t(95)=3.11, p=0.00, and ammonia nitrogen; r^2=0.16, t(95)=-4.44, p=0.00 versus time. TSS is significantly increasing over time (Figure 23) and ammonia is significantly decreasing (Figure 24). This station is located on a large intermittent tributary of Plum Creek that has high agricultural production and influence from nonpoint source runoff. This station was frequently dry during routine sampling events and many of the samples collected occurred during conditions when stream flow was either absent or very low. Flows were generally only present following significant rainfall runoff events. Water was available to sample at this station during approximately 70% of the monthly sampling events. The volatility of stream flows and intermittent data collections likely explain the lack of many significant correlations in this tributary of Plum Creek.

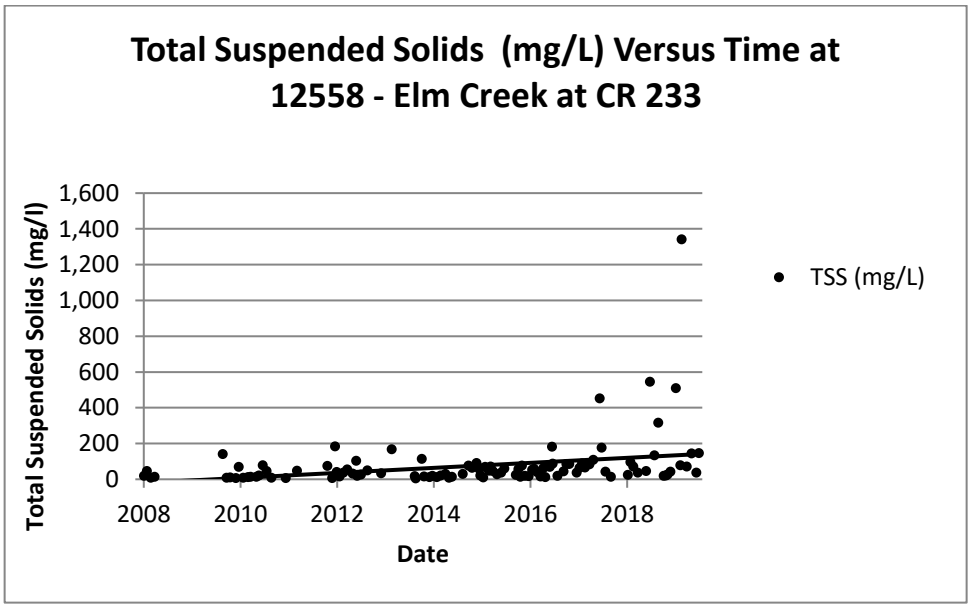

Figure 23. Total Suspended Solids versus Time at Station 12558 – Elm Creek at CR 233. TCEQ has not set a screening criterion for TSS. The black line is the trend line.

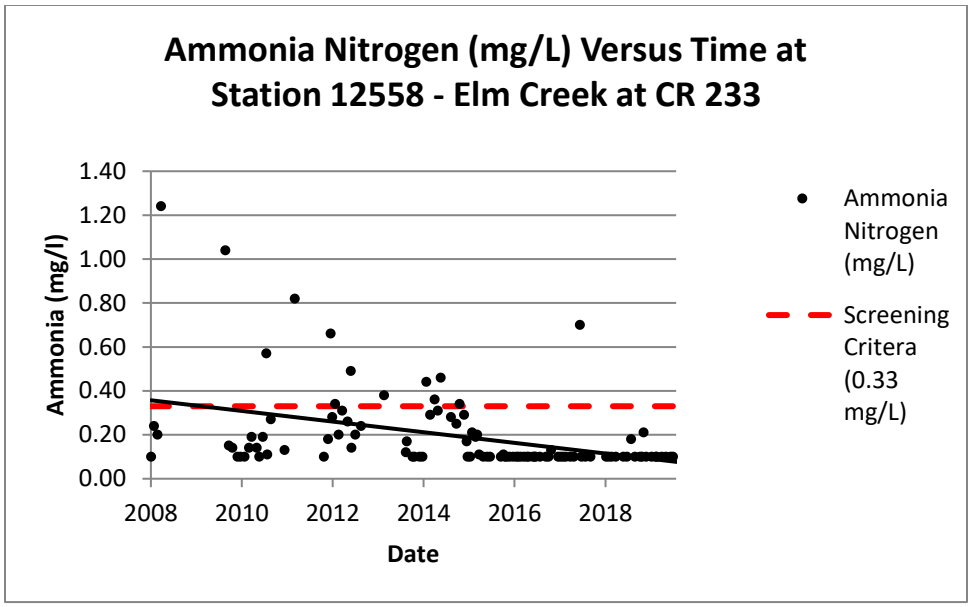

Figure 24. Ammonia nitrogen versus time at station 12558 – Elm Creek at CR 233. . The red line is the screening concentration (0.33 mg/L) for concerns set by TCEQ. The black line is the trend line.

At station 20491 (Dry Creek at FM 672) statistically significant correlations were found between several parameters and time. Ammonia nitrogen; r^2=0.08, t(54)=-2.11, p=0.04, is significantly decreasing over time (Figure 25). TDS ; r^2=0.08, t(54)=2.21, p=0.03, is significantly increasing over time (Figure 26). The chloride; r^2=0.13, t(51)=2.67, p=0.01, and sulfate anions; r^2=0.14, t(51)=2.81, p=0.01, that contribute to TDS are also increasing with time (Figures 27 & 28). No significant changes in stream flow over time were occurring at this station. The Dry Creek is a large intermittent tributary of Plum Creek, which routinely goes dry for extended periods. GBRA has collected Fifty-five samples at this site since 2008, and approximately 60% have been collected following large rainfall runoff events. Water was only available to sample at this station during 35% of the monthly site visits. The limited sample size and small flow variability during collection events likely contributed to the lack of statistically significant correlations at this station. The GBRA has proposed the removal of this station in future monitoring projects due to limited water availability.

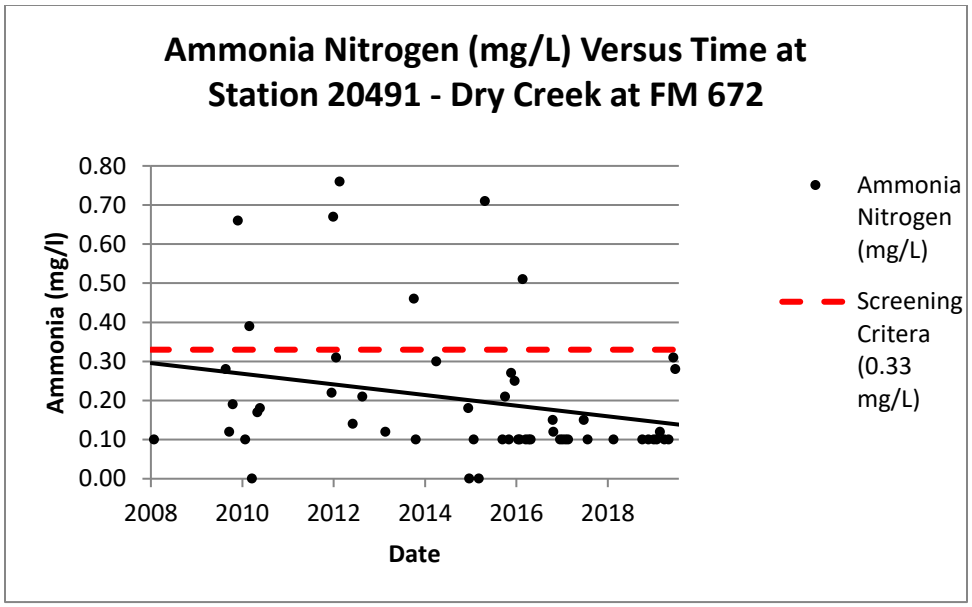

Figure 25. Ammonia nitrogen versus time at station 20491 – Dry Creek at FM 672. . The red line is the screening concentration (0.33 mg/L) for concerns set by TCEQ. The black line is the trend line.

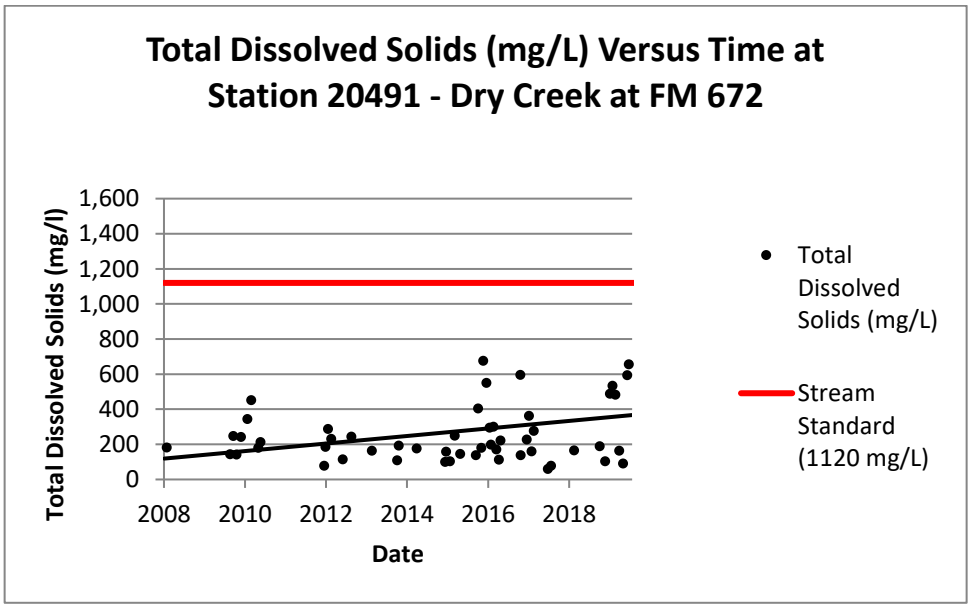

Figure 26. Total dissolved solids (TDS) versus time at station 20491 – Dry Creek at FM 672. The red line is the screening concentration (1120 mg/L) for concerns set by TCEQ. The black line is the trend line.

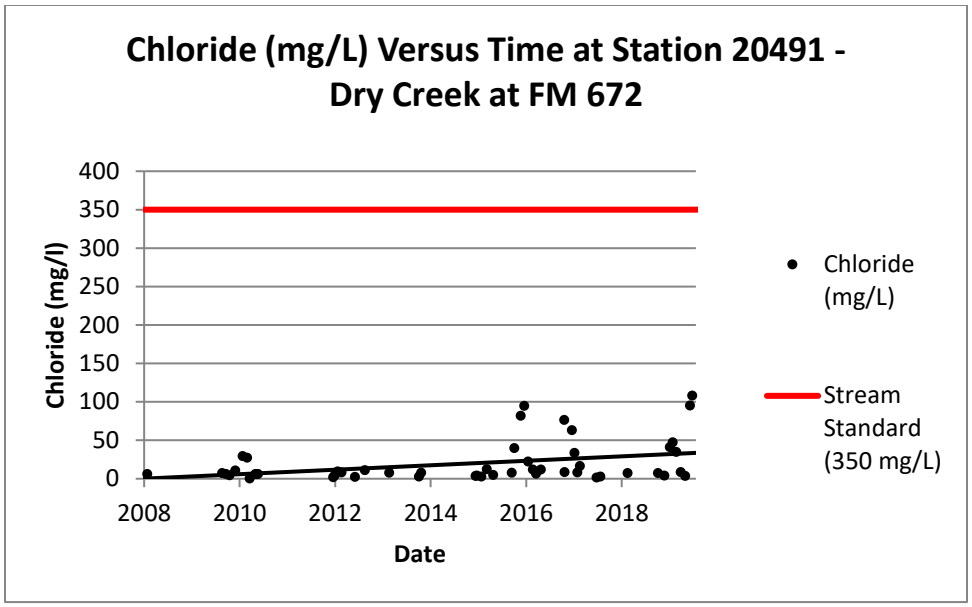

Figure 27. Chloride versus time at station 20491 – Dry Creek at FM 672. The red line is the screening concentration (350 mg/L) for concerns set by TCEQ. The black line is the trend line.

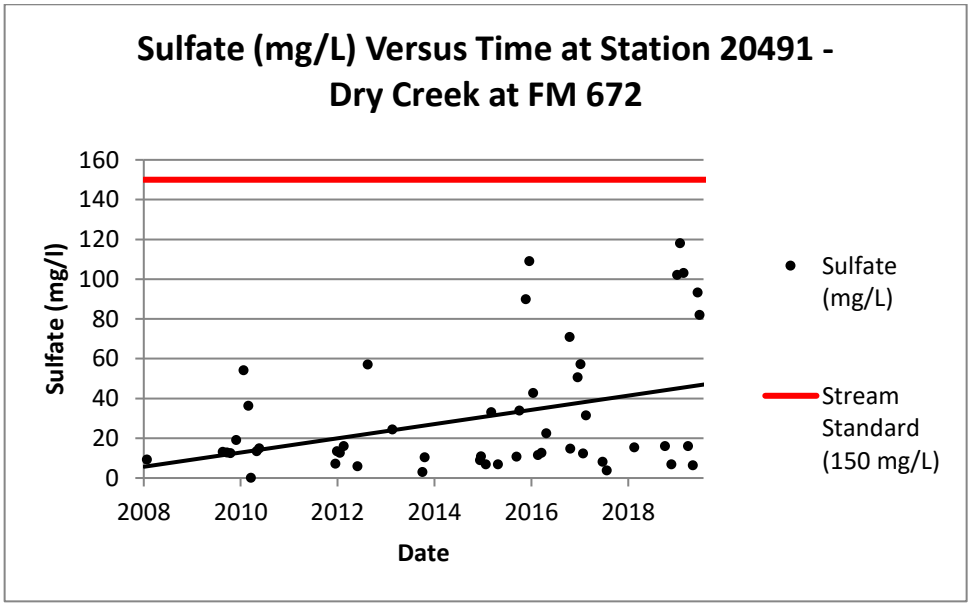

Figure 28. Sulfate versus time at station 20491 – Dry Creek at FM 672. The red line is the screening concentration (150 mg/L) for concerns set by TCEQ. The black line is the trend line.

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 Plum Creek WPP during targeted flow conditions. The GBRA attempted to conduct targeted watershed monitoring at thirty-seven 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 thirty-seven sites, eight sites were the same as the sites for routine ambient monitoring, allowing for twenty-nine sites for targeted watershed monitoring only. Sampling captured spatial, seasonal and meteorological variations in these snapshots of watershed water quality. GBRA referenced USGS gaging stations to determine if a rain event had increased flows from previous base flows to create wet weather targeted conditions.

A review of the monitoring data from project #17-09 revealed that very little data was available for collection at several stations due to dry conditions. When these stations did have water available to sample, there was rarely any stream flow present. GBRA has proposed that the TSSWCB remove three of the historical targeted monitoring stations from future monitoring projects in order to maximize monitoring resources. The three stations that will be affected by this change are Dry Creek at FM 672 (20491), Elm Creek at SH 21 (20483) and Brushy Creek at SH21 (20487). The stream flow of all the targeted monitoring stations was often influenced by the twenty-eight NRCS dams located in the Plum Creek Watershed. NRCS built these dams in the 1960-70s and the Plum Creek Conservation District currently maintains them. The structures retain floodwaters and slowly release the captured water in a controlled manner. Due to the slow release of water after a rain event, the flows into the affected streams maintain elevated wet weather flows over an extended time. Several high flow events affected the 17-09 implementation monitoring. The USGS gage above Lockhart recorded a 16.91-foot rise in the creek and corresponding 7,070 cubic foot per second (cfs) discharge on 03/28/18. This event was followed by a 16.27-ft rise and 5,040 cfs event on 01/03/19 and a 16.24-ft rise with corresponding 5,380 cfs discharge on 05/04/19. Due to the prolonged discharges retained in the NRCS structures, stream flows in the watershed remained elevated for approximately one month after each of these events.

A compilation of the data collected at the targeted sites is in Tables 6, 7, 8 and 9. Tables 6 and 7 list the average *E. coli* and nutrient concentrations during wet and dry weather conditions at all of the Plum Creek main stem monitoring locations. The only main stem stations with base flow nutrient levels below the screening criteria (0.69 mg/L of Total Phosphorus & 1.95 mg/L of Nitrate Nitrogen) are located upstream of any permitted wastewater discharges (Plum Creek at NRCS#1 & Plum Creek at Lehman Rd). Tables 8 and 9 list the same average monitoring parameter concentrations in tables 6 and 7 for all the Plum Creek targeted tributary monitoring stations.

Table 6. Compilation of Stream Flow, *E. coli* and Total Phosphorus data collected at Plum Creek main stem routine and targeted sampling stations. *E. coli* calculated in MPN/100ml. Total Phosphorus (Tot. P) concentrations are in mg/L. Stations are listed in order from upstream to downstream.

Monitoring Station	Median Flow (cfs) 2008 – 2019*	Median Flow (cfs) - Wet	Median Flow (cfs) - Dry	*E. coli* Geomean 2008 – 2019*	*E. coli* Geomean - Wet	*E. coli* Geomean - Dry	Total P Mean 2008 – 2019*	Total P Mean Wet	Total P Mean Dry
Plum Creek at NRCS #1	0.0	0.6	0.0	41	77	17	0.22	0.20	0.25
Plum Creek at Lehman	0.6	3.7	0.10	255	474	131	0.05	0.07	0.03
Plum Creek at Heidenreich	4.1	10.0	2.7	1324	1652	1092	2.47	1.69	3.25
Plum Creek at PC Rd	4.7	23.5	2.2	484	761	379	1.95	0.98	2.47
Plum Creek at CR 233	7.4	34.0	2.7	288	643	129	1.47	0.90	2.04
Plum Creek at HWY 183	8.0	90.0	3.2	240	643	84	1.18	0.80	1.59
Plum Creek at CR 186	7.3	49.0	3.8	389	690	207	0.88	0.72	1.06
Plum Creek at CR 202	10.0	54.0	6.3	324	654	210	1.01	0.74	1.18
Plum Creek at CR 197	9.5	44.0	5.4	439	819	196	0.93	0.76	1.14
Plum Creek at FM 1322	12.5	60.0	6.4	449	1134	168	0.83	0.74	0.93
Plum Creek at CR 131	19.0	91.5	7.4	475	1047	205	0.76	0.76	0.76
Plum Creek at CR 135	19.0	69.0	10.0	245	616	138	0.71	0.64	0.75

*Entire data set under all flow conditions through December of 2019.

Stations highlighted have a base flow geometric mean greater than the water quality standard of 126 organisms/100 mL under dry conditions.

Table 7. Compilation of Stream Flow, Nitrate Nitrogen and Ammonia Nitrogen data collected at Plum Creek main stem routine and targeted sampling stations. Nitrate Nitrogen (NO3-N) and Ammonia Nitrogen (NH3-N) concentrations are in mg/L. Stations are listed in order from upstream to downstream.

Monitoring Station	Median Flow (cfs) 2008 - 2019	Median Flow (cfs) - Wet	Median Flow (cfs) - Dry	NO3-N Mean 2008 – 2019*	NO3-N Mean Wet	NO3-N Mean Dry	NH3-N Mean 2008 – 2019*	NH3-N Mean Wet	NH3-N Mean Dry
Plum Creek at NRCS #1	0.0	0.6	0.0	0.51	0.39	0.69	0.25	0.15	0.39
Plum Creek at Lehman	0.6	3.7	0.10	0.64	0.75	0.52	0.15	0.15	0.14
Plum Creek at Heidenreich	4.1	10.0	2.7	11.05	9.17	12.93	1.97	1.09	2.82
Plum Creek at PC Rd	4.7	23.5	2.2	9.70	4.87	12.31	0.92	0.72	1.02
Plum Creek at CR 233	7.4	34.0	2.7	5.98	3.39	8.56	0.23	0.24	0.21
Plum Creek at HWY 183	8.0	90.0	3.2	3.54	2.12	5.05	0.32	0.44	0.19
Plum Creek at CR 186	7.3	49.0	3.8	5.07	2.68	7.69	0.16	0.16	0.16
Plum Creek at CR 202	10.0	54.0	6.3	5.31	3.43	6.48	0.18	0.15	0.19
Plum Creek at CR 197	9.5	44.0	5.4	3.75	2.86	4.87	0.17	0.15	0.21
Plum Creek at FM 1322	12.5	60.0	6.4	3.16	2.27	4.13	0.16	0.16	0.15
Plum Creek at CR 131	19.0	91.5	7.4	2.46	2.20	2.74	0.18	0.19	0.18
Plum Creek at CR 135	19.0	69.0	10.0	2.34	2.31	2.35	0.17	0.17	0.18

*Entire data set under all flow conditions through December of 2019.

Stations highlighted have a base flow Nitrate concentration greater than the water quality screening criteria of 1.95 mg/L under dry conditions.

Table 8. Compilation of Stream Flow, *E. coli* and Total Phosphorus data collected at Plum Creek tributary routine and targeted sampling stations. *E. coli* calculated in MPN/100ml. Total Phosphorus, (Tot. P) concentrations are in mg/L. Tributary stations are listed in order from upstream to downstream in the watershed.

Monitoring Station	Median Flow (cfs)	Median Flow Wet	Median Flow Dry	*E. coli* (MPN/100mL) Geomean	*E. coli* Geomean Wet	*E. coli* Geomean Dry	Total P (mg/L) Mean	Total P Mean Wet	Total P Mean Dry
Unnamed at FM 150	0.30	0.60	0.25	316	338	267	0.05	0.05	0.05
Andrew's at CR 131	1.30	1.90	1.05	324	511	202	0.23	0.18	0.28
Richmond at Dacy	0.10	0.40	0.01	380	645	220	0.08	0.07	0.09
Unnamed at Quail Cove*	0.03	0.06	0.01	552	858	39	0.12	0.13	0.03
Porter at Dairy Lane	1.70	5.00	1.10	454	816	211	0.11	0.14	0.08
Cowpen at Schuelke	2.40	2.60	0.00	1151	1268	820	0.25	0.25	0.25
Bunton at Dacy	0.35	2.40	0.04	144	386	52	0.08	0.10	0.07
Bunton at Heidenreich	1.05	6.40	0.40	321	486	165	0.07	0.08	0.04
Brushy at FM 2001	0.08	0.08	0.05	98	234	15	0.12	0.12	0.11
Brushy at SH21	0.80	6.80	0.01	244	766	57	0.11	0.13	0.07
Brushy Creek at Rocky Rd	0.01	0.10	0.00	210	785	83	0.12	0.14	0.11
Elm Creek at SH 21	0.02	0.10	0.01	194	377	40	0.11	0.11	0.09
Elm Creek at CR 233	0.00	0.50	0.00	158	645	51	0.17	0.19	0.15
Clear Fork at Farmers Rd	0.02	0.02	0.04	59	88	35	0.10	0.11	0.08
Clear Fork at PR10	1.80	3.55	1.20	167	368	74	0.09	0.13	0.04
Clear Fork at Old Luling Rd	1.60	4.70	0.90	157	304	79	0.10	0.15	0.05
Clear Fork at Salt Flat Rd	2.90	6.65	1.30	253	629	142	0.11	0.16	0.08
Town Branch at Stueve Ln*	0.00	0.00	0.00	498	445	2400	0.67	0.70	0.30
Town Branch at E. Market St	1.40	1.55	0.84	566	960	312	0.09	0.14	0.04
Dry Creek at FM 672	0.20	0.85	0.00	551	1059	160	0.29	0.31	0.26
Dry Creek at FM 713	0.50	1.10	0.00	963	1554	354	0.23	0.25	0.18
Tenney Creek at Tenney Crk Rd	4.00	4.70	0.15	845	1044	112	0.34	0.35	0.24
Hines Branch at Tenney Crk Rd*	0.00	0.00	0.00	350	487	68	0.27	0.29	0.18
Copperas at Tenney Crk Rd	0.06	0.20	0.01	730	1011	366	0.78	1.01	0.30
West Fork at FM 671	0.05	0.15	0.01	448	616	135	0.15	0.17	0.07
West Fork at Biggs Rd	0.01	0.02	0.01	134	418	58	0.41	0.37	0.44
Salt Branch at Salt Flat Rd	0.01	0.06	0.00	847	1140	566	0.33	0.26	0.44
Salt Branch at FM 1322	0.30	0.70	0.20	343	602	185	2.61	1.49	3.85

*Historical station. No monitoring occurred at this location during the 17-09 Implementation Monitoring Project.

Highlighted stations have an *E. coli* geometric mean concentration greater than the regulatory standard of 126 MPN/100 ml during base flows.

Table 9. Compilation of Stream Flow, Nitrate Nitrogen and Ammonia Nitrogen data collected at Plum Creek tributary routine and targeted sampling stations. Nitrate Nitrogen (NO3-N) and Ammonia Nitrogen (NH3-N) concentrations are in mg/L. Tributary stations are listed in order from upstream to downstream in the watershed.

Monitoring Stations	Median Flow (cfs) 2008 - 2019	Median Flow (cfs) - Wet	Median Flow (cfs) - Dry	NO3-N Mean 2008 – 2019*	NO3-N Mean Wet	NO3-N Mean Dry	NH3-N Mean 2008 – 2016*	NH3-N Mean Wet	NH3-N Mean Dry
Unnamed at FM 150	0.30	0.60	0.25	1.36	1.57	0.85	0.17	0.18	0.16
Andrew's at CR 131	1.30	1.90	1.05	10.57	7.28	13.96	0.19	0.19	0.20
Richmond at Dacy	0.10	0.40	0.01	0.63	0.93	0.30	0.30	0.16	0.45
Unnamed at Quail Cove**	0.03	0.06	0.01	0.35	0.40	0.06	0.16	0.17	0.10
Porter at Dairy Lane	1.70	5.00	1.10	0.83	0.70	1.02	0.20	0.18	0.22
Cowpen at Schuelke	2.40	2.60	0.00	0.51	0.60	0.17	0.25	0.28	0.12
Bunton at Dacy	0.35	2.40	0.04	0.36	0.50	0.21	0.17	0.16	0.17
Bunton at Heidenreich	1.05	6.40	0.40	3.51	0.60	8.17	0.16	0.16	0.17
Brushy at FM 2001	0.08	0.08	0.05	0.31	0.39	0.11	0.15	0.17	0.13
Brushy at SH21	0.80	6.80	0.01	0.43	0.56	0.21	0.18	0.14	0.22
Brushy Creek at Rocky Rd	0.01	0.10	0.00	0.29	0.44	0.19	0.19	0.16	0.21
Elm Creek at SH 21	0.02	0.10	0.01	0.28	0.34	0.15	0.14	0.16	0.10
Elm Creek at CR 233	0.00	0.50	0.00	0.23	0.38	0.11	0.19	0.18	0.20
Clear Fork at Farmers Rd	0.02	0.02	0.04	5.64	4.51	7.16	0.14	0.16	0.12
Clear Fork at PR10	1.80	3.55	1.20	3.74	2.86	4.64	0.18	0.16	0.21
Clear Fork at Old Luling Rd	1.60	4.70	0.90	2.58	1.98	3.20	0.17	0.18	0.17
Clear Fork at Salt Flat Rd	2.90	6.65	1.30	1.47	1.57	1.41	0.17	0.15	0.18
Town Branch at Stueve Ln**	0.00	0.00	0.00	1.67	1.22	8.03	0.29	0.29	0.26
Town Branch at E. Market St	1.40	1.55	0.84	11.07	10.19	12.06	0.18	0.17	0.19
Dry Creek at FM 672	0.20	0.85	0.00	0.37	0.49	0.16	0.21	0.20	0.24
Dry Creek at FM 713	0.50	1.10	0.00	0.31	0.31	0.32	0.19	0.18	0.19
Tenney Creek at Tenney Crk Rd	4.00	4.70	0.15	0.31	0.33	0.17	0.14	0.14	0.16
Hines Branch at Tenney Crk Rd**	0.00	0.00	0.00	0.51	0.60	0.05	0.23	0.23	0.24
Copperas at Tenney Crk Rd	0.06	0.20	0.01	0.26	0.34	0.09	0.90	1.12	0.32
West Fork at FM 671	0.05	0.15	0.01	0.28	0.34	0.05	0.16	0.14	0.22
West Fork at Biggs Rd	0.01	0.02	0.01	0.27	0.26	0.28	0.18	0.18	0.19
Salt Branch at Salt Flat Rd	0.01	0.06	0.00	0.24	0.19	0.31	0.71	0.21	1.38
Salt Branch at FM 1322	0.30	0.70	0.20	10.68	5.14	16.75	0.37	0.33	0.41

*Historical station. No monitoring occurred at this location during the 17-09 Implementation Monitoring Project.

Stations highlighted have a base flow Nitrate concentration greater than the water quality screening criteria of 1.95 mg/L under dry conditions.

Wastewater Effluent Monitoring

The GBRA conducted grab sampling at seven wastewater treatment facilities (WWTF) that discharge into Plum Creek and its tributaries in order to monitor effects on the parameters of interest. GBRA monitored the WWTF stations monthly for the same field, flow, bacteria, and conventional parameter groups analyzed at the routine monitoring stations, and for wastewater specific parameters. The Plum Creek watershed protection plan made recommendations for commonly permitted discharge concentration limits of biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia-nitrogen (NH3-N) and total phosphorus (Total P) in order to meet pollutant-loading goals identified by the stakeholders. Table 10 identifies the common wastewater parameters and compares them to the Plum Creek WPP permit recommendations. Table 11 compares the results from the wastewater monitoring to the TCEQ stream standards and screening criteria. The GBRA's Regional Laboratory conducted sample analysis. Field parameters are pH, temperature, conductivity and dissolved oxygen. Conventional parameters are total suspended solids, sulfate, chloride, nitrate nitrogen, ammonia-nitrogen, Total Kjeldahl Nitrogen and total phosphorus. Flow parameters are flow collected by gauge, electric, mechanical or Doppler, including severity. Bacteria parameters are *E. coli*. Effluent parameters are BOD, CBOD and COD.

The objective of the task that covered effluent monitoring was to provide water quality data to access the effectiveness of implementing the Plum Creek WPP through effluent monitoring. The Buda WWTF discharges into the Andrew's Branch of Porter Creek, which merges with Plum Creek just upstream of the Plum Creek at Plum Creek Road (17406) CRP monitoring station. The Kyle WWTF discharges into Plum Creek just upstream of the Plum Creek at Heidenreich Lane (20484) targeted monitoring station. The Sunfield and Shadow Creek facilities discharge into the Brushy Creek Tributary of Plum Creek, which merges with Plum Creek just upstream of the Plum Creek at CR 233 targeted monitoring station (12649). The Lockhart #1 facility discharges into the Town Branch tributary of Plum Creek, which merges with Plum Creek upstream of the Plum Creek at CR 186 (12648) targeted monitoring station. The Lockhart #2 facility discharges into Plum Creek upstream of the Plum Creek at CR 202 (12647) CRP monitoring station. The Luling North WWTF discharges into the Salt Branch Tributary of Plum Creek before it merges with Plum Creek upstream of the Plum Creek at CR 135 (12640) CRP monitoring station. Several large outlier events occurred during this project at the Kyle WWTF, when E. coli was 2,400 MPN/100 mL on 07/11/18, and 870 MPN/100 mL in the grab sample effluent on 07/10/19 and 08/07/19.

Table 10. Compilation of wastewater water quality sampling parameters compared to PC WPP recommended permit limits.

Monitoring Station	Median Flow (CFS)	Geomean *E. coli* (MPN/100 mL)	Mean pH (S.U.)	Mean D. O. (mg/L)	Mean TSS (mg/L)	Mean Total P (mg/L)	Mean BOD (mg/L)	Mean CBOD (mg/L)	Mean COD (mg/L)	Mean NH3-N (mg/L)
PC WPP Recommended Permit Limits	7Q2 = 2.3	126	6.5 to 9	5	5	1.0	5	5	N/A	2.0
Buda WWTF	1.6	2	7.5	8.2	1	0.39	1.6	1.3	18.0	0.38
Kyle WWTF	2.9	68	7.4	25.8	11	3.58	4.2	3.6	34.3	1.95
Sunfield WWTF	0.1	1	7.7	8.6	1	0.53	1.5	1.5	16.7	0.21
Shadow Creek WWTF	0.2	3	7.5	7.8	1	0.52	1.5	1.4	18.5	0.84
Lockhart #2 WWTF	1.5	11	7.6	8.4	5	2.53	1.5	1.5	21.0	0.46
Lockhart #1 WWTF	0.7	2	7.0	8.3	3	2.97	2.0	2.3	21.5	0.71
Luling North WWTF	0.3	3	7.1	8.2	10	4.26	2.0	2.5	28.7	0.49

Stations highlighted have concentrations greater than the Plum Creek WPP recommended permit limits.

Table 11. Compilation of wastewater water quality sampling parameters compared to stream screening criteria.

Monitoring Station	Median Flow (CFS)	Geomean *E. coli* (MPN/100 mL)	Mean Temperature (°C)	Mean Conductivity (*uS*/cm)	Mean Total P (mg/L)	Mean NO3-N (mg/L)	Mean NH3-N (mg/L)	Mean Chloride (mg/L)	Mean Sulfate (mg/L)	Mean TKN (mg/L)
Stream Screening Criteria	7Q2 = 2.3	126	32.2	1723	0.69	1.95	0.33	350	150	N/A
Buda WWTF	1.6	2	25.31	1423	0.39	15.49	0.38	233	156	0.84
Kyle WWTF	2.9	68	25.83	1207	3.58	19.35	1.95	155	100	2.94
Sunfield WWTF	0.1	1	22.86	1566	0.53	39.01	0.21	250	141	0.33
Shadow Creek WWTF	0.2	3	25.4	1177	0.52	14.67	0.84	172	106	1.25
Lockhart #2 WWTF	1.5	11	23.2	979	2.53	7.61	0.46	128	61	1.10
Lockhart #1 WWTF	0.7	2	24.7	912	2.97	17.07	0.71	106	64	1.04
Luling North WWTF	0.3	3	22.7	1007	4.26	29.81	0.49	126	57	0.83

Stations highlighted have concentrations greater than the TCEQ water quality screening criteria.

Diurnal Monitoring

GBRA conducted diurnal during the TCEQ index period months of April through December of 2018 and 2019. Two diurnal stations went completely dry and 24 monitoring did not occur during those months. The three main stem sites, the Clear Fork, Brushy Creek and West Fork tributaries maintained flow throughout the project. The Dry Creek at FM 672 (20491) only holds water following rainfall events and it did not have enough water to deploy a probe during the months of March, June, July, August, September and October of 2018. There was also no water available during August and September of 2019. In the Elm Creek at CR 233 (12558) station also did not have any water to deploy probes in June and August of 2018 or during September of 2019. The Brushy Creek (20488) station did not have water to sample in September of 2019.

The deployed probes in the three Plum Creek monitoring stations (12640, 12647, & 17406) and the Clear fork tributary (12556) consistently reported dissolved oxygen values that met the TCEQ stream standard for high aquatic life use. The average dissolved oxygen concentrations at these four stations were above the 24-hour screening criteria of 5 mg/L and 24-hour minimum concentrations of 4 mg/L. The probes deployed at the Brushy Creek (20488), Elm Creek (12558), West Fork (20500) and Dry Creek (20491) tributaries generally reported values consistent with the presumed Limited aquatic life use for an unclassified intermittent stream with perennial pools. The limited aquatic life use criteria presume an average dissolved oxygen level of 3 mg/L and a minimum dissolved oxygen level of 2 mg/L. All four tributaries fell below the minimum dissolved oxygen criteria on separate occasions.

Spring Flow Monitoring

The objective of the spring flow monitoring task was to provide water quality data to access the effectiveness of implementing the Plum Creek WPP through spring flow monitoring. The GBRA conducted spring flow monitoring at 3 springs once per season collecting field, conventional, flow and bacteria parameter groups. All sampling events were conducted.

The GBRA's Regional Laboratory conducted sample analysis. Field parameters are pH, temperature, conductivity and dissolved oxygen. Conventional parameters are total suspended solids, sulfate, chloride, nitrate nitrogen, ammonia nitrogen, Total Kjeldahl Nitrogen and total phosphorus. Flow is collected by mechanical or Doppler, including severity. Bacteria parameters were *E. coli*.

GBRA performed sampling of spring flows as close to the headwaters of each spring as possible. All three springs had elevated nitrate nitrogen concentrations, which is consistent with previous analyses performed on the Leona Aquifer (mean concentrations: Boggy Creek Springs – 6.99 mg/L; Clear Fork Springs – 7.25 mg/L; and Lockhart Springs – 11.77 mg/L). One water quality condition that was somewhat unexpected was the elevated *E. coli* bacteria concentrations. All three sites had a geometric mean for *E. coli* that exceeded the contact recreation stream standard (Boggy Creek Springs – 201 MPN per 100 milliliters; Clear Fork Springs – 272 MPN per 100 milliliters; and Lockhart Springs – 261 MPN per 100 milliliters). These high *E. coli* levels may partially be due to occasional non-point source runoff from the surrounding watershed into the sample collection locations following rainfall events or intrusion of bacteria into the Leona groundwater. Table 12 summarizes the results of the water quality monitoring collected during this monitoring task.

Table 12. Compilation of water quality monitoring parameters collected in springs of the Leona Aquifer.

Monitoring Station	Median Flow CFS	Geomean E. coli MPN/100 mL	Mean TSS mg/L	Mean D. O. mg/L	Mean SC *uS*/cm	Mean Total P mg/L	Mean NO3-N mg/L	Mean Chloride mg/L	Mean Sulfate mg/L	Mean NH3-N mg/L	Mean TKN mg/L
Stream Screening Criteria	7Q2 = 2.3	126	N/A	5	1723	0.69	1.95	350	150	0.33	N/A
Boggy Creek Springs at Boggy Creek Road	0.3	201	7.9	7.6	713	0.05	6.99	14	48	0.23	0.32
Clear Fork Springs at Borchert Loop	1.1	272	9.3	8.7	758	0.04	7.25	25	82	0.14	0.35
Lockhart Springs	0.9	261	2.5	9.2	790	0.05	11.77	29	63	0.15	0.24

Highlighted values exceed the TCEQ stream standard or screening criteria for Plum Creek.

Conclusion

Implementation of the Plum Creek WPP is continuing through the TSSWCB Clean Water Act Section 319(h) Project 17-09 titled *Surface Water Quality Monitoring to Support the Implementation of the Plum Creek 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 supports the Plum Creek partnership by providing regular updates of changes in water quality conditions. The partnership uses this information to support adaptive management strategies, for the development of targeted grants proposals, and to educate the public about water quality conditions.

The water quality monitoring that GBRA conducted in the Plum Creek watershed has assisted stakeholders with the assessment of best management practices in the watershed. The analysis of results from this monitoring has shown that *E. coli* bacteria concentrations on the main stem of Plum Creek have not significantly decreased since the implementation of the WPP. GBRA found a significant increase in the *E. coli* bacteria concentrations in the section of Plum Creek, immediately downstream of the City of Lockhart, TX and in the Clear tributary of Plum Creek, near Luling, TX. The effect of increased stream flows and rainfall runoff during the monitoring period for this project may have increased nonpoint source pollution. At least three flood events occurred during the sample period of this project and likely washed pollutants from surrounding agricultural fields into the watershed. The nitrate nitrogen concentrations are significantly increasing in the middle and lower portions of the watershed, immediately downstream of Lockhart, TX. This increase is likely due to increased nitrification efficiency in wastewater effluents. Chlorophyll *a* concentrations are also significantly increasing in the Plum Creek main stem downstream of Lockhart, which may be an indicator that more biologically available forms of nutrients, such as nitrate, are available in the system. The total phosphorus concentrations are significantly decreasing throughout the watershed. The decrease in total phosphorus is likely due to increased efficiency of wastewater treatment discharges and the dilution effect from increased rainfall and streamflow. The total dissolved solids and associated anions are significantly decreasing throughout the entire watershed, which is likely due to dilution from increased precipitation and associated streamflow. While WWTFs contribute to nitrate nitrogen levels in the watershed and the nitrification process that these plants employ optimally converts raw ammonia-nitrogen to nitrate nitrogen. Ammonia-nitrogen and TKN levels are significantly increasing in the upper portion of the watershed, downstream of the cities of Kyle, TX and Buda, TX. The increasing levels of

these parameters may be due to upsets in wastewater treatment operations documented during grab sample monitoring during this project. GBRA recommends continued public education efforts and best management practices in the watershed in order to ensure that future degradation of the water quality in the Plum Creek watershed does not occur. Reevaluation of the pollutant load reductions recommended by the steering committee in the 2008 Plum Creek Watershed Protection Plan might be useful in order to determine the impact of population growth and land use changes that have occurred during the ten-year implementation period of this project.

Sampling Site Locations and Monitoring Regime

TCEQ Station ID	Site Description	Workplan Task	Monitor Type	DO 24hr	Bacteria	Conventional	Flow	Field	Comments
12556	Clear Fork Plum Creek at Salt Flat Road	3.1	RTWD		21	21	21	21	1
12556	Clear Fork Plum Creek at Salt Flat Road	3.2	BFBA		7	7	7	7	
12556	Clear Fork Plum Creek at Salt Flat Road	3.3	BSWD	14			7	7	
12558	Elm Creek at CR 233	3.1	RTWD		21	21	21	21	1
12558	Elm Creek at CR 233	3.2	BFBA		7	7	7	7	
12558	Elm Creek at CR 233	3.3	BSWD	14			7	7	
12640	Plum Creek at CR 135	3.1	RTWD		21	21	21	21	1, 3
12640	Plum Creek at CR 135	3.2	BFBA		7	7	7	7	
12640	Plum Creek at CR 135	3.3	BSWD	14			7	7	
12647	Plum Creek at Old McMahan Road (CR 202)	3.1	RTWD		10	10	10	10	1, 3
12647	Plum Creek at Old McMahan Road (CR 202)	3.2	BFBA		7	7	7	7	
12647	Plum Creek at Old McMahan Road (CR 202)	3.3	BSWD	14			7	7	
17406	Plum Creek at Plum Creek Road	3.1	RTWD		10	10	10	10	1, 3
17406	Plum Creek at Plum Creek Road	3.2	BFBA		7	7	7	7	
17406	Plum Creek at Plum Creek Road	3.3	BSWD	14			7	7	
20488	Brushy Creek at Rocky Road (Upstream of NRCS 14)	3.1	RTWD		10	10	10	10	1
20488	Brushy Creek at Rocky Road (Upstream of NRCS 14)	3.2	BFBA		7	7	7	7	
20488	Brushy Creek at Rocky Road (Upstream of NRCS 14)	3.3	BSWD	14			7	7	
20491	Dry Creek at FM 672	3.1	RTWD		10	10	10	10	1
20491	Dry Creek at FM 672	3.2	BFBA		7	7	7	7	

TCEQ Station ID	Site Description	Workplan Task	Monitor Type	DO 24hr	Bacteria	Conventional	Flow	Field	Comments
20491	Dry Creek at FM 672	3.3	BSWD	7			7	7	
20500	West Fork Plum Creek at Biggs Road (CR 131)	3.1	RTWD		21	21	21	21	
20500	West Fork Plum Creek at Biggs Road (CR 131)	3.2	BFBA		7	7	7	7	
20500	West Fork Plum Creek at Biggs Road (CR 131)	3.3	BSWD	14			14	14	
12555	Salt Branch at FM 1322	3.2	BFBA		14	14	14	14	
12557	Town Creek at E. Market St. (Upstream of Lockhart #l WWTP)	3.2	BFBA		14	14	14	14	
12559	Porter Creek at Dairy Road	3.2	BFBA		14	14	14	14	
12642	Plum Creek at Biggs Road (CR 131)	3.2	BFBA		14	14	14	14	
12643	Plum Creek at FM 1322	3.2	BFBA		14	14	14	14	
12645	Plum Creek at Young Lane (CR 197)	3.2	BFBA		14	14	14	14	
12648	Plum Creek at CR 186	3.2	BFBA		14	14	14	14	
12649	Plum Creek at CR 233	3.2	BFBA		14	14	14	14	
14945	Clear Fork Plum Creek at Old Luling Road (CR 213)	3.2	BFBA		14	14	14	14	
18343	Plum Creek Upstream of US 183	3.2	BFBA		14	14	14	14	
20480	Plum Creek Downstream of NRCS 1 Spillway	3.2	BFBA		14	14	14	14	
20481	Bunton Branch at Heidenreich Lane	3.2	BFBA		14	14	14	14	
20482	Brushy Creek at FM 2001 (Downstream of NRCS 12)	3.2	BFBA		14	14	14	14	
20487	Brushy Creek at SH 21	3.2	BFBA		14	14	14	14	
20483	Elm Creek at SH 21 (Downstream of NRCS 16)	3.2	BFBA		14	14	14	14	
20489	Cowpen Creek at Schuelke Road	3.2	BFBA		14	14	14	14	
20496	Tenney Creek at Tenney Creek Road	3.2	BFBA		14	14	14	14	
20490	Clear Fork Plum Creek at Farmers Road	3.2	BFBA		14	14	14	14	
20493	Clear Fork Plum Creek at PR 10 (State Park)	3.2	BFBA		14	14	14	14	
20497	West Fork Plum Creek at FM 671	3.2	BFBA		14	14	14	14	
12538	Andrews Branch at CR 131	3.2	BFBA		14	14	14	14	
20495	Dry Creek at FM 713	3.2	BFBA		14	14	14	14	

TCEQ Station ID	Site Description	Workplan Task	Monitor Type	DO 24hr	Bacteria	Conventional	Flow	Field	Comments
20484	Plum Creek at Heidenreich Lane (Downstream of Kyle WWTP)	3.2	BFBA		14	14	14	14	
20501	Salt Branch at Salt Flat Road (Upstream of Luling WWTP)	3.2	BFBA		14	14	14	14	
20498	Copperas Creek at Wattsville Road (CR 140, Downstream of Cal-Maine)	3.2	BFBA		14	14	14	14	
20505	Richmond Branch at Dacy Lane	3.2	BFBA		14	14	14	14	
20503	Plum Creek at Lehman Road	3.2	BFBA		14	14	14	14	
20502	Bunton Branch at Dacy Lane (upstream of NRCS 5)	3.2	BFBA		14	14	14	14	
20479	Unnamed Tributary at FM 150 near Hawthorn Dr.	3.2	BFBA		14	14	14	14	
20492	10210-001 City of Lockhart and GBRA #1(Larremore plant)	3.4	-		21	21	21	21	2
20494	10210-002 City of Lockhart and GBRA #2 (FM 20 plant)	3.4	-		21	21	21	21	2
20499	10582-002 City of Luling	3.4	-		21	21	21	21	2
20486	11041-002 City of Kyle and Aquasource Inc.	3.4	-		21	21	21	21	2
99923	11060-001 City of Buda and GBRA	3.4	-		21	21	21	21	2
99936	14431-001 GBRA Shadow Creek	3.4	-		21	21	21	21	2
99937	14377-001 GBRA Sunfield	3.4	-		21	21	21	21	2
20509	Lockhart Springs	3.5	BSWD		7	7	7	7	
20507	Clear Fork Springs at Borchert Loop (CR 108)	3.5	BSWD		7	7	7	7	
20508	Boggy Creek Springs at Boggy Creek Road (CR 218)	3.5	BSWD		7	7	7	7	

1. The eight “routine” sites double as “targeted” sites. “Targeted” sampling will collect biased flow (BF) samples twice per quarter – once under wet weather conditions and once under dry weather conditions. Whether these samples will satisfy the wet (biased high flow) or dry (biased low flow) weather conditions depends on the flow condition when samples are collected during the “routine’ sampling that quarter.

2. The data collected from WWTF sampling will not be used for enforcement or compliance monitoring by TCEQ. As such, results will not be reported to TCEQ for inclusion in SWQMIS. Monitor type code is not applicable.

3. These samples are collected/analyzed by GBRA utilizing Texas CRP funding and serve as a portion of the non-federal match for this project. This project may collect additional monitoring at this station to cover lapses in the CRP data collection effort.

List of Acronym's

7Q2……Low flow statistic that is calculated by the annual 7-day minimum flow with a 2-year recurrence interval.
BF…….. Biased Flow
BMP…….. Best Management Practices
BOD…….. Biochemical Oxygen Demand
CBOD…….. Carbonaceous Biochemical Oxygen Demand
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
MG/L…….. Milligrams/Liter
ML…….. Milliliter
MPN…….. Most Probable Number
NH3-N…….. Ammonia-nitrogen
NO3-N…… Nitrate as Nitrogen
NRCS…… Natural Resources Conservation Service
PCWP……Plum Creek Watershed Partnership
QAPP…….. Quality Assurance Protection Plan
QA/QC……. Quality Assurance/Quality Control
UMHOS/CM… Micro mhos per centimeter (Unit of Conductance)
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…….. Wastewater Treatment Facility