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Water Quality Monitoring in the Buck Creek Watershed and Facilitation of Buck Creek Watershed Partnership: Final Report

Lucas Gregory, Texas Water Resources Institute
Phyllis Dyer, Texas A&M AgriLife Research
Kevin Wagner, Texas Water Resources Institute
Paul DeLaune, Texas A&M AgriLife Research

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Final Report

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EXECUTIVE SUMMARY

The "Water Quality Monitoring in the Buck Creek Watershed and Facilitation of Buck Creek Watershed Partnership" project was developed to continue water quality monitoring on Buck Creek and to continue to engage watershed stakeholders during the Buck Creek WPP review process. This project continued monthly monitoring of Buck Creek when flowing water was present and kept the watershed partnership engaged through public meetings and semi-annual newsletters.

Water quality monitoring began in May 2011 during the early stages of the most intense one-year drought on record in Texas and ran through April 2013. While much of the state returned to a semi-normal state of moisture conditions, the Texas Panhandle did not fare so well. The drought coupled with increased groundwater pumping to keep crops viable yielded sufficient water to sample in the creek during four sampling dates in this two-year period.

Despite the minimal number of samples collected, the data produced are quite useful in illustrating the current level of bacteria loading in the stream. Due to the extended drought conditions experienced, the presence of water in the creek was a direct result of recent rain events. Higher than normal *Escherichia* coliforms (*E. coli*) were expected as a result of this rainfall and sampling pattern; however, the highest single *E. coli* count recorded during this project was 293 colony-forming units (cfu) per 100 ml of water.

Keeping the Buck Creek Watershed Partnership engaged was another key component of this project. The development and distribution of semi-annual newsletters was the primary method used to update the stakeholders on the status and progress of the WPP and activities in an around the watershed. Two public meetings also provided an opportunity to discuss project progress and Buck Creek in general with partnership members. E-mails and phone calls from the watershed coordinator also served to keep landowners engaged.

Education and outreach was provided in the form of the Texas Well Owners Network program and the Rolling Plains Summer Crops Field Day. These programs were delivered to provide an educational opportunity to private well owners on the placement and care of water wells and onsite sewage facilities and to farmers on the use improved cropping system strategies related to irrigation and nutrient management.

ACKNOWLEDGEMENTS

TWRI and Texas A&M AgriLife Research – Vernon prepared the following report. Lucas Gregory and Phyllis Dyer served as principle authors. Drs. Kevin Wagner and Paul DeLaune were the principle investigators for this project.

We would like to extend a special thanks to members of the Hall-Childress Soil and Water Conservation District (SWCD) #109, Salt Fork SWCD #133, Donley County SWCD #127 and the Red River Authority of Texas. Without their help, this project would not have been possible. The assistance of Catrina Moody with the Salt Fork Soil and Water Conservation District in arranging meeting locations and providing event information to local newspapers is greatly appreciated.

Thanks to Buck Creek landowners Kirk Skipper and Curtis and Ruth Ann Scrivner for allowing access to their property on Buck Creek for monitoring purposes. A special thank you goes to Burl and Mary Brim for their generous hospitality and their interest in this study, sampling efforts, wildlife counts and seasonal creek information. Landowner feedback on the condition of the creek was especially useful during this project. The drought caused the creek to be dry the vast majority of the time and landowners were a great help in letting the project team know when and where rain events occurred.

Funding for this project was 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

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AU	assessment units
BMP	best management practice
BST	bacterial source tracking
cfs	cubic feet per second
cfu	colony-forming units of bacteria
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
FM	Farm to Market Road
µS/cm	micro Siemens per centimeter
mg/L	milligrams per liter
mL	milliliters
NPS	nonpoint source
OSSF	on-site septic facility
pH	potential hydrogen
QAPP	Quality Assurance Project Plan
RRA	Red River Authority of Texas
SWCD	Soil and Water Conservation District
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids (specific conductance)
TMDL	total maximum daily load
TSSWCB	Texas State Soil and Water Conservation Board
TWON	Texas Well Owners Network
TWRI	Texas Water Resources Institute
USDA	United States Department of Agriculture
WPP	watershed protection plan

INTRODUCTION

Buck Creek (Segment 0207A) is a small tributary in the Red River basin. Buck Creek joins the Lower Prairie Dog Town Fork of the Red River (Segment 0207) to form the Red River above Pease River (Segment 0206). The creek originates close to Hedley, Texas in Donley County and intermittently flows 68 miles in an east-southeast direction across the Oklahoma border to its Red River confluence. The Red River Basin includes 30 classified segments and 11 major reservoirs, which cover approximately 145,169 acres.

Designated uses of Buck Creek include limited aquatic life, contact recreation and fish consumption. For assessment purposes, TCEQ dissects Buck Creek into two assessment units (AU), 0207A_01 and 0207A_02. AU 0207A_01 extends from the Oklahoma state line to Buck Creek's confluence with House Log Creek (25 miles) while AU 0207A_02 stretches from the House Log Creek confluence to the upper end of the segment (43 miles). In 2000, AU 0207A_01 was determined to be non-supporting of contact recreation use due to bacteria levels exceeding Texas Surface Water Quality Standards. This assessment was based on data collected above the US 83 bridge crossing. The aquatic life use was found to be fully supported and fish consumption was not assessed. Due to this failure to meet water quality standards for the stream's designated use, it was added to the *2000 303(d) List*. In 2002, Buck Creek was re-assessed and remained on the *303(d) List* due to the bacterial impairment. The segment was classified as a category "5a" stream meaning that a total maximum daily load (TMDL) was underway, scheduled, or will be scheduled; but was given a low priority for initiating the TMDL process. Stakeholders across the watershed disliked the suggested TMDL approach to reducing the bacterial impairment and sought to have the stream re-classified. As a result, the creek remained on the impaired list after the 2004 evaluation but was re-categorized as 5c meaning that more data and information will be collected before a TMDL is scheduled.

As a result of this action, a series of projects on Buck Creek ensued to better define the creek's water quality, develop a watershed protection plan and provide supplemental water quality data. The first project, *"Bacterial Monitoring for the Buck Creek Watershed"* (TSSWCB Project 03-07), was designed to collect an intensive dataset that would better illustrate the spatial and temporal variability of bacteria loading in the Buck Creek watershed. This project began in October 2003 and continued through September 2007. Project results indicated that periodically elevated bacteria levels existed; however, their source was unknown. These findings spawned a subsequent project.

The second project implemented was entitled *"Watershed Protection Plan Development for Buck Creek"* (TSSWCB Project 06-11) and continued intensive water quality monitoring, worked to identify bacteria loading sources in the watershed and combined project findings with stakeholder guidance to develop a watershed protection plan (WPP). Water quality monitoring conducted under this project began in October 2007 and concluded in June 2010. Data collected confirmed that periodic spikes in *E. coli* still existed and were most often associated with rainfall events or stream bed disturbances. Bacterial source tracking (BST) conducted through the project

confirmed the assumptions of watershed partnership members that wildlife and feral hogs were the primary bacteria contributors followed by livestock and, to a lesser extent, humans.

Concurrently, a project entitled *"Modeling Support for Buck Creek Watershed Protection Plan Development"* (TSSWCB Project 08-05) was carried out and applied computer-based modeling techniques to develop a predictive model of the Buck Creek watershed. This model evaluated the potential for bacterial loading across the entire watershed and provided watershed partnership members with tools to assist them in deciding what types of management measures were needed and where they would be most cost effective. Collectively, results from these three projects were combined with stakeholder guidance to develop the Buck Creek WPP, which was completed in December 2012.

This project, the "*Water Quality Monitoring in the Buck Creek Watershed and Facilitation of Buck Creek Watershed Partnership*" (TSSWCB Project 10-06) referred to as the "Interim Monitoring" project throughout the remainder of this report, was developed continue water quality data collection and minimize the gap in water quality data collected during WPP development and its implementation began. Water quality monitoring conducted under this project began May 30, 2011, which coincided with height of exceptional drought conditions experienced in the watershed and concluded April 9, 2013. These drought conditions continued at some level throughout the course of the project and resulted in a much smaller data set than anticipated. Regardless, the data collected illustrate that *E. coli* levels in Buck Creek are well within the state's contact recreation standard of 126 cfu per100 mL of water. As was seen in previous work, periodic spikes in *E. coli* levels are observed shortly following rainfall events but quickly return to more normal levels after a rain. In addition to water quality monitoring, continued engagement of watershed stakeholders was also a cornerstone of this project. Newsletters, public meetings and the project website were used to continually engage watershed stakeholders and keep them abreast of watershed conditions and development progress of the Buck Creek WPP.

Project Goals

The Interim Monitoring project was primarily developed as a concise project that provided resources for continued data collection and stakeholder engagement. The two goals of the project were:

- To maintain water quality sampling utilized in earlier projects to ensure that adequate water quality data are collected to provide for future water quality assessments that illustrate the effects of implementing the Buck Creek WPP to achieve water quality restoration
- To maintain stakeholder engagement in the watershed planning process as a shift is made to implementation, specifically, through development and distribution of newsletters to Buck Creek stakeholders, updating the Buck Creek project website and hosting meetings of the stakeholders group

WATER QUALITY MONITORING

When the Interim Monitoring project was developed, the recommendations for future monitoring outlined in the Buck Creek WPP were utilized as a guide for developing the project's monitoring plan. The WPP called for strategically planned monitoring to be conducted across the watershed to provide a benchmark of information to verify implementation impacts on water quality (Gregory 2012).

Monitoring Locations

The Buck Creek WPP specifically identified five locations in the watershed as primary locations where water quality data should be collected long-term to evaluate WPP implementation effectiveness. Of these stations, two are in AU 0207A_01 (stations 15811 & 20376); two are in AU 0207A_02 (stations 20365 & 20368) and one is located on a tributary of the creek (station 20367). Building on this recommendation, two additional sites were included in the Interim Monitoring project. These added stations are located on a private ranch that has allowed monitoring throughout the course of all projects conducted on Buck Creek. Under normal flow conditions, these stations (20371 and 20373) provide water quality data that is impacted by near stream best management practices (BMPs) that the landowner has implemented. Figure 1 illustrates and Table 1 describes the distribution of these monitoring stations across the watershed.

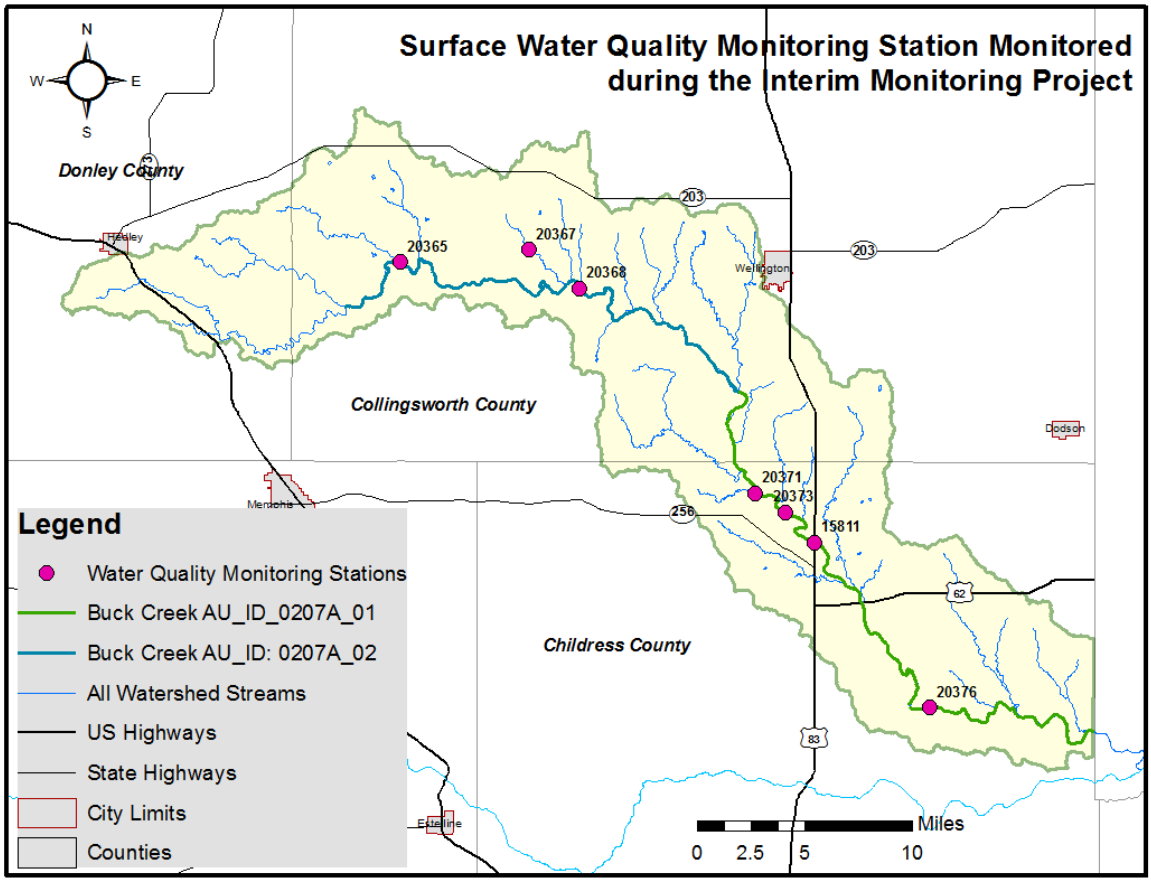


Figure 1. Surface water quality monitoring sites monitored during the Interim Monitoring project

Table 1. Water quality monitoring station descriptions

Project Site No.	TCEQ Monitoring Station No.	General Station Location & Description	County	TCEQ Assessment Unit Station is Located In
BC 03	20365	Buck Creek Upstream of CR 40	Collingsworth	0207A_02
BC 05	20367	Unnamed Tributary of Buck Creek upstream of FM 1056	Collingsworth	N/A
BC 06	20368	Buck Creek Upstream of CR 110	Collingsworth	0207A_02
BC 10A	20371	Buck Creek on Private Property off SH 256	Childress	0207A_01
BC 10C	20373	Buck Creek on Private Property off SH 256	Childress	0207A_01
BC 11	15811	Buck Creek Upstream of US 83	Childress	0207A_01
BC 13	20376	Buck Creek Upstream of CR 19	Childress	0207A_01

N/A: This site is located outside of the defined Assessment Unit areas

Monitoring stations highlighted in green are selected index sites in the two designated AUs

Sampling Frequency and Parameters

Routine water quality monitoring was conducted on a monthly basis by Texas A&M AgriLife Research personnel at Vernon at the seven monitoring sites described above when flow was present. During each sampling event, a field data report (Appendix A) was generated for each site even if a water sample was not collected. These reports recorded the sampling location, site ID, time, date, sample ID number, monitoring type, the chain of custody number, the collector's name and the collecting agency. The field data report also contains information on stream flow, method used to measure flow, the number of days since the last significant rainfall event, air temperature, wind and current weather conditions. In addition, the color, clarity and odor of the water and biological activity were noted. Water quality parameters monitored in the field included DO, pH, temperature, specific conductance as well as instantaneous stream flow measurements. With sampling being planned monthly at seven sites for 18 months, 126 samples were anticipated.

Biased flow monitoring following six storm events was also planned at each of the seven sampling sites. Field observations and field parameters monitored were the same as those described above for routine sample collection. In total, 42 biased flow samples were planned.

Due to the rapid rise and fall of Buck Creek and the lack of automated stream flow monitoring, first-hand landowner knowledge was used to determine when biased flow events could be collected. When rain was suspected or radar data indicated rainfalls, a series of three landowners on Buck Creek were contacted to verify that rain had occurred and determine if runoff was produced. The typical thresholds used to trigger a biased flow sampling event was at least 1 inch of rainfall and/or noted increases in stream flow by landowners. Even with the use of local contacts, collecting storm influence samples proved quite difficult. Only two sampling events were conducted as a result of this process; only one of those yielded samples.

Impacts of Drought

The worst one-year drought Texas has experienced since record keeping began in 1895 was at its height when water quality sampling began on May 31, 2011 (Figure 2). Several watershed landowners reported receiving only 1 to 2 inches of precipitation on their properties in the watershed during this drought. Although drought conditions eased over the course of monitoring, average annual rainfall remained well below normal levels and prevented the creek from recovering. Additionally, what rainfall did occur typically came in higher intensity, shorter duration events, which led to more flashy runoff events and lower volumes of water entering the soil profile. This paired with exceptionally high temperatures led to non-typical irrigation practices being employed. For example, 2.5 times the normal amount of irrigation water was applied to a cotton crop south of the watershed near Chillicothe to sustain the crop for research purposes (Personal Communication, 2012). While this was not the case for all irrigated crops as many farmers opted to abandon the year's crop, it clearly illustrates the abnormally large volumes of water that were required to sustain a crop. Many farmers were also forced to irrigate winter crops as well as their summer crops leading to nearly continuous irrigation.

The Blaine and Seymour Aquifers underlie the creek and are the primary sources of irrigation water in the watershed. While the connectivity of these aquifers to the creek is not clearly understood, observations made since 2003 suggest that there is a strong groundwater/surface water interaction. In typical years, irrigation generally begins in May and the creek goes dry about a month later. When irrigations typically end in September or October, the creek begins to flow again in November.

Water Sample Collection Procedures

Regardless of sample type, water samples were collected directly from the stream (midway in the stream channel) into sterile wide-mouthed polypropylene bottles or bags and returned to the Texas A&M AgriLife Research Lab at Vernon for *E. coli* and nitrate analysis. All sample containers were labeled with the collection date, collection time, sample location and sampler's initials. The surface microlayer of water was avoided during sample collection as it might have been enriched with bacteria and not representative of the water column.

Above all else, safety was a primary concern when collecting samples. If the research technician felt that their safety was in jeopardy at any point, they were given the discretion to not collect samples. If a sampling event was skipped for safety concerns, this was noted in the field notebook and a later attempt to collect the sample was made.

Deep dry grasses were typical on rangelands in late summer 2011. This was the beginning of the worst fire season Texas has seen in years.

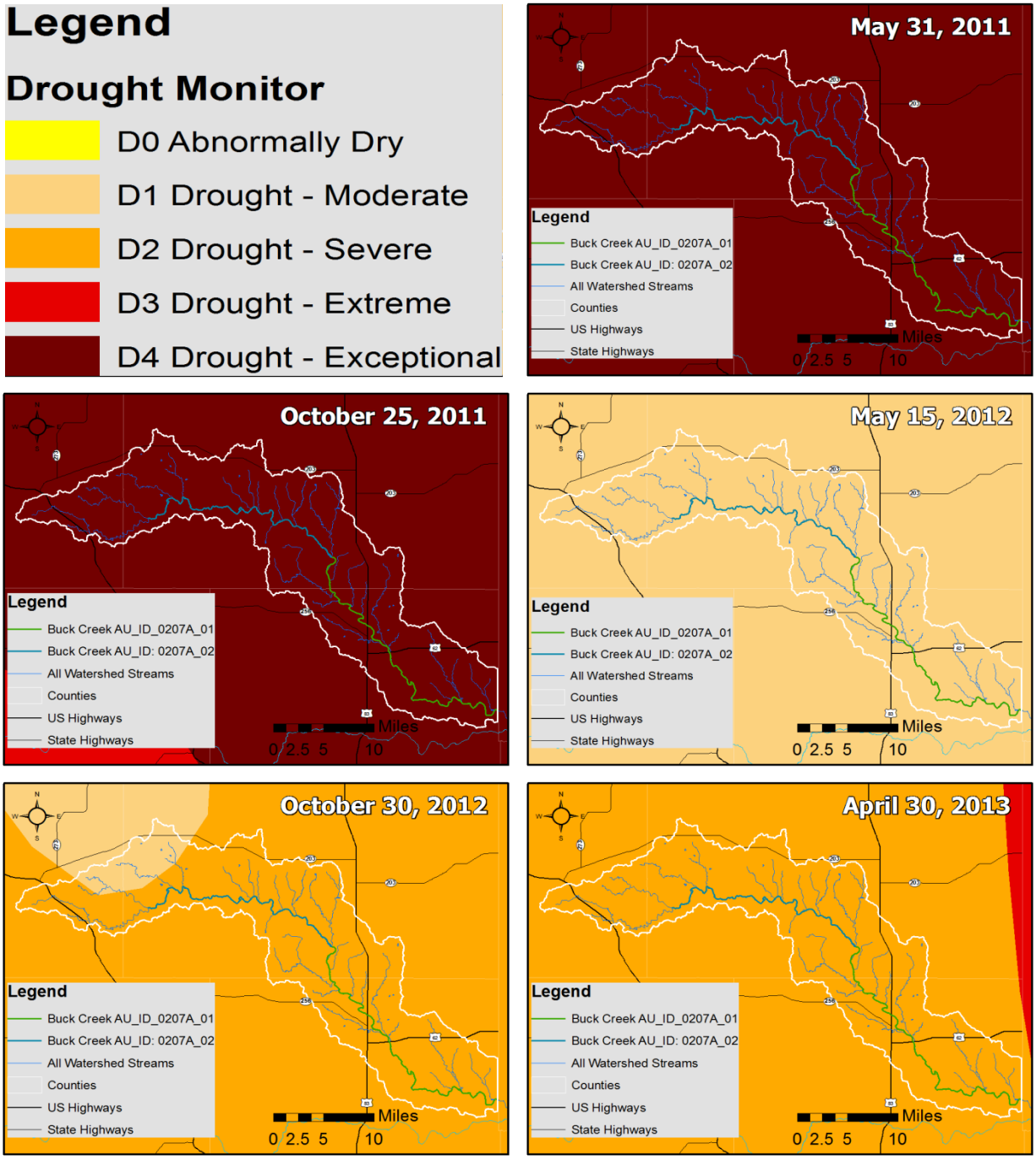


Figure 2. Drought Monitor maps for Buck Creek spanning the project's sampling period

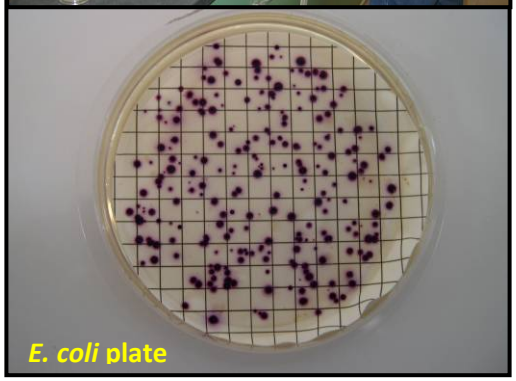
Field and Lab Analysis Procedures

Field-based analyses were limited to dissolved oxygen, pH, specific conductance, salinity and water temperature. A hand-held water quality meter (YSI 556 MPS, YSI Incorporated; Yellow Springs, Ohio) allows for each of these readings to be taken simultaneously. Utilizing the procedures for operating this device described in the Texas Commission on Environmental Quality's *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical*

Monitoring Methods (TCEQ 2008) and the project's approved quality assurance project plan (QAPP), the technician deployed the instrument, allowed it to equilibrate and then recorded the readings for each parameter.

Instantaneous stream flow was also determined in the field using a hand-held velocity meter (Global Water Flow Probe, Global Water Instrumentation; College Station, Texas) paired with a top-setting wading rod. Utilizing the procedures for measuring instantaneous stream flow described in *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods* (TCEQ 2008) and the project QAPP, the technician recorded average velocities and depth at the midpoint of an appropriate number of stream cross sections onto the field data report (Appendix A). Once back in the lab, the average velocities and midpoint depths were inputted into a spreadsheet allowing the calculation of instantaneous stream flow in cubic feet per second (cfs).


Technician filtering water samples


E. coli plate

E. coli in water samples were isolated and enumerated using modified mTEC agar, USEPA Method 1603 (USEPA 2006). The modified mTEC method is a single-step method that uses one medium and does not require testing using any other substrate. Samples are first filtered through a membrane that retains the bacteria. Filter membranes are then placed in a selective growth medium and incubated. Magenta-colored colonies of bacteria appear after the incubation period providing a direct count of *E. coli* in the water sample.

Nitrate levels in water were assessed using an automated process described in USEPA Method 353.2 where a filtered sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. This nitrate is mixed to form a dye that is then measured with a colorimeter (USEPA 1993).

Water Quality Monitoring Results

Water quality in Buck Creek was monitored through the Interim Monitoring project from May 2011 through April 2013. As mentioned earlier in this report, drought conditions ranging from moderate to exceptional existed in the watershed during the entirety of the project. The creek was dry the vast majority of the time during the sampling period thus drastically reducing the number of water samples collected during the project.

Temperature

Water temperatures in °C were recorded at each sampling location when flowing water was

present. The maximum water temperature recorded along the creek was 23.65°C on June 11, 2012 and was well below the maximum temperature criteria of 33.9°C. The lowest water temperature recorded during the two years of sampling was 12.83°C on March 14, 2013.

Dissolved Oxygen (DO)

DO grab sampling was conducted when sufficient water was present in the creek to fully immerse the multiprobe. Of the sites monitored, only four had sufficient water present at some point during the project to collect DO samples. Throughout the course of monitoring, DO levels ranged between 6.54 to 11.56 milligrams per liter (mg/L). Due to its limited aquatic life use designation, DO levels in the creek are required to remain at or above 3.0 mg/L and not go below 2.0 mg/L. Data recorded showed that DO levels during sampling events were well within these standards.

Specific Conductance and pH

Specific conductance, an indirect measure of total dissolved solids (TDS), and pH standards do not exist for Buck Creek. As a point of comparison, the standards set for the adjacent Lower Prairie Dog Town Fork of the Red River (segment 0207) were used. The criteria for this segment state that pH should remain at or above 6.5 and not exceed 9.0, and TDS should not exceed 46,200 mg/L. According to TCEQ's *2012 Guidance for Assessing and Reporting Surface Water Quality in Texas* (TCEQ 2012a), TDS levels in a stream can be calculated by multiplying specific conductance levels by 0.65. Applying this factor to the TDS standard of 46,200 mg/L for the Lower Prairie Dog Town Fork of the Red River, a specific conductance threshold of 71,077 micro Siemens per centimeter (µS/cm) can be inferred for Buck Creek. Specific conductance levels recorded in the creek during the course of the study ranged between 712 and 3,641 µS/cm thus well below the maximum allowable level.

Throughout the course of this project, pH readings taken along the creek ranged from a minimum of 7.8 to a maximum of 8.33 and averaged 8.03 between all sites and samples. Specific conductance levels recorded in the creek ranged from a minimum of 712 µS/cm recorded at station 20367 up to 3,641 µS/cm at station 15811. In both the case of pH and specific conductance, measurements taken from Buck Creek fully supported the water quality criteria established for the neighboring stream.

E. coli

Water samples were collected and analyzed for *E. coli* at four of the seven monitored sites. Stations 20367, 20371, 20373 and 15811 had sufficient water present to collect samples while stations 20365 and 20368 did not. In total, only 10 water samples were collected and processed for *E. coli* during the two-year monitoring period. This low number of samples collected clearly shows how the drought has adversely impacted flow conditions in the creek. Results showed that a narrow range of *E. coli* were present in the stream during monitoring events. *E. coli* counts ranged from 11cfu/100 mL to 293cfu/100 mL. Table 2 depicts all individual *E. coli* counts from collected water samples throughout the course of this Interim Monitoring project.

Table 2. All *E. coli* data collected on Buck Creek between May 2011 and April 2013

Assessment Units (AUs)	TCEQ Monitoring Station No.	*E. coli* counts (cfu/100mL) by Date*				AU Geometric Mean
		13-May 2011	11-Jun 2012	14-Mar 2013	9-Apr 2013	
N/A	20367	-	-	69	18	-
0207A_02: Buck Creek upstream of House Log Creek	20365	-	-	-	-	-
	20368	-	-	-	-	
0207A_01: Oklahoma State Line to House Log Creek	20371	293	272	40	-	81.4
	20373	11	114	61	-	
	15811	42	189	-	-	
	20376	-	-	-	-	

* none of these samples were collected following a runoff producing rain event

N/A: This site is located outside of the defined Assessment Unit areas

Given the minimal number of samples collected at each sampling site, estimating geometric means of *E. coli* on an individual site basis isn't pertinent. Instead, utilizing TCEQ's water body assessment approach where available data are aggregated at the AU level provides a better measure of water quality collected during this project. However, this approach is still not ideal, as it yields no samples for the upper AU and eight for the lower AU. Using this tact, the *E. coli* geometric means calculated in cfu/100mL for the lower portion of the creek was 81.4 (Table 2), which is well within the applicable primary contact recreation standard of 126 cfu/100 mL.

Further applying TCEQ's water body assessment approach, where a minimum of 20 bacteria samples collected over a seven-year assessment period is used, provides the most appropriate method to evaluate the limited amount of data collected through the Interim Monitoring project. To perform this assessment, a seven-year monitoring period spanning May 1, 2006 to April 30, 2013 was selected. *E. coli* data collected during this time frame comes from the *"Bacterial Monitoring for the Buck Creek Watershed"* project (TSSWCB Project 03-07), the *"Watershed Protection Plan Development for Buck Creek"* project (TSSWCB Project 06-11) and this project. Collectively, this yielded 173 and 137 individual *E. coli* samples respectively for AUs 0207A_01 and 0207A_02 and greatly improved the number of samples available at each station monitored during the Interim Monitoring project with the exception of Station 20376 (Table 3).

The influences of the drought that continues to grip the Buck Creek watershed skew the distribution of available samples within this expanded time period heavily toward the first half of this seven-year period of record. Despite this fact, the data set does capture the climatic and stream flow conditions that Buck Creek and its watershed has experienced during this time frame. As such, the assessment of these data and their use in determining the creek's ability to

support its designated contact recreation use is justified. .

Utilizing this expanded data set, geometric means of *E. coli* collected at each site are based on a reasonable number of samples with the exception of Station 20376. TCEQ's requirement of 20 samples collected over the assessment period only applies at the AU level; however, it is fitting to use this as threshold for a needed number of samples to produce site-by-site geometric means that are representative of an extended period. Table 3 illustrates the number of samples available at each site, the date range that samples were available and the geometric mean of those samples. Additionally, the table includes a geometric mean assessment of ALL *E. coli* data available from, and aggregated within Buck Creek's two AUs.

Table 3. Buck Creek *E. coli* geometric means from the most recent 7 years of available data

Assessment Units (AUs)	TCEQ Monitoring Station No.	Number of Samples	Earliest Sampling Date	Latest Sampling Date	Site Geometric Mean
N/A	20367	39	5/2/06	4/13/13	63.2
0207A_02: Buck Creek upstream of House Log Creek	20365	42	5/2/06	5/13/09	18.5
	20368	28	5/10/06	7/30/09	31.5
*AU 0207A_02 Total		102	AU Geometric Mean		37.2
0207A_01: Oklahoma State Line to House Log Creek	20371	50	5/9/06	3/14/13	90.6
	20373	52	5/9/06	3/14/13	41.7
	15811	40	5/2/06	6/11/12	27.7
	20376	3	5/10/06	5/14/07	221.4
*AU 0207A_01 Total		173	AU Geometric Mean		61.1

* AU totals and geometric means also include data from Stations 20364, 20366, 20369, 20370 (AU 0207A_02) 20372 and 20375 (AU 0207A_01) as well. These Stations are also included in TCEQ's bi-annual water body assessments for these AUs.

N/A: This site is located outside of the defined Assessment Unit areas

Comparing the results of this assessment to previously conducted assessments by TCEQ and the evaluation conducted through the development of the Buck Creek WPP, *E. coli* levels in Buck Creek are quite similar. The *2012 Texas Integrated Report* (TCEQ 2012b) reported *E. coli* levels for AU 0207A_02 and AU 0207A_01 of 36.6 and 69.8 cfu/100 mL respectively while the *Buck Creek Watershed Protection Plan* (Gregory 2012) reported 35.1 and 68.8 cfu/100 mL for these assessment units.

Flow Conditions

As with *E. coli,* flow measurements were made at four of the seven monitoring locations throughout the course of the Interim Monitoring project. The extended and severe drought conditions coupled with increased groundwater pumping throughout the watershed logically had adverse effects on stream flow conditions. Throughout the course of this project, flowing water was present in the stream during only four sampling events. Ensuring that *E. coli* sample holding times were met prevented flow velocities from being recorded on three sampling occasions. Observations of the research team and watershed landowners indicate that monitoring stations and the creek in general were dry or existed as a series of disconnected pools during much of the project. Flow in the creek only occurred for very brief amounts of time and was observed to be from small amounts of spring flow feeding the stream following several low intensity, non-runoff producing rain events. Table 4 illustrates the temporal and spatial distribution of the small range of stream flows recorded during the project.

Table 4. Measured stream flow rates at monitored locations during the Interim Monitoring project

Assessment Units (AUs)	TCEQ Monitoring Station No.	Measured Flow Rate (cfs) by Date			
		13-May 2011	11-Jun 2012	14-Mar 2013	9-Apr 2013
N/A	20367	-	-	1.253	0.896
0207A_02: Buck Creek upstream of House Log Creek	20365	-	-	-	-
	20368	-	-	-	-
0207A_01: Oklahoma State Line to House Log Creek	20371	0.9453	1.1125	---	-
	20373	2.1046	1.1364	---	-
	15811	---	3.951	-	-
	20376	-	-	-	-

- No data available due to dry or No flow conditions

--- No flow rate measured to ensure that *E. coli* samples holding times were met

N/A: This site is located outside of the defined Assessment Unit areas

Nitrates

The quantity of nitrates data was much like that of *E. coli* and flow measurements. Throughout the course of the project 10 water samples were collected and six of those were analyzed for nitrate levels. Instrument malfunctions prevented four water samples collected from having nitrate analysis completed. Of the six samples analyzed, all but one exceeded the established screening level for nitrates in freshwater stream, which is set at 1.95 mg/L (Table 5). The average of these six data point was 3.05 mg/L and was relatively consistent with those reported

in the *2012 Texas Integrated Report* (TCEQ 2012b), which listed average nitrate levels in AU 0207A_01 for samples exceeding the screening level at 3.79 mg/L. The average of all nitrate data assessed in that report and collected between December 1, 2003 and November 30, 2010 was 3.47 mg/L. Applying the seven-year data window to include nitrates collected from this project (May 1, 2006 to April 30, 2013), the average of all nitrate data collected in AU 0207A_01 was 3.46 mg/L. Surprisingly, the long-term, moving average of nitrates proved extremely consistent between assessment periods.

Table 5. Nitrate levels recorded at monitored locations during the Interim Monitoring project

Assessment Units (AUs)	TCEQ Monitoring Station No.	Nitrate concentrations (mg/L) by Date			
		13-May 2011	11-Jun 2012	14-Mar 2013	9-Apr 2013
N/A	20367	-	-	---	---
0207A_02: Buck Creek upstream of House Log Creek	20365	-	-	-	-
	20368	-	-	-	-
0207A_01: Oklahoma State Line to House Log Creek	20371	3.85	3.03	---	-
	20373	4.74	2.71	---	-
	15811	1.59	2.39	-	-
	20376	-	-	-	-

- No data available due to dry or No flow conditions

--- No nitrate data available due to instrument malfunction

N/A: This site is located outside of the defined Assessment Unit areas

STAKEHOLDER ENGAGEMENT

The focus of stakeholder engagement carried out through this project was to maintain contact with stakeholders and keep them engaged in the watershed planning process as the shift was made from WPP development to WPP implementation. Using previously utilized methods, and some of those described in the Education and Outreach chapter of the Buck Creek WPP, stakeholders were effectively engaged and kept informed on Buck Creek WPP development and implementation.

Newsletters

A series of four newsletters were developed on a roughly semi-annual basis. These newsletters provided updates on water quality data collection efforts and progress toward implementing the WPP and other information relevant to the watershed. Once developed, newsletters were distributed to watershed stakeholders via e-mail or traditional mail and were posted to the project website. Topics discussed in the newsletter series included:

- Water quality monitoring
- Cooperative feral hog management efforts
- Feral hog management options
- Stakeholder highlights
- Buck Creek WPP updates, reviews and comments
- The Buck Creek water quality success story
- In-stream nitrate levels
- Landowner perspectives on the 1950s drought and the 2011 drought
- Nitrogen crediting
- Mesquite control methods
- The Rolling Plains Field Day
- Texas Well Owner Network program
- Candidacy for the Texas Environmental Excellence Awards
- Partnership meeting announcements

Copies of each newsletter are housed on the project website and can be accessed at any time at: http://buckcreek.tamu.edu/publications/.

Public Meetings

Hosting Buck Creek Watershed Partnership meetings and participating in existing meetings to highlight efforts related to the WPP also served as a critical avenue for public engagement. These events provided opportunities for project personnel and watershed stakeholders to interact and discuss Buck Creek.

Buck Creek Watershed Partnership meetings were held twice during the project: August 25, 2011 and January 10, 2012. These meetings focused on the continued review and refinement of the Buck Creek WPP. The first meeting highlighted changes made to the WPP in response to

agency comments received while the second provided an opportunity for watershed stakeholders to provide comments on the WPP directly to the project team. Each meeting was attended by the core group of stakeholders that have remained engaged in the WPP development process for its duration.

Other public meetings where Buck Creek WPP development was discussed provided excellent opportunities to highlight the effectiveness of the collective efforts in the watershed to a wider audience. Content provided during these meetings was more general in nature as meeting participants were usually less familiar with the project than the local audience in the watershed was. Meetings where Buck Creek was discussed include:

- Texas State Soil and Water Conservation Board November 2012 Board meeting
- Red River Authority annual Clean Rivers Program meetings (2011, 2012, 2013)
- Texas Well Owner Network Workshop (March 2013)
- Soil and Water Conservation District meetings area-wide

Program Website

The program website originally developed in 2003 at the start of the *Bacterial Monitoring for the Buck Creek Watershed* project and maintained throughout the course of watershed characterization and WPP development efforts was updated to include information from this project. The website continues to house information from earlier projects and serves as a repository for project materials including meeting materials, quarterly reports, watershed maps, the WPP and general program information and updates.

Throughout the course of this project, the website was visited 1,182 times. Monthly site visits peaked around well-publicized events in the watershed including the two watershed partnership meetings and the announcement of the Texas Environmental Excellence Award winners.

www.buckcreek.tamu.edu

Educational Programming

Providing educational resources to watershed stakeholders remains a critical need in the Buck Creek watershed. The draft WPP describes a host of educational programs that will be delivered in the watershed pending resource availability. These programs cover topics including feral hog management, grazing management, nutrient management, riparian and stream ecosystem health, septic system operation and maintenance, soil and water testing, wildlife management, and well head protection and management. Utilizing existing programs currently being delivered regionally and statewide, two educational programs have been delivered in the watershed.

In July 2012, the Rolling Plains Summer Crops field day was held at the Texas A&M AgriLife Research Station near Chillicothe and about an hour southeast of the watershed. During the program, producers and agency personnel received information focused heavily on efficient and

appropriate nutrient utilization. Topics discussed during the field day highlighted trials conducted at the Research Station that evaluated irrigation scheduling technologies, optimizing fertilizer application to maximize profits, no-till and cover cropping methods, soil health, nitrate availability in soils and well water, and accounting for nitrate in soils and irrigation water when planning crop nutrient applications. This is a regional program that is held bi-annually and focuses on cropping systems management.

Dr. Srinivasan Ale discussing crop response under nitrate crediting schemes during the July 2012 Rolling Plains Summer Crops Field Day

The Texas Well Owners Network (TWON) program was also delivered in the watershed in March 2013. This program focused on providing information to private drinking water well owners on well water quality screening, water treatment, septic system maintenance, groundwater sources and well maintenance. This event also provided participants a low-cost opportunity to have drinking water well quality tested to screen for fecal contaminants, total dissolved solids, nitrates, arsenic and radioactivity. The TWON program was developed and is delivered by the Texas A&M AgriLife Extension Service and is funded by the Texas State Soil and Water Conservation Board (TSSWCB Project 10-04) through Clean Water Act Section 319(h) funding from U.S. EPA. More information about this program can be found at: http://twon.tamu.edu/.

CONCLUSIONS

Completion of the *Water Quality Monitoring in the Buck Creek Watershed and Facilitation of Buck Creek Watershed Partnership* project during extended and severe drought conditions proved quite challenging; especially where water quality monitoring is concerned. Despite the abnormally dry conditions, Buck Creek and its inhabitants showed their resilience as minnows and recent signs of beaver activity were commonly observed in the stream when water was present. This suggests that despite its drying up; at least a few pools were maintained somewhere along the creek during the project that were sufficient to support aquatic life.

Water quality monitoring conducted through the project continued to provide useful information about the creek and how it is connected to its surrounding watershed. Flow conditions during this two-year monitoring period were far from normal with the creek being largely dry for much of this time. When water was present, *E. coli* levels recorded were normal with only three of the ten samples being above the state's long-term geometric mean criteria for primary contact recreation. While this was an exceptionally small data set, combining project data with earlier data illustrates that Buck Creek continues to support this use; however, the lack of water didn't allow for much contact recreation.

Stakeholder involvement was also effective maintained through this project with newsletters, partnership meetings, news releases and the project website. Drought conditions limited discussions on water quality findings, but allowed for more focus to be placed on other critical aspects of successful watershed planning efforts such as the watershed stakeholders. Throughout the course of the project, a number of stakeholders were interviewed for newsletters, magazine articles and even videos. The videos were associated with the Buck Creek Watershed Partnership's receipt of the Texas Environmental Excellence Award in Agriculture in 2013, which was awarded for the collective efforts of the watershed partnership to monitor the creek, evaluate the sources of pollutants in the creek, develop a plan to restore the creek, begin implementing that plan and ultimately have the creek be removed from the *2010 Texas Integrated Report* as an impaired water body. This award resulted in widespread regional and statewide media attention about the work in Buck Creek and the water quality improvements made, which furthered stakeholder engagement during the project.

Despite not collecting near as many water samples as planned, this project accomplished its primary goals. Water quality monitoring was conducted such that real hydrologic and quality conditions on the creek were accurately defined during the worst one-year drought in recorded history. Stakeholders remained engaged throughout the project and were recognized for their work in the watershed that led its water quality to improve. The continued efforts of watershed stakeholders will ensure that Buck Creek remains healthy for years to come.

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APPENDICES

APPENDIX A: Field Data Report

AgriLIFE RESEARCH
Texas A&M System

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ML0001

Vernon Water Quality Laboratory
NELAC Accredited: T104704480-10-1
National Lab Code: TX 02640

Date:		Station Location:					TCEQ ID:	
Time:		Basin/Reach/Segment:	0207A				HUA No:	11120105
County:		Monitoring Type:					Rainfall Event:	Yes NO
Site ID Number:		Sample Chain of Custody Number:	504286-__					
Tech(s):			Section-	Midpoint	Depth	Veocity	Discharge:	
Storet Code:		Salinity_____ TDS_____	1					
00300		Dissolved Oxygen (mg/L)	2					
00400		pH (Standard Units)	3					
00094		Specific Conductance	4					
00010		Water Temp °C	5					
01351		Flow: 1 none 2low 3normal 4flood 5high 6dry	6					
00061		Flow(CFS) Lab complete shaded area	7					
89835		Flow: 1 Gauge 2 Electronic 3 Mechanical	8					
		4 Wier/Flume 5 Doppler	9					
20424		Water Clarity: 1 Excellent 2 Good 3 Fair	10					
		4 Poor 5 Other:_____	11					
89969		Water Color: 1 Brown 2 Reddish 3 Green	12					
		4 Black 5 Clear 6 Other_____	13					
89971		Water Odor: 1 Sewage 2 Oily/Chem 3 Sulfur	14					
		4 Musky 5 Fishy 6 None 7 Other_____	15					
00021		Air Temp °F	16					
89966		Weather: 1 Clear 2 Partly Cloudy 3 Cloudy	17					
		4 Rain 5 Other_____	18					
89965		Wind: 1 Calm 2 Slight 3 Moderate 4 Strong	19					
		Direction: N NE NW E SE S SW W	20					
72053		Significant Precipitation (<or>Days)		Total Flow in CFS:				
Water Sample Depth:		Split: YES NO					Photos: YES NO	
Biological Activity:								
Comments:								

Lab Reporting Only: AW: 1___ 2___ 3___4___5___ E. coli _____ Dup_____ Nitrates_____ Dup_____
Water Isolates: **A B C D E**