Streamflow and Water Quality Properties in the Thompsons Creek Watershed in the Vicinity of Bryan/College Station, 2020–2022

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make every drop count

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Abstract

Texas Water Resources Institute, in cooperation with the Texas Commission on Environmental Quality, measured continuous streamflow from March 2020 to March 2021 and collected discrete streamflow and water quality data from January 2020 to March 2022 in the Thompsons Creek watershed. The project's goal was to collect data and information vital for improving the understanding the hydrology (streamflow and water quality) of Thompsons Creek and its tributaries, and identifying the presence or absence of impairments.

Continuous flow data measurements were made at surface water quality monitoring stations 16396 and 16397 on Thompsons Creek and station 16882 on Still Creek. Measured continuous data was used to develop discharge-stage rating relationships, which were then used to develop long-term daily streamflow data at the three stations. The derived long-term daily streamflow data was then used for estimation of flows at three additional unmonitored stations (17378 on Still Creek and 17597 and 17598 on Cottonwood Branch) using the drainage-area ratio method. Discrete streamflow and water quality parameters (temperature, transparency, specific conductance, pH, dissolved oxygen concentration, and *E. coli* loads) were also measured at the above six stations monthly.

This report describes the study area, sample collection, and processing methods for streamflow and water quality data from six sites located in the Thompsons Creek watershed. The data and methods presented in this report support analyses of the relations among water quality impairment status and causes and basin hydrology in the watershed.

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Abbreviations

ADV	Acoustic Doppler Velocimeter
APHA	American Public Health Association
AU	Assessment Unit
cfs	Cubic Feet per Second
cfu	Colony Forming Unit
CWA	Clean Water Act
°C	Degrees Celsius
DAR	Drainage-Area Ratio
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
µS/cm	Micro Siemens per Centimeter
mg/L	Milligrams per Liter
mL	Milliliter
MPN	Most Probable Number
NWIS	National Water Information System
QAPP	Quality Assurance Project Plan
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TWRI	Texas Water Resources Institute
TCEQ	Texas Commission on Environmental Quality
USGS	U.S. Geological Survey
WWTF	Wastewater Treatment Facility

Introduction

Background

Bacteria impairments account for the most impairments of water bodies across the state of Texas. According to the 2020 Texas Integrated Report of Surface Water Quality for Clean Water Act (CWA) Sections 305(b)[1] and 303(d)[2] (TCEQ 2020), approximately 33.5% of the 1,009 category 5 impaired[3] water bodies in the state are impaired due to high bacteria concentration levels. Thompsons Creek and its tributaries draining part of the Bryan/College Station urban area (Still Creek and Cottonwood Branch) are among the many water bodies included on the state's 2020 303(d) list as impaired (TCEQ 2020).

The CWA requires action to be taken to restore water quality in a water body once the water body has been listed. Several options exist to achieve this. The options include additional monitoring, a standards assessment, development of a total maximum daily load, or implementing alternative pollution control measures such as development of a watershed protection plan.

To support the determination and development of approaches for addressing bacteria impairments in the watershed, the Texas Water Resources Institute (TWRI), in cooperation with the Texas Commission on Environmental Quality (TCEQ), measured continuous streamflow from March 2020 to March 2021 and collected discrete streamflow and water quality data from January 2020 to March 2022 in the Thompsons Creek watershed. The project's goal was to collect data and information vital for better understanding of the watershed's hydrology and identifying the presence or absence of impairments.

This report presents results of the discrete streamflow and water quality monitoring activity. The approach used to estimate long-term daily data at selected surface water quality monitoring (SWQM) stations in the watershed is discussed in Schramm et. al (2021). Daily streamflow estimates by Schramm et. al (2021) are abstractly discussed and used to derive flow estimates at other SWQM stations in the watershed.

Description of the Study Area

The Thompsons Creek watershed lies within the Brazos River above Navasota River watershed, within the vicinity of the Bryan/College Station urban area. Thompsons Creek (Segment ID[4] 1242D) and its tributaries—Still Creek (1242C), Cottonwood Branch (1242B), and an unnamed tributary of Cottonwood Branch (1242G)—drain 33,297 acres of land in Brazos County. Physical properties of the watershed including land use, climate, soil properties, population, and population projections are described in Gitter et al. (2020) and are not discussed any farther in this report.

Five of the seven assessment units (AUs) in the watershed are listed as impaired for concentrations of *Escherichia coli (E. coli)* in water (Figure 1, Table 1) in the 2020 Texas Integrated Report (TCEQ

[1] Section 305(b) reports provide information on the water quality status of all waters in the state.
[2] Section 303(d) lists the states' waters that are impaired by a pollutant and in need of a total maximum daily load (TMDL).
[3] Category 5 – Impaired or threatened by pollutant(s) for one or more designated uses and requiring a TMDL. These are the waters entered onto a states' 303(d) list. Impaired waters are those waters that do not meet water quality standards for one or more pollutants.
[4] TCEQ describes surface water bodies (called segments) with a specific "identifier" (Segment ID) and further divides segments into hydrologically distinct assessment units (AUs).

2020). Additionally, the upper portion of Thompsons Creek (AU 1242D_02) is listed as impaired for elevated concentrations of depressed dissolved oxygen (DO). Several assessments units in the watershed also have screening level concerns for nitrate, total phosphorous, ammonia, chlorophyll-a, and depressed DO and use concerns for impaired fish and macrobenthic communities in water (Table 1).

Table 1. Impairments/levels of concern for assessment units (AUs) in the Thompsons Creek watershed.

Segment	AU	AU drainage area (acres)	Integrated level of support[5]
Cottonwood Branch (1242B)	1242D_01	4,147	NS (bacteria) CS (nitrate, total phosphorous)
	1242D_02	2,419	NS (bacteria)
Still Creek (1242C)	1242C_01	10,645	-
	1242C_02	6,423	NS (bacteria) CS (depressed dissolved oxygen, nitrate, total phosphorous)
Thompsons Creek (1242D)	1242D_01	33,297	NS (bacteria) CN (impaired fish community) CS (nitrate, total phosphorous)
	1242D_02	15,68	NS (bacteria, depressed dissolved oxygen) CN (impaired macrobenthic community) CS (ammonia, chlorophyll-a)
Unnamed tributary of Cottonwood Branch (1242G)	1242G_01	1,621	-

[5]Level of support as classified in the 2020 Texas Integrated Report: NS = Nonsupport, CS = Screening Level Concern, CN = Use Concern.

Measurement of Streamflow and Water Quality Parameters

The federal CWA gives states the primary responsibility for implementing programs to protect and restore water quality, including monitoring and assessing the nation's waters and reporting on their quality. In Texas, TCEQ is the agency with primary responsibly for implementing the monitoring, assessment, and reporting requirements of the CWA. The TCEQ SWQM program coordinates the collection of physical, chemical, and biological samples throughout the state. SWQM data is stored in the TCEQ Surface Water Quality Monitoring Information System (SWQMIS) database (TCEQ 2021). Relatedly, the U.S Geological Survey (USGS) is the principal agency mandated to collect streamflow data across the nation. It operates several streamflow gages nationwide and routinely measures stream stage and flow data. Recorded data is published in the National Water Information System (NWIS) database (USGS 2021). There are no available records of daily streamflow data in the Thompsons Creek watershed. To address this gap, TCEQ contracted TWRI to develop a record of daily streamflows for SWQM stations in the watershed and measure ambient water quality properties to facilitate development of total maximum daily loads and watershed-based plans.

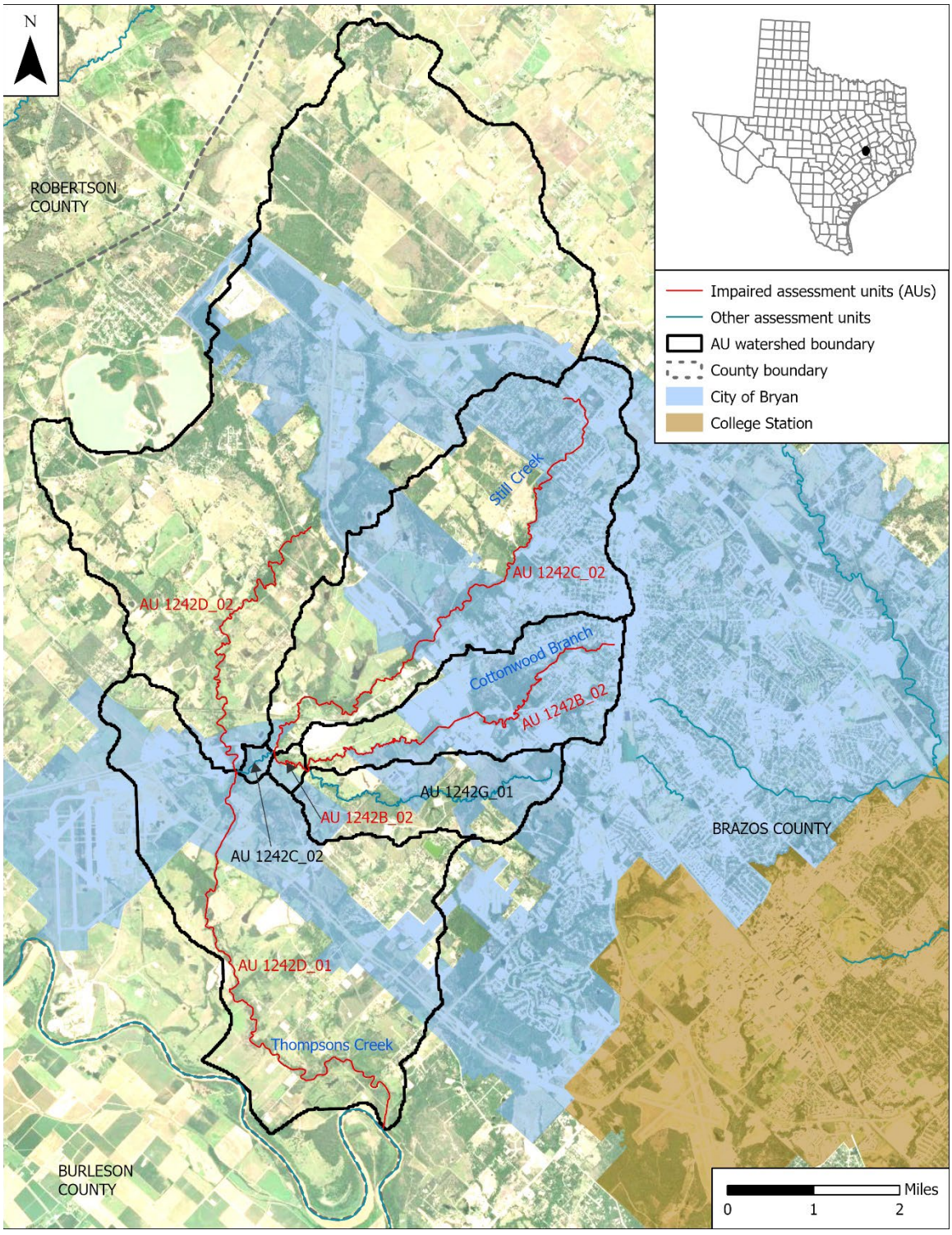


Figure 1. Overview map of the Thompsons Creek watershed.

Derivation of Continuous Streamflows

Continuous stream discharge data are essential to watershed projects that focus on pollutant loads. Streamflow records are required for estimating loads of constituents of concern and determining the variability of constituents based on seasonal or daily variations in flow, point-source discharges, or other variables. Because long-term hydrologic data in the form of daily streamflow records were unavailable in the Thompsons Creek watershed, Schramm et al. (2021) collected continuous streamflow data and developed daily streamflow records for SWQM stations 16396, 16397, and 16882 (Figure 3) from March 3, 2020, through March 31, 2021. Long-term daily flows (2003–2021) for the three stations were then generated using a catchment water balance model that relates runoff to rainfall and evapotranspiration (Schramm et al. 2021).

Naturalized[5] daily flows at SWQM stations 16396, 16397, and 16882 were analyzed to assess whether flows at SWQM stations with no flow data can be calculated based on drainage area ratios. The drainage area ratio (DAR) method estimates flow at an ungaged location by multiplying the measured flow at the nearby reference gage by the area ratio of the ungaged to gaged drainage area. The method is algebraically simple and is the most straightforward of the techniques to implement and is widely used for numerous applications requiring streamflow transference.

Regression analysis indicated that flows at any upstream point can be estimated by multiplying the flow at a downstream reference gage by the watershed area ratio. The area ratio alone explained 93% of the variance in the slopes of relationships between upstream and downstream flows. Using the DAR method for estimating flows in the watershed was therefore established as justifiable, and as such, flows at SWQM stations without data were calculated using the DAR method. The DAR method is described in Asquith et al. (2006), and the method is not described further in this section. Daily streamflows at the ungaged SWQM stations 17378, 17597, and 17598 (Figure 2) were extrapolated from flows at station 16882 using the DAR approach. Station 16882 is the closest station to either of the three stations that had no simulated flow data.

[5] Naturalized discharges are adjusted flows that are adjusted to take account of net abstractions and discharges upstream of a station. Naturalized flow is the flow without water rights diversions or permitted discharges. This document uses "TMDL flows" to refer to flows that have diversions and discharges factored in.

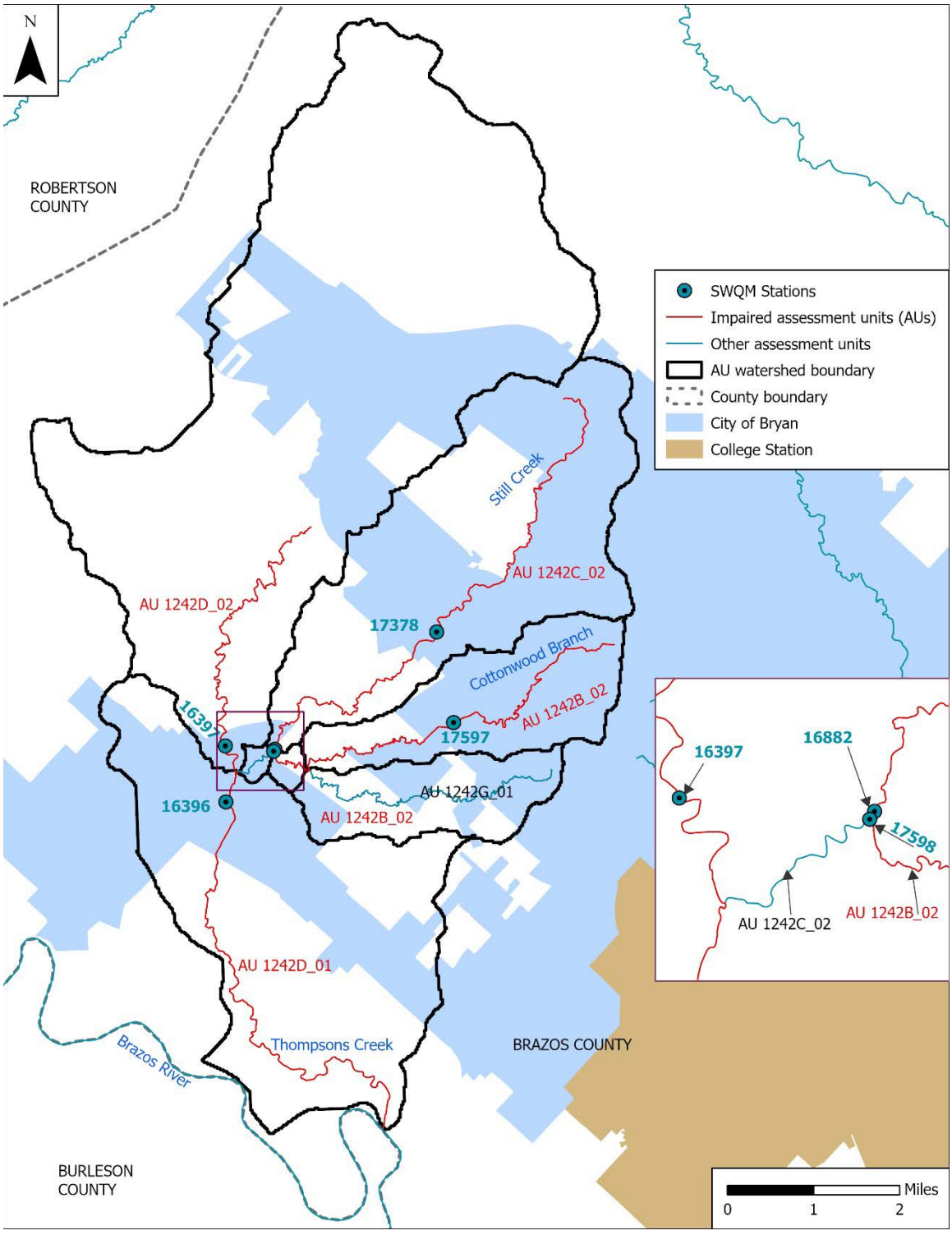


Figure 2. Texas Commission on Environmental Quality (TCEQ) surface water quality monitoring (SWQM) stations in the Thompsons Creek watershed with recorded *E. coli* data.

Discrete Measurements

Streamflow measurements were made periodically in conjunction with the measurement of water temperature, clarity, specific conductance, pH, and DO. Samples were also collected and analyzed for *E. coli* concentration. In total, 21 discrete streamflow and water quality properties were measured from January 2020–March 2021 in accordance with TCEQ's most recent SWQM procedures (TCEQ 2012) at each of the six SWQM stations.

All the streams are relatively shallow at the monitoring sites; water depths are less than 3 feet. Therefore, stream measurements were made while wading using a Sontek FlowTracker2 acoustic doppler velocimeter (ADV) flowmeter, following the methodology and best practices described in Turnipseed and Sauer (2010) and Mueller et al. (2010) .

Water samples for *E. coli* measurement were collected via sampling techniques described in TCEQ (2012) and transported on ice to Aqua-Tech Laboratories, Inc. in the city of Bryan, which is accredited by the National Environmental Laboratory Accreditation Program for analysis. Samples were transported within 2 hours of collection to the laboratory and analyzed using the enzyme substrate coliform test (9223-B method) described in American Public Health Association standard (APHA) methods for examination of water and wastewater (APHA 2018).

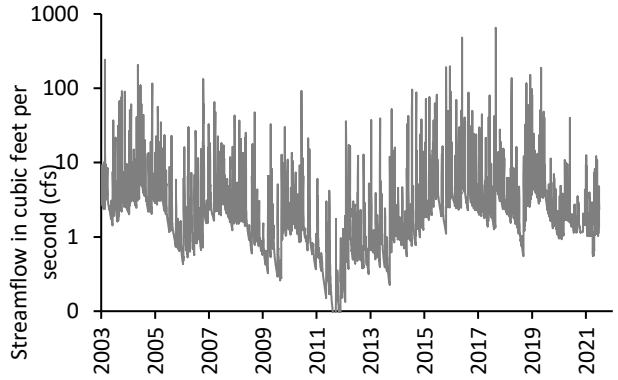
Other water quality field parameters (pH, DO, specific conductance, water temperature, and transparency) were measured following methods detailed in TCEQ (2012). To ensure quality control requirements for sample collection, data management, and documentation described in TCEQ (2012), a quality assurance project plan (QAPP) for this activity was prepared and approved by TCEQ. The QAPP describes measurement, handling, and analysis methods and equipment used for all monitored parameters.

Streamflow and Water Quality Properties

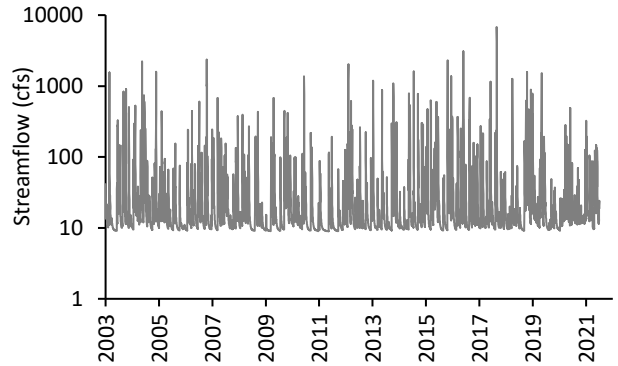
Streamflows

Figure 3 shows plots of simulated streamflows for the 2003–2021 period for flows estimated in Schramm et al. (2021). Figure 4 shows timeseries plots for flows derived using the drainage area ratio method.

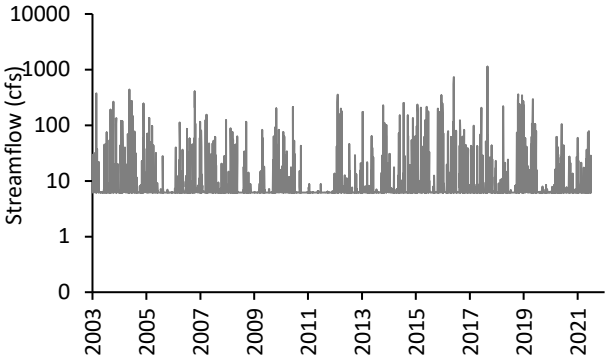
At the most downstream SWQM station on Thompsons Creek, 16396, naturalized streamflows were adjusted to include total effluent discharges from all the upstream permitted wastewater treatment facilities (WWTFs; Table 2). The adjusted TMDL flows range from 9.0 cubic feet per second (cfs) to 6803.1 cfs. There are no permitted discharges into Thompsons Creek above station 16397, and as such, naturalized flows were not adjusted to TMDL flows at this station. Estimated naturalized streamflows for Still Creek ranged from zero to a maximum of 1131 cfs. Because station 16882 is located downstream of the outfall for the Still Creek WWTF with a permitted maximum discharge of 6.19 cfs, the adjusted minimum TMDL flow is 6.19 cfs. Like the portion of Still Creek above the outfall for the Still Creek WWTF, the minimum estimated flow in Cottonwood Branch is zero at all stations, indicating that both that portion of Still Creek and Cottonwood Branch dry out during prolonged or extreme drought conditions.



(a) Surface water quality monitoring (SWQM) station 16397



(b) SWQM station 16396



(c) SWQM station 16882

Figure 3. Timeseries plot of daily mean streamflow data at SWQM stations (a) 16397 on Thompsons Creek, assessment unit (AU) 1242D_02; (b) 16396 on Thompsons Creek, AU 1242D_01; and (c) 16882 on Still Creek, AU 1242C_02.

Table 2. Permitted wastewater treatment facilities (WWTF) upstream of surface water quality monitoring station 16396 in the Thompsons Creek watershed.

Receiving assessment unit	Facility	Primary discharge type	Permitted discharge (cubic feet per second)
1242D_01	Riverside WWTF	Treated domestic wastewater	0.06
1242C_02	Still Creek WWTF	Treated domestic wastewater	6.19
1242B_01	Sanderson Farms, Inc.	Poultry processing wastewater	2.60
		Total	8.85

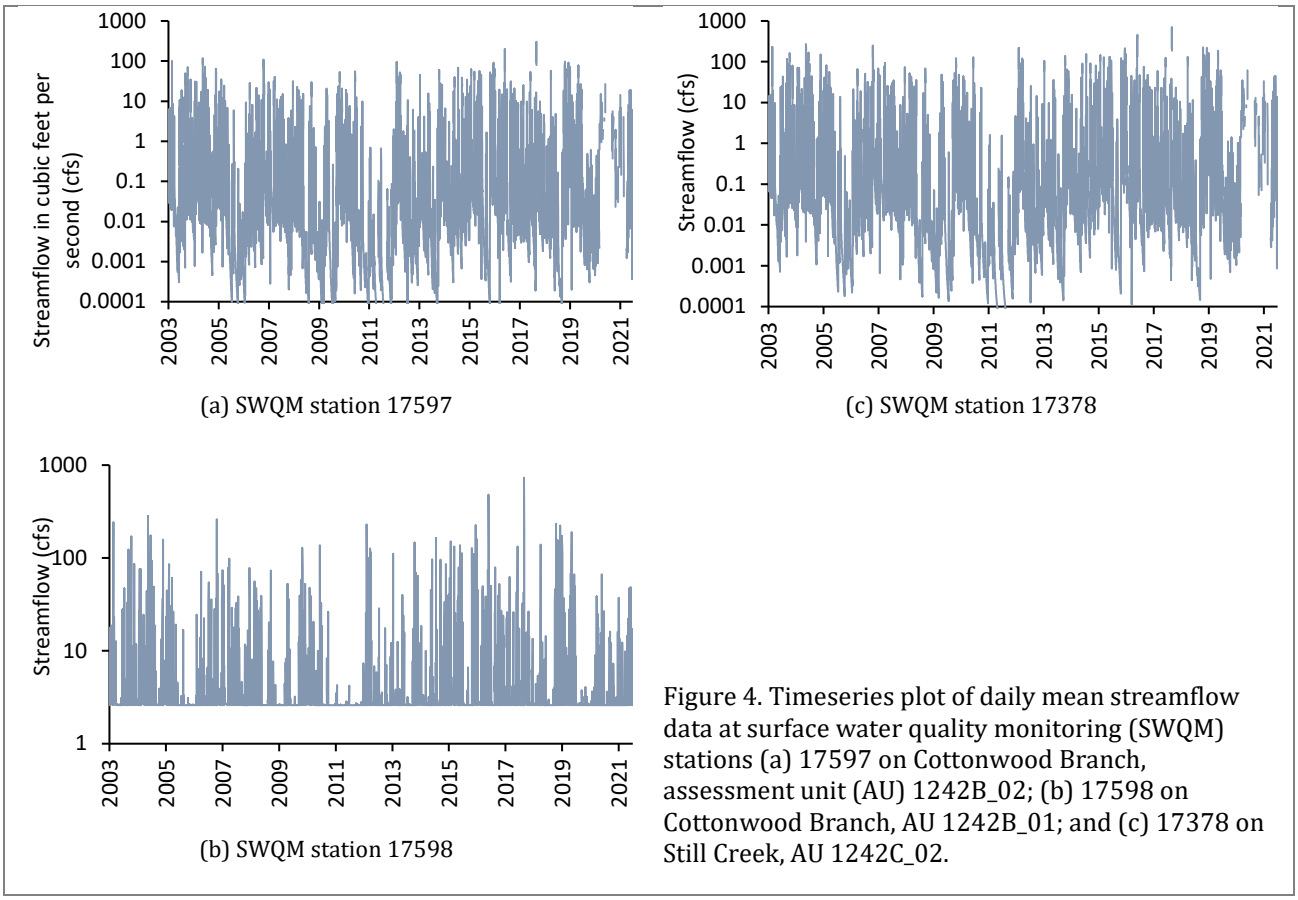


Figure 4. Timeseries plot of daily mean streamflow data at surface water quality monitoring (SWQM) stations (a) 17597 on Cottonwood Branch, assessment unit (AU) 1242B_02; (b) 17598 on Cottonwood Branch, AU 1242B_01; and (c) 17378 on Still Creek, AU 1242C_02.

Water Quality

Discrete streamflow and water quality parameter values measured during the January 2020–March 2021 period are presented in tables 6–11. All data was uploaded to TCEQ's SWQMIS database and can be accessed at https://www80.tceq.texas.gov/SwqmisPublic/index.htm.

Effect of precipitation events on water quality parameters

Water quality parameters are always changing from day to day (and even minute to minute), especially due to the influence of precipitation events and thus runoff from the watershed. It is therefore important that water quality samples be collected on different days after precipitation events if representative average water quality conditions are being assessed.

For this water quality monitoring activity, most sampling occurred within a week of a precipitation event. The value for the number of days since a precipitation event ranged from 0 to 24 days. Generally, *E. coli* concentration, streamflow, conductance, and water temperature increased with increasing days after precipitation events (Table 3). Specific conductance had the highest positive correlation with the number of days since the precipitation event, whereas DO had the highest negative correlation.

Table 3. Correlation of days since precipitation event with other measured water quality parameters at surface water quality monitoring stations in the Thompsons Creek watershed (01/2020–03/2022).

Monitoring station	Waterbody depth	*E. coli*	Streamflow	Dissolved oxygen	pH	Specific conductance	Water temperature	Transparency
17597	-0.13	-0.33	-0.32	-0.57	-0.23	0.78	0.40	0.08
17598	0.09	-0.18	-0.32	-0.33	0.29	0.65	0.43	-0.12
17378	0.19	-0.18	-0.31	-0.49	-0.51	0.73	0.42	0.56
16882	0.01	-0.29	-0.26	-0.34	0.41	0.45	0.47	-0.08
16397	0.23	-0.13	-0.04	-0.40	-0.34	-0.31	0.42	0.32
16396	-0.27	-0.03	-0.45	-0.42	0.46	0.66	0.44	-0.07

Dissolved Oxygen

DO is required for the metabolism of aerobic organisms in water and influences inorganic chemical reactions. DO analysis measures the amount of gaseous oxygen dissolved in an aqueous solution. Texas water quality standards require DO concentrations to be sufficient to support existing, designated, presumed, and attainable aquatic life uses. The establishment of numerical criteria for aquatic life is highly dependent on desired use, sensitivities of aquatic communities, and local physical and chemical characteristics. Six subcategories of aquatic life use are established. They include minimal, limited, intermediate, high, and exceptional aquatic life and oyster waters. For freshwater bodies, perennial streams are generally presumed to have a high aquatic life use and corresponding DO criteria (a 24-hour DO mean[6] of at least 5.0 milligrams per liter [mg/L] and 24-hour minimum DO concentration of 3.0 mg/L). Intermittent streams are presumed to have a limited aquatic life use and corresponding DO criteria (a 24-hour DO mean of at least 2.0 mg/L and 24-hour minimum DO concentration of 1.5 mg/L). The DO measurements taken in this activity and presented in this report were instantaneous measurements and do not represent the daily 24-hour minimum or average. However, as shown in Table 4, the minimum instantaneous value for DO in several AUs was below the 24-hour average or minimum DO.

[6] Dissolved oxygen means are applied as a minimum average over a 24-hour period

Table 4. Measured dissolved oxygen (DO) at surface water quality monitoring (SWQM) stations in the Thompsons Creek watershed, January 2020–March 2022.

Assessment unit (AU)	SWQM station	AU classification	Numerical criteria for DO, for the AU class		Instantaneous in-situ measurements		
			24-hour average (mg/L)	24-hour minimum (mg/L)	Minimum (mg/L)	Mean (mg/L)	Maximum (mg/L)
1242B_01	17598	Intermittent	1.5	2	6.4	8.8	14.2
1242B_02	17597	Intermittent	1.5	2	0.6	7.9	15.8
1242C_01	-	Perennial	3	5	-	-	-
1242C_02	16882	Perennial	3	5	5.4	6.9	10.0
1242D_01	16396	Perennial	3	5	5.9	7.6	11.1
1242D_02	16397	Intermittent	1.5	2	0.6	4.1	11.4
1242G_01	-	Intermittent	1.5	2	-	-	-

mg/L: milligram per liter

Table 5 shows a high negative correlation between the number of days after precipitation event and water temperature. Long days with no precipitation events lead to high water temperatures, which in turn result in reductions in DO. Also, high volume inflows following rainfall events that significantly disturb stratification can lead to increased DO, and as such, longer days with no precipitation events would lead to low DO levels.

Table 5. Correlation of dissolved oxygen with other measured water quality parameters at surface water quality monitoring stations in the Thompsons Creek watershed (01/2020–03/2022).

Monitoring station	Waterbody depth	*E. coli*	Streamflow	Days after precipitation	pH	Specific conductance	Water temperature	Transparency
17597	0.01	0.02	0.12	-0.57	0.22	-0.25	-0.53	0.17
17598	-0.32	-0.18	-0.28	-0.33	0.35	-0.28	-0.82	0.40
17378	-0.08	0.34	0.15	-0.49	0.77	-0.35	-0.71	-0.25
16882	-0.08	-0.28	-0.11	-0.34	0.21	-0.17	-0.61	0.31
16397	-0.24	0.41	-0.12	-0.40	0.55	0.08	-0.58	-0.08
16396	-0.22	-0.02	0.29	-0.42	-0.14	-0.49	-0.89	0.14

pH

The acidity or basicity of water is indicated by pH, which is a function of the molar concentration of hydrogen ions in solution. Acidic waters have relatively large hydrogen ion concentrations and therefore small pH values (< 7). Alkaline waters have relatively small hydrogen ion concentrations and large pH values (> 7), and neutral waters have pH values of approximately 7. The pH of surface water affects the solubility and availability of some nutrients and toxic metals. The Texas water quality standards require that pH levels in all surface water in the state be maintained to not interfere with the reasonable use of such water. Federal and state regulations suggest that pH values remain between approximately 6.5 and 8.5 to ensure the quality of water for recreational use, aquatic life, and drinking water (TCEQ 2018). In the watershed, pH values ranged from a minimum of 6.9 standard units recorded in December 2021 at SWQM station 16397 to a maximum of 8.6 standard units in June 2020 on Cottonwood Branch AU 1242B_01.

pH values measured in the watershed did not have a noticeable significant correlation with other parameters. The coefficient of determination for pH relative to other parameters was low, indicating that changes in other parameters do not necessarily lead to changes in pH.

E. coli Concentration

Elevated concentrations of bacteria in the water can make humans sick if they come into contact with it. Therefore, to maintain water quality in Texas water bodies, the Texas water quality standards have adopted criteria for bacteria that is protective of recreation for several recreation-use-designated water bodies. For indication of bacteria levels in freshwater, the standards recommend establishing *E. coli* concentrations, expressed in either colony forming units (cfu) or most probable number (MPN) of bacteria per 100 milliliters. The standards also categorize recreation uses into five categories: (i) primary contact recreation 1; (ii) primary contact recreation 2; (iii) secondary contact recreation 1; (iv) secondary contact recreation 2; and (v) noncontact recreation waters. Water bodies in Texas are presumed to have contact recreation except where specifically proven otherwise by a use-attainability analysis. Cottonwood Branch is a freshwater body with secondary contact recreation 1 use, whereas Still Creek and Thompsons Creek have primary contact recreation 1 uses. Primary contact recreation 1 use activities involve a significant risk of water ingestion (e.g., swimming), whereas secondary contact recreation 1 uses have limited body contact incidental to the shoreline activity (e.g., fishing) and are presumed to pose less risk of water ingestion. The associated criterion for *E. coli* for these category uses and summary statistics for the measured values from January 2020 to March 2021 are listed Table 6.

Table 6. Summary statistics for *E. coli* measurements (01/2020–03/2022) and applicable bacteria criteria in the Thompsons Creek watershed.

Assessment unit (AU)	Surface water quality monitoring station	Designated use	*E. coli* criteria (cfu/100mL)	Observed value (cfu/100mL)		
				Minimum	Geomean	Maximum
1242B_01	17598	Secondary contact recreation 1	630	770	1774	9900
1242B_02	17597	Secondary contact recreation 1	630	6	160	8400
1242C_01	-		-	-	-	-
1242C_02	16882	Primary contact recreation 1	126	100	552	5120
1242D_01	16396	Primary contact recreation 1	126	770	1599	4600
1242D_02	16397	Primary contact recreation 1	126	35	363	3600
1242G_01	-		-	-	-	-

cfu/100mL = colony forming units per 100 milliliters

The correlation of *E. coli* values with streamflows was significantly high in the Cottonwood Branch subwatershed (Table 7). With coefficients of determination of 0.88 and 0.8 at monitoring gages 17597 and 17598, it can be inferred that whenever there are high flows in Cottonwood Branch, *E. coli* levels are high. Of all the watersheds, the Cottonwood Branch watershed is the most urban, and as such, most of the flows in the water body are likely from point sources and/or urban storm runoff.

Table 7. Correlation of *E. coli* concentrations with other measured water quality parameters at surface water quality monitoring stations in the Thompsons Creek watershed (01/2020–03/2022).

Monitoring station	Waterbody depth	Days after precipitation	Streamflow	Dissolved oxygen	pH	Specific conductance	Water temperature	Transparency
17597	-0.11	-0.33	0.94	0.02	0.25	-0.37	0.08	-0.36
17598	0.42	-0.18	0.89	-0.18	-0.22	-0.31	0.09	-0.16
17378	0.15	-0.29	0.31	0.34	0.24	-0.23	-0.33	-0.16
16882	-0.37	-0.29	0.10	-0.28	-0.39	-0.10	-0.31	0.27
16397	0.05	-0.13	-0.02	0.41	0.14	-0.20	-0.24	-0.31
16396	0.21	-0.03	-0.10	-0.02	0.04	0.09	-0.12	0.06

Conductivity

Conductivity is an indirect measure of the ion concentration in water. Conductivity is often used as a surrogate for total dissolved solids (TDS) or salinity. Large concentrations of TDS can be toxic to aquatic life and can reduce habitat. Conductivity is affected by temperature: warmer water dissolves ions better, increasing the conductivity. For this reason, conductivity in water is standardized to 25° C, which is called specific conductivity (SPC), measured in microsiemens per centimeter (µS/cm). Specific conductance values ranged from a minimum of 192 µS/cm recorded in April 2020 at SWQM station 17378 on Still Creek AU 1242C_02 to a maximum of 3000 µS/cm recorded in August 2020 at station 17598 on Cottonwood Branch AU 1242B_01 (Figure 5). Generally, conductance was positively correlated with water temperature and pH and negatively correlated with DO, *E. coli*, and water body depth.

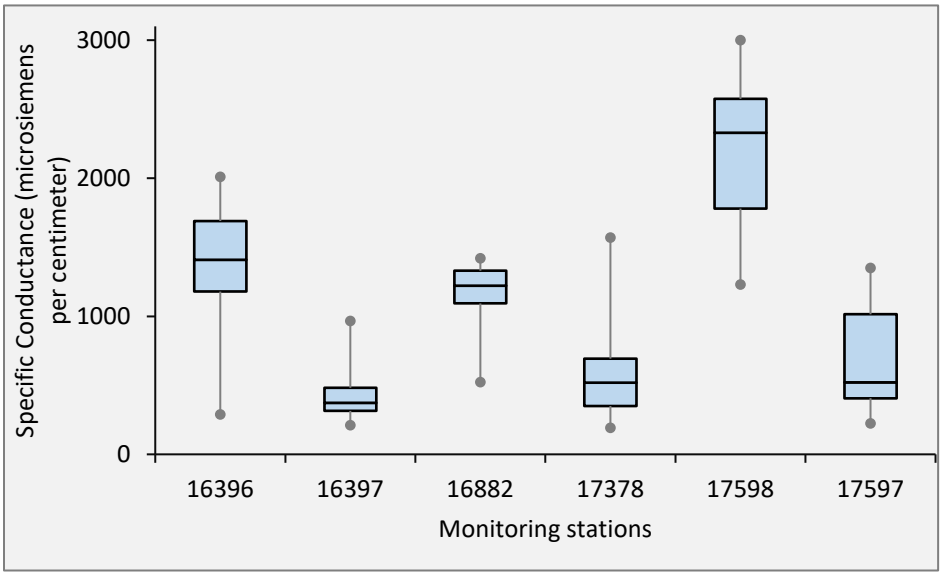


Figure 5. Box plot for measured specific conductivity values at different monitoring stations in the Thompsons Creek watershed.

Temperature

Water temperature affects many physical, chemical, and biological processes in aquatic systems. As an unclassified segment, the Thompsons Creek watershed has no site-specific standard for temperature. For evaluation purposes, the standards criteria for the classified water body receiving flows from Thompsons Creek (Brazos River above Navasota River, segment 1242D), which has a receiving water maximum temperature criterion of 95 ^{0}F (TCEQ 2018), was used. In the watershed, water temperature values ranged from a minimum of 43^{0}F recorded in January 2021 at SWQM station 16397 on Still Creek to a maximum of 89^{0}F recorded in June 2021 at SWQM station 17597 on Cottonwood Branch.

Turbidity

Turbidity is a measure of water clarity. Large turbidity values can block sunlight required for photosynthesis by aquatic vegetation and subsequently reduce aquatic life and diversity. Turbidity can be used as a surrogate for suspended solids concentration but requires calibration at each location and for different seasons to ensure accuracy. A Secchi disc is a simple way to measure turbidity. Secchi depth values that are high indicate clearer water, and low Secchi depths indicate high turbidity. Secchi depth values ranged from a minimum of 0.07 meters recorded in May 2020 at SWQM station 17598 on Cottonwood Branch AU 1242B_01 to a maximum of 1.02 meters recorded in March 2022 at station 16882 on Still Creek AU 1242B_01.

Water transparency/turbidity values had a negative correlation with streamflow and to a lesser extent with pH values (Table 8). However, the coefficient of determination between turbidity and any measured parameter was insignificant, indicating that changes in other parameters do not necessarily translate into changes in turbidity.

Table 8. Correlation of measured Secchi disc values with other water quality parameters at surface water quality monitoring stations in the Thompsons Creek watershed (01/2020–03/2022).

Monitoring station	Days since precipitation	Waterbody depth	*E. coli*	Streamflow	Dissolved oxygen	pH	Specific conductance	Water temperature
17597	0.08	0.30	-0.36	-0.30	0.17	-0.24	0.16	-0.37
17598	-0.12	0.13	-0.16	-0.11	0.40	-0.03	-0.31	-0.38
17378	0.56	-0.01	-0.16	-0.48	-0.25	-0.17	0.64	0.02
16882	-0.08	-0.16	0.27	-0.41	0.31	-0.23	0.05	-0.56
16397	0.32	-0.18	-0.31	-0.34	-0.08	-0.28	-0.01	0.22
16396	-0.07	-0.16	0.06	-0.22	0.14	-0.13	0.20	-0.43

Summary

This report describes the study area, sample collection, and processing methods for water quality data from six sites located in the Thompsons Creek watershed. Water quality data discussed in this report was uploaded to TCEQ's SWQMIS database and can be accessed at https://www80.tceq.texas.gov/SwqmisPublic/index.htm. The data and methods presented in this report support analyses of the relations among water quality impairment status and causes and basin hydrology in the watershed.

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Appendix A

Table A-1. Measured water quality data at SWQM station 17598 on AU 1242B_01, Cottonwood Branch, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli*, Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (°C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.21	2400	1.62	1.4	9.6	8.4	2530	11.8	0.18
2/26/2020	6	0.22	1900	1.8	1.4	10.5	8.5	2420	11.8	0.11
4/1/2020	10	0.15	2000	2.15	1.7	10.1	8.6	2320	16.8	0.11
4/29/2020	0	0.42	9900	1.75	12.0	6.4	8.1	1230	21.8	0.13
5/26/2020	1	0.15	2000	1.9	1.9	8.6	8.5	2330	22.7	0.07
6/25/2020	1	0.27	770	1.8	2.8	7.2	8.4	1370	25.7	0.20
7/21/2020	13	0.24	1700	1.45	2.0	7.3	8.6	2940	27.2	0.15
8/25/2020	24	0.23	1300	1.15	1.5	7.2	8.4	3000	25.5	0.16
10/13/2020	15	0.18	1700	1.25	1.4	8.6	8.5	2810	20.0	0.13
11/10/2020	12	0.18	1700	1.083	1.7	7.0	8.4	2700	22.3	0.17
12/14/2020	2	0.24	2000	1.38	2.1	10.4	8.3	2560	10.3	0.10
1/14/2021	3	0.18	1100	1.33	2.8	11.1	8.3	1350	8.7	0.20
6/15/2021	6	0.37	1600	0.97	2.3	7.3	8.1	2160	27.4	0.12
7/14/2021	1	0.37	1400	0.93	3.3	7.2	7.9	1240	25.2	0.14
8/12/2021	24	0.49	2400	1.08	1.6	6.5	8.3	2750	27.8	0.15
10/5/2021	3	0.18	1730	1.15	1.6	7.9	8.3	2505	21.4	0.15
11/1/2021	4	0.30	2160	1.05	1.6	8.2	8.3	2575	17.0	0.23
12/12021	6	0.21	1120	1	2.0	9.1	8.2	2286	15.6	0.19
1/13/22	1	0.30	921	0.85	2.2	10.7	8.4	1780	10.7	0.22
2/10/22	5	0.27	1300	0.98	2.2	10.6	8.3	2119	8.3	0.25
3/2/2022	4	0.30	3230	1.08	1.8	14.2	8.5	1287	13.3	0.26

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

Table A-2. Measured water quality data at SWQM station 17597 on AU 1242B_02, Cottonwood Branch, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli,* Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (^{0}C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.02	130	0.78	0.3	8.9	7.4	391	10.4	0.46
2/26/2020	6	0.02	110	1	0.1	11.7	7.6	521	10.9	0.47
4/1/2020	10	0.01	33	1.3	0.0	10.3	7.4	787	20.0	0.15
4/29/2020	0	0.05	8400	1	4.6	7.6	7.7	302	22.9	0.14
5/26/2020	1	0.01	330	1.32	0.2	9.3	7.6	602	24.8	0.30
6/25/2020	1	0.01	460	1.15	0.6	7.0	7.4	224	26.6	0.17
7/21/2020	13	0.01	6	0.95	0.0	0.6	7.3	1080	27.7	0.38
8/25/2020	24	0.01	10	0.83	0.0	3.6	7.4	1350	26.2	0.61
10/13/2020	15	0.00	50	0.78	0.0	5.0	7.7	1070	20.9	0.12
11/10/2020	12	0.00	110	0.68	0.0	4.6	7.2	923	21.5	0.60
12/14/2020	2	1.00	240	0.7	0.0	5.4	7.7	462	9.0	0.57
1/14/2021	3	1.00	770	0.85	0.9	11.2	7.8	304	8.1	0.55
6/15/2021	6	1.00	110	0.63	0.3	9.0	7.8	975	31.5	0.26
7/14/2021	1	1.00	1400	0.5	0.4	7.8	7.2	236	27.8	0.38
8/12/2021	24	1.00	10	0.57	0.0	3.4	7.3	1150	29.4	0.39
10/5/2021	3	1.00	461	0.57	0.0	7.6	7.4	455.9	22.5	0.52
11/1/2021	4	1.00	144	0.68	0.0	8.7	7.42	509	16.7	0.70
12/12021	6	1.00	291	0.62	0.0	7.5	7.4	406.6	14.8	0.51
1/13/22	1	0.30	1200	0.63	0.1	10.4	7.5	488.1	10.2	0.20
2/10/22	5	0.30	167	0.6	1.3	11.3	7.0	1262	12.8	0.54
3/2/2022	5	0.18	84.2	0.68	0.2	15.8	7.6	1014	14.0	0.77

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

Table A-3. Measured water quality data at SWQM station 17378 on AU 1242C_02, Still Creek, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli,* Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (^{0}C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.01	58	0.38	0.2	6.0	7.3	347	11.0	0.57
2/26/2020	6	0.03	96	0.5	0.3	8.4	7.3	470	10.9	0.24
4/1/2020	10	0.01	44	0.5	0.1	7.4	7.2	785	19.0	0.63
4/29/2020	0	0.10	12000	0.5	10.4	5.8	7.3	192	21.2	0.12
5/26/2020	1	0.01	250	0.7	0.2	4.1	7.3	375	23.4	0.40
6/25/2020	1	0.01	870	0.67	0.8	5.0	7.2	225	25.6	0.21
7/21/2020	13	0.01	18	0.53	0.0	3.1	7.2	1570	27.4	0.68
8/25/2020	24	0.50	1400	0.5	0.0	0.8	7	1240	25.1	0.60
10/13/2020	15	1.00	20	0.47	0.0	1.0	7	685	21.0	0.52
11/10/2020	12	1.00	75	0.42	0.0	4.3	7.2	529	18.7	0.52
12/14/2020	2	1.00	24	0.4	0.0	9.6	7.5	396	9.4	0.34
1/14/2021	3	1.00	46000	0.5	1.7	10.5	7.5	331	7.5	0.40
6/15/2021	6	1.00	57	0.38	0.0	6.7	7.3	744	28.3	0.18
7/14/2021	1	1.00	150	0.28	1.2	5.1	7.2	518	25.7	0.48
8/12/2021	24	1.00	46	0.37	0.1	5.6	7	879	28.7	0.54
10/5/2021	3	1.00	214	0.27	0.2	4.5	7.3	314.2	22.8	0.29
11/1/2021	4	1.00	597	0.32	0.0	4.6	6.98	349.7	15.7	0.41
12/12021	6	1.00	81.3	0.3	0.0	6.5	7.3	453.7	14.3	0.52
1/13/22	1	0.30	2420	0.22	0.7	8.6	7.4	597	10.3	0.41
2/10/22	5	0.32	365	0.35	3.7	9.6	7.4	539	10.0	0.40
3/2/2022	5	0.30	178	0.45	0.5	10.9	7.9	693	11.7	0.53

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

Table A-4. Measured water quality data at SWQM station 16882 on AU 1242C_02, Still Creek, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli,* Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (^{0}C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.52	250	1.53	2.4	9.0	8	1360	12.8	0.90
2/26/2020	6	0.37	100	1.5	2.8	9.3	8.1	1210	14.0	0.72
4/1/2020	10	0.58	180	2.5	2.4	7.9	8.1	1360	18.9	0.35
4/29/2020	0	0.42	1600	2.6	24.0	6.3	8	1420	23.9	0.22
5/26/2020	1	0.34	290	2.2	2.6	7.7	8.2	1270	23.5	0.52
6/25/2020	1	0.58	980	2.32	4.6	6.4	7.6	523	25.4	0.14
7/21/2020	13	0.49	460	2.28	2.5	6.0	8.2	1330	28.1	0.38
8/25/2020	24	0.50	230	1.62	2.8	5.8	8	1330	26.6	0.76
10/13/2020	15	0.37	260	1.93	2.7	6.4	8	1300	22.4	0.47
11/10/2020	12	0.30	170	2.08	2.6	6.4	7.9	1380	22.3	0.50
12/14/2020	2	0.29	440	1.85	2.9	8.1	7.7	1180	12.6	0.77
1/14/2021	3	0.38	550	1.9	3.8	10.0	7.8	673	10.1	0.81
6/15/2021	6	0.54	140	2	2.7	6.4	7.8	1250	27.8	0.74
7/14/2021	1	0.37	350	1.95	4.5	6.8	7.7	998	25.7	0.57
8/12/2021	24	0.27	520	2.18	3.0	5.8	8	1380	28.7	0.46
10/5/2021	3	0.34	914	2	2.7	5.9	7.8	1093	22.6	0.46
11/1/2021	4	0.27	5120	1.85	2.6	5.5	7.76	1191	18.0	0.85
12/12021	6	0.67	727	1.6	3.0	5.4	7.6	1088	16.3	0.81
1/13/22	1	0.34	2420	1.25	3.1	6.3	7.7	996	12.5	0.67
2/10/22	5	0.37	2420	1.52	3.8	6.9	7.7	1154	12.8	0.53
3/2/2022	4	0.30	3180	1.62	2.7	7.5	7.8	1221	14.3	1.02

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

Table A-5. Measured water quality data at SWQM station 16396 on AU 1242D_01, Thompsons Creek, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli,* Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (^{0}C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.46	920	2.98	5.4	9.4	8.2	1690	12.5	0.33
2/26/2020	6	0.35	920	3	5.9	9.3	8.2	1390	12.5	0.22
4/1/2020	10	0.53	4600	4.5	5.0	8.3	8.3	1650	17.2	0.19
4/29/2020	0	0.58	1700	4.6	8.2	6.9	8.1	1490	22.5	0.17
5/26/2020	1	0.52	870	4	7.1	7.4	8.1	1210	22.3	0.17
6/25/2020	1	0.55	2000	4.55	13.0	6.8	7.8	598	25.0	0.16
7/21/2020	13	0.46	1400	3.63	5.1	6.4	8.4	1920	27.3	0.26
8/25/2020	24	0.43	1200	2.52	5.2	6.4	8.1	2010	25.6	0.15
10/13/2020	15	0.43	1300	3.12	4.9	7.2	8.2	1760	21.0	0.21
11/10/2020	12	0.46	2700	3.28	5.2	6.6	8.2	1840	21.3	0.25
12/14/2020	2	0.43	1400	2.88	5.7	9.2	7.9	289	10.9	0.16
1/14/2021	3	0.67	2400	3.85	15.0	11.1	7.7	508	7.5	0.20
6/15/2021	6	0.64	2400	4.13	7.5	5.9	7.6	1260	26.8	0.19
7/14/2021	1	0.67	770	3.35	13.0	7.0	7.7	886	25.2	0.18
8/12/2021	24	0.52	1100	2.5	6.0	5.9	8.1	1770	27.8	0.25
10/5/2021	3	0.61	1730	3.3	6.5	6.7	7.9	1342	22.0	0.16
11/1/2021	4	0.61	4260	2.85	5.0	6.7	7.89	1561	16.5	0.34
12/12021	6	0.64	1050	2.68	6.1	7.4	7.7	1408	14.5	0.52
1/13/22	1	0.43	1410	2.45	7.9	8.6	7.6	1035	11.1	0.34
2/10/22	5	0.40	1550	3.27	8.6	8.8	7.7	1179	10.7	0.27
3/2/2022	5	0.37	2420	3.12	6.7	8.3	8.0	1462	11.9	0.55

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

Table A-6. Measured water quality data at SWQM station 16397 on AU 1242D_02, Thompsons Creek, January 2020–March 2022.

Date	Days since precipitation event (days)	Depth of bottom of water body at sample site (feet)	*E. coli* (MPN/100mL)	*E. coli,* Colilert, holding time (hours)	Instantaneous streamflow (cfs)	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Water temperature (^{0}C)	Transparency, Secchi depth (meters)
1/30/2020	2	0.30	610	2.65	0.1	4.2	7.7	322	10.6	0.17
2/26/2020	6	0.32	730	2.75	0.4	5.5	7.6	294	11.3	0.16
4/1/2020	10	0.43	310	4	0.0	1.4	7	287	16.7	0.17
4/29/2020	0	0.52	1200	3.43	2.4	4.0	7.6	705	21.3	0.16
5/26/2020	1	0.49	610	3	2.4	4.3	7.4	377	22.1	0.29
6/25/2020	1	0.37	410	3.43	2.1	4.2	7.2	359	24.1	0.19
7/21/2020	13	0.28	35	3.28	0.0	1.7	7.2	371	25.6	0.22
8/25/2020	24	0.40	48	2.18	0.0	2.6	7.3	291	24.4	0.35
10/13/2020	15	0.50	2400	2.8	0.0	0.6	7.1	350	19.1	0.26
11/10/2020*	12	0.00	-	-	0.0	-	-	-	-	-
12/14/2020	2	1.00	58	2.52	7.9	0.9	7.3	883	9.1	0.08
1/14/2021	3	0.64	3600	2.88	1.3	11.4	7.4	211	5.9	0.15
6/15/2021	6	0.30	1600	3.45	5.5	2.6	7.2	605	26.1	0.20
7/14/2021	1	0.46	520	2.6	0.0	4.8	7.2	639	24.9	0.30
8/12/2021	24	1.00	99	2.35	5.0	1.2	7	389	26.9	0.36
10/5/2021	3	0.40	196	2.56	0.0	1.6	7.0	441.4	20.0	0.33
11/1/2021	4	0.40	38.9	2.52	0.0	1.7	7.06	321.6	14.3	0.35
12/12021	6	0.40	548	2.07	0.3	3.3	6.9	289.2	12.7	0.45
1/13/22	1	0.43	722	1.72	1.3	6.4	7.2	417	8.8	0.22
2/10/22	5	0.37	613	2.42	2.3	9.5	7.3	440.5	7.8	0.19
3/2/2022	4	0.24	292	2.45	1.3	9.4	7.8	966	9.8	0.43

[cfs, cubic feet per second; °C, degrees Celsius; µS/cm, micro-siemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; MPN/100mL, most probable number per 100 milliliters; AU, assessment unit; SWQM, surface water quality monitoring]

* Stream was dry. No streamflows