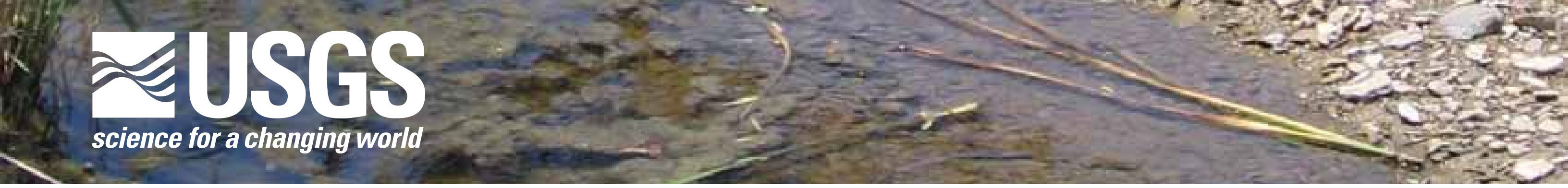

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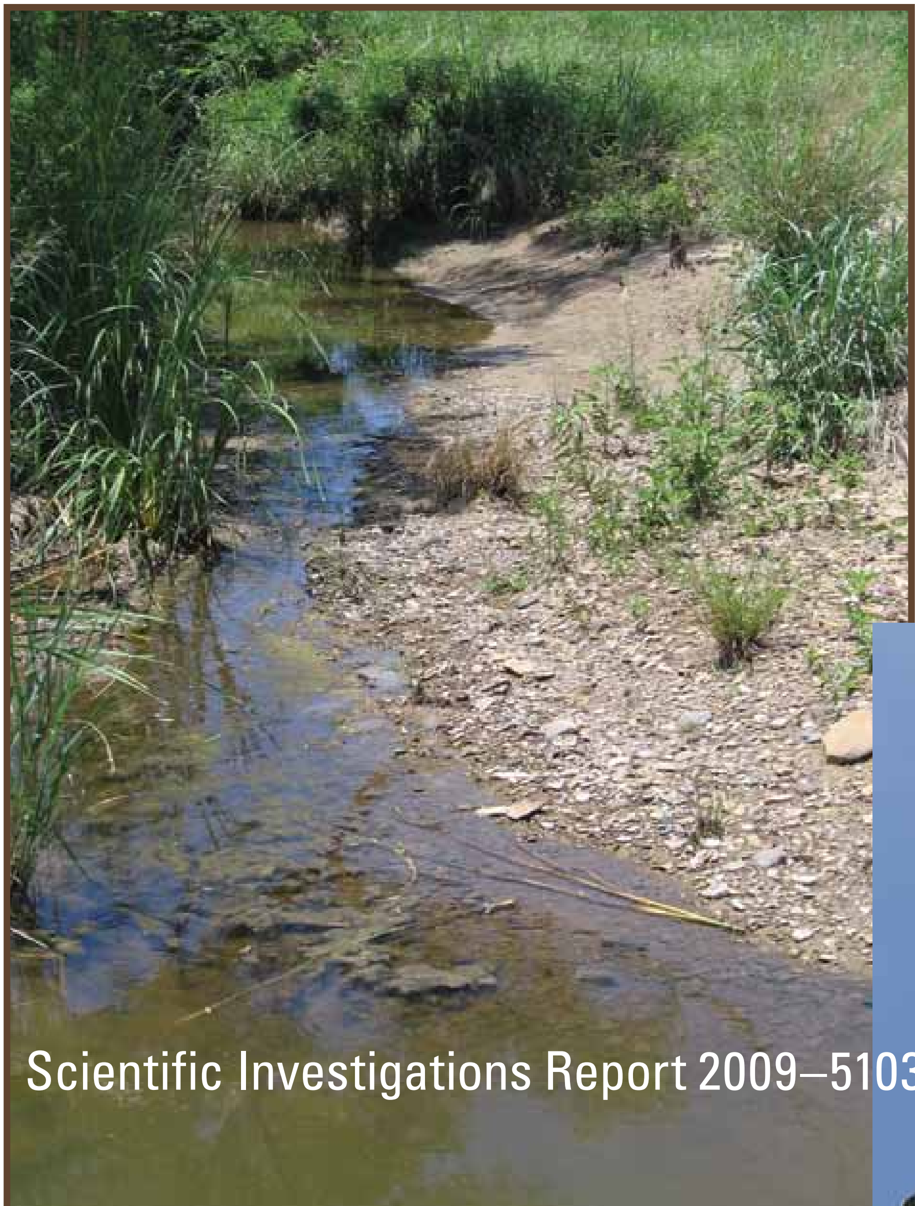
Occurrence and Distribution of Fecal Indicator Bacteria, and Physical and Chemical Indicators of Water Quality in Streams Receiving Discharge From Dallas/Fort Worth International Airport and Vicinity, North-Central Texas, 2008



Scientific Investigations Report 2009–5103

U.S. Department of the Interior
U.S. Geological Survey

Front cover:

Left, Cottonwood Creek at Bethel Rd., Grapevine, Tex., looking upstream, June 2, 2008.

Right, Airplane approaching Dallas/Fort Worth International Airport for landing from north side of airport, May 1, 2008.

Back cover:

Left, Little Bear Creek at State Highway 360, Euless, Tex., looking downstream from below State Highway 360 bridge, April 7, 2008.

Right, Grapevine Creek at North Airfield Dr., Grapevine, Tex., looking upstream from North Airfield Dr., February 20, 2008.

Occurrence and Distribution of Fecal Indicator Bacteria, and Physical and Chemical Indicators of Water Quality in Streams Receiving Discharge From Dallas/Fort Worth International Airport and Vicinity, North-Central Texas, 2008

By Glenn R. Harwell and Craig A. Mobley

In cooperation with the Dallas/Fort Worth International Airport

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
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Contents

Figures

Tables

Conversion Factors, Datums, and Water-Quality Units

SI to Inch/Pound

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
meter (m)	3.281	foot (ft)
millimeter (mm)	0.03937	inch (in.)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27) and the North American Datum of 1983 (NAD 83).

Water-Quality Units

μS/cm, microsiemens per centimeter at 25 degrees Celsius

mg/L, milligrams per liter

cfu/100 mL, colony-forming units per 100 milliliters

MPN/100 mL, most-probable number per 100 milliliters

psu, practical salinity units

Occurrence and Distribution of Fecal Indicator Bacteria, and Physical and Chemical Indicators of Water Quality in Streams Receiving Discharge From Dallas/Fort Worth International Airport and Vicinity, North-Central Texas, 2008

By Glenn R. Harwell and Craig A. Mobley

Abstract

This report, done by the U.S. Geological Survey in cooperation with Dallas/Fort Worth International (DFW) Airport in 2008, describes the occurrence and distribution of fecal indicator bacteria (fecal coliform and *Escherichia* [*E.*] *coli*), and the physical and chemical indicators of water quality (relative to Texas Surface Water Quality Standards), in streams receiving discharge from DFW Airport and vicinity. At sampling sites in the lower West Fork Trinity River watershed during low-flow conditions, geometric mean *E. coli* counts for five of the eight West Fork Trinity River watershed sampling sites exceeded the Texas Commission on Environmental Quality *E. coli* criterion, thus not fully supporting contact recreation. Two of the five sites with geometric means that exceeded the contact recreation criterion are airport discharge sites, which here means that the major fraction of discharge at those sites is from DFW Airport. At sampling sites in the Elm Fork Trinity River watershed during low-flow conditions, geometric mean *E. coli* counts exceeded the geometric mean contact recreation criterion for seven (four airport, three non-airport) of 13 sampling sites. Under low-flow conditions in the lower West Fork Trinity River watershed, *E. coli* counts for airport discharge sites were significantly different from (lower than) *E. coli* counts for non-airport sites. Under low-flow conditions in the Elm Fork Trinity River watershed, there was no significant difference between *E. coli* counts for airport sites and non-airport sites. During stormflow conditions, fecal indicator bacteria counts at the most downstream (integrator) sites in each watershed were considerably higher than counts at those two sites during low-flow conditions. When stormflow sample counts are included with low-flow sample counts to compute a geometric mean for each site, classification changes from fully supporting to not fully supporting contact recreation on the basis of the geometric mean contact recreation criterion. All water temperature measurements at sampling sites in the lower West Fork Trinity River watershed were less than the maximum criterion for water temperature for the lower West Fork Trinity segment. Of the measurements at sampling sites in the Elm Fork Trinity River watershed, 95 percent were less than the maximum criterion for water temperature for the Elm Fork Trinity River segment. All dissolved oxygen concentrations were greater than the minimum criterion for stream segments classified as exceptional aquatic life use. Nearly all pH measurements were within the pH criterion range for the classified segments in both watersheds, except for those at one airport site. For sampling sites in the lower West Fork Trinity River watershed, all annual average dissolved solids concentrations were less than the maximum criterion for the lower West Fork Trinity segment. For sampling sites in the Elm Fork Trinity River, nine of the 13 sites (six airport, three non-airport) had annual averages that exceeded the maximum criterion for that segment. For ammonia, 23 samples from 12 different sites had concentrations that exceeded the screening level for ammonia. Of these 12 sites, only one non-airport site had more than the required number of exceedances to indicate a screening level concern. Stormflow total suspended solids concentrations were significantly higher than low-flow concentrations at the two integrator sites. For sampling sites in the lower West Fork Trinity River watershed, all annual average chloride concentrations were less than the maximum annual average chloride concentration criterion for that segment. For the 13 sampling sites in the Elm Fork Trinity River watershed, one non-airport site had an annual average concentration that exceeded the maximum annual average chloride concentration criterion for that segment.

Introduction

As required by the Federal Clean Water Act, the State of Texas must establish water-quality standards that describe how surface-water bodies are used and monitor the status of those water bodies relative to the standards. Texas Administrative Code, Title 30, Chapter 307, defines the Texas Surface Water Quality Standards (Texas Commission on Environmental Quality, 2008a). The designated uses for streams receiving discharge from Dallas/Fort Worth International (DFW) Airport in north-central Texas are aquatic life, contact recreation, and fish consumption. Aquatic life standards are designed to protect plant and animal species that live in or around water. Contact recreation standards are designed to ensure that water is safe for swimming and other activities involving direct human contact with water. Fish consumption standards are designed to protect people from eating contaminated fish and shellfish.

The Texas Commission on Environmental Quality (TCEQ) assesses water quality for these designated uses. When data indicate that a water body is not supporting a designated use, the water body is placed on the State 303(d) list (Texas Commission on Environmental Quality, 2008b), and the Total Maximum Daily Load (TMDL) program (Texas Commission on Environmental Quality, 2009a) works to improve water quality in the impaired water body. There are 386 water bodies on the 2008 State 303(d) list with a total of 543 impairments for all uses (Texas Commission on Environmental Quality, 2008c); 274 of those impairments are for nonsupport of the contact recreation use because of elevated bacteria in water.

The Texas Surface Water Quality Standards adopted in 2000 use *Escherichia* (*E.*) *coli*, a subgroup of fecal coliform bacteria, as the indicator bacteria to determine whether a freshwater body is impaired and does not meet the standard for contact recreation use (Texas Commission on Environmental Quality, 2008a). Fecal coliform bacteria, a subgroup of the total coliform group, are present in the intestinal tracts and feces of warm-blooded animals (Texas Commission on Environmental Quality, 2008a). The total coliform group is a large collection of different kinds of bacteria that exist in the environment (Washington State Department of Health, 2008). Total coliform, fecal coliform, and *E. coli* are all indicators of water quality. Fecal coliform and *E. coli* are the fecal indicator bacteria of this report.

Segments of the Trinity River receive flow from DFW tributaries (fig. 1) and are on the 2008 State 303(d) list because of fecal indicator bacteria. The listed segments are the lower West Fork Trinity River (Segment 0841) and the Elm Fork Trinity River below Lewisville Lake (Segment 0822) (Texas Commission on Environmental Quality, 2008b). In addition to flow from DFW tributaries, these segments receive municipal and industrial wastewater discharge and storm discharge from agricultural, industrial, and urban areas. In 2008, the U.S. Geological Survey (USGS), in cooperation with DFW, did a study to address the occurrence and distribution of fecal indicator bacteria, and the physical and chemical indicators of water quality (relative to Texas Surface Water Quality Standards), in streams receiving discharge from DFW Airport and vicinity.

Purpose and Scope

The purpose of this report is to describe the occurrence and distribution of fecal indicator bacteria (fecal coliform and *E. coli*), and the physical and chemical indicators of water quality (relative to Texas Surface Water Quality Standards), in streams receiving discharge from DFW Airport and vicinity. The findings are intended to help DFW Airport management better understand the extent to which airport discharge is responsible for the 303(d) listing for bacteria of two segments of the Trinity River downstream from the airport. Occurrence and distribution are described for low-flow conditions on the basis of analysis of samples collected at 21 sites (eight in the lower West Fork Trinity River watershed and 13 in the Elm Fork Trinity River watershed) in the tributaries on DFW Airport property and in streams receiving discharge at points upstream and downstream from DFW Airport property (which thus includes discharge from sources other than DFW Airport); and for stormflow conditions at two sites on streams receiving discharge at points downstream from DFW Airport property. Samples for low-flow conditions were collected almost monthly (10 times) from each of the 21 sites (flow permitting) during February–December 2008, thus representing all seasons. Samples for stormflow conditions were collected from the two downstream sites during three storms in March, April, and August 2008, respectively. Eight samples were collected at each downstream site during the three storms. In addition to fecal indicator bacteria, samples were analyzed for total coliform. Total coliform results are tabulated but not described because total coliform is not primarily an indicator of fecal matter; values for total coliform frequently exceeded upper reporting levels and thus are qualified as greater-than values. Physical and chemical water-quality data (water temperature, dissolved oxygen [DO], pH, specific conductance, ammonia nitrogen (ammonia), total suspended solids [TSS], and chloride) obtained from the low-flow and stormflow samples are compared with water-quality criteria supporting the uses for the 303(d)-classified segments on the lower West Fork Trinity River and the Elm Fork Trinity River (Texas Commission on Environmental Quality, 2008b).

Description of Dallas/Fort Worth International Airport and Vicinity and Sampling Sites

The DFW Airport comprises a 77.2-square-kilometer (km^2) area in north-central Texas that straddles the boundary between Tarrant and Dallas Counties (fig. 1). With respect to daily aircraft operations, DFW Airport is the third busiest airport in the world and the seventh busiest with respect to total number of passengers served (Dallas/Fort Worth International Airport, 2008).

Eight of the 21 sampling sites are on the west and south sides of DFW Airport on streams that ultimately flow into the lower West Fork Trinity River and thus are in the West Fork Trinity River watershed (fig. 1; table 1). These eight sites are in the Big Bear Creek watershed of the West Fork Trinity River watershed. Four of the eight sites are listed as “DFW Airport discharge sites” in table 1. Hereinafter, airport discharge sites, or airport sites, are those at which the major

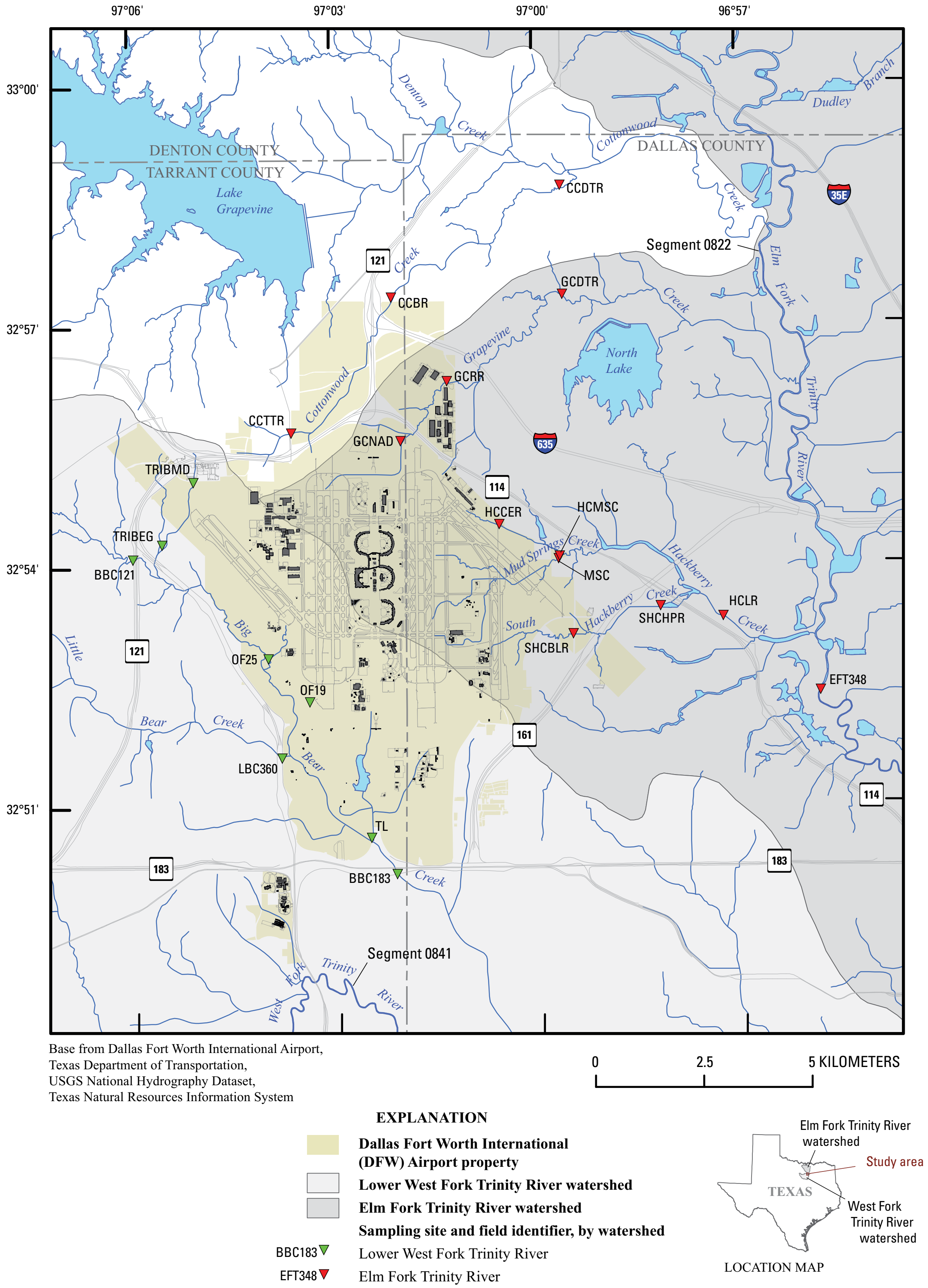


Figure 1. Location of Dallas/Fort Worth International Airport, north-central Texas, and sampling sites on streams receiving discharge from the airport and vicinity, 2008.

Table 1. Descriptive information for sampling sites on streams receiving discharge from Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

[USGS, U.S. Geological Survey; DFW, Dallas/Fort Worth International; latitude/longitude, datum is NAD 27 unless otherwise specified]

Field identifier (fig. 1)	USGS site identifier	USGS site name	DFW Airport discharge site	Latitude (decimal degrees)	Longitude (decimal degrees)
Lower West Fork Trinity River watershed					
BBC121	0804955100	Big Bear Creek at State Highway 121, Euless, Tex.	No	32.90178	097.09972
TRIBMD	0804955150	Unnamed Bear Creek tributary at Mustang Dr., Grapevine, Tex.	No	32.91777	097.08453
TRIBEG	0804955175	Unnamed Bear Creek tributary at Euless Grapevine Rd., Grapevine, Tex.	Yes	32.90492	097.09232
OF25	08049555	DFW Airport Outfall 25 at Glade Rd., Euless, Tex.	Yes	32.88095	097.06650
OF19	08049556	Unnamed tributary to Big Bear Creek (Outfall 19), Euless, Tex.	Yes	[1]32.87194	[1]097.05667
LBC360	08049558	Little Bear Creek at State Highway 360, Euless, Tex.	No	32.86045	097.06357
TL	0804956750	Trigg Lake Outfall tributary upstream of Bear Creek, Euless, Tex.	Yes	32.84353	097.04180
BBC183	08049569	Big Bear Creek at State Highway183, Euless, Tex.	No	[1]32.83556	[1]097.03583
Elm Fork Trinity River watershed					
CCTTR	08055100	Cottonwood Creek at Texan Trail Rd., Grapevine, Tex.	No	32.92762	097.06008
CCBR	08055120	Cottonwood Creek at Bethel Rd., Grapevine, Tex.	Yes	32.95549	097.03497
CCDTR	08055140	Cottonwood Creek at Denton Tap Rd., Grapevine, Tex.	No	32.97820	096.99302
GCNAD	08055510	Grapevine Creek at North Airfield Dr., Grapevine, Tex.	Yes	32.92555	097.03337
GCRR	08055512	Grapevine Creek at railroad bridge, Irving, Tex.	Yes	32.93782	097.02153
GCDTR	08055514	Grapevine Creek at Denton Tap Rd., Irving, Tex.	No	32.95554	096.99293
HCCER	08055520	Hackberry Creek upstream of Cabell and Esters Rd., Irving, Tex.	Yes	32.90795	097.00945
HCMSC	08055524	Hackberry Creek upstream of Mud Springs Creek, Irving, Tex.	Yes	32.90151	096.99439
MSC	08055526	Mud Springs Creek upstream of Hackberry Creek, Irving, Tex.	Yes	32.90126	096.99459
SHCBLR	08055530	South Hackberry Creek at Belt Line Rd., Irving, Tex.	Yes	32.88523	096.99124
SHCHPR	08055534	South Hackberry Creek at High Point Rd., Irving, Tex.	No	32.89050	096.96965
HCLR	08055538	Hackberry Creek at Love Rd., Irving, Tex.	No	32.88874	096.95426
EFT348	08055560	Elm Fork Trinity River at Spur 348, Irving, Tex.	No	[1]32.87333	[1]096.93056

[1] Datum is NAD 83.

fraction of discharge is from DFW Airport. Upstream from the most downstream (integrator) sampling site on Big Bear Creek (BBC183), Big Bear Creek watershed is 199 km^2, predominantly urban (table 2), and extends westward from DFW Airport. The watersheds of the four airport discharge sites that contribute flow at BBC183 (TRIBEG, OF25, OF19, and TL) account for 11 percent of the contributing area to BBC183, and these watersheds are greater than 50-percent urban. A major contributor to flow at BBC183 is Little Bear Creek. The watershed of sampling site LBC360 on Little Bear Creek accounts for 31 percent of the contributing area to BBC183, and this watershed is 75-percent urban. Sampling site BBC121 is the most upstream site on Big Bear Creek and likely is not affected by airport discharge. Its watershed accounts for 45 percent of the contributing area to BBC183 and is 62-percent urban. BBC121 was selected because it provides an indication of conditions in Big Bear Creek before airport influence.

Thirteen of the 21 sites are on the east and north sides of DFW Airport; 12 of those sites are on streams that flow into the Elm Fork Trinity River and thus are in the Elm Fork Trinity River watershed (fig. 1; table 1). Seven of the 13 sites are listed as “DFW Airport discharge sites” in table 1. As for the lower West Fork Trinity River sites, airport discharge sites, or airport sites, are those at which the major fraction of discharge is from DFW Airport. The most downstream (integrator) of the 13 sampling sites (EFT348) is on Elm Fork Trinity River. Contributing area to EFT348 is 6,570 km^2 and includes Lake Grapevine and Lake Lewisville (a 94-km^2 reservoir about 15 kilometers northeast of Lake Grapevine [not shown in fig. 1]). The contributing areas to Lake Grapevine and Lake Lewisville are 1,800 and 4,300 km^2, respectively. Flow at EFT348 depends on dam releases from these two lakes and the remaining 470 km^2 that is downstream from the two lakes. The 12 sampling sites are on smaller creeks, including Cottonwood Creek (CCTTR, CCBR, CCDTR), Grapevine Creek (GCNAD, GCRR, GCDTR), Hackberry Creek (HCCER, HCMSC, HCLR), Mud Springs Creek (MSC), and South Fork Hackberry Creek (SHCBLR, SHCHPR); these creeks ultimately

Table 2. Size and land use of watershed areas upstream from sampling sites on streams receiving discharge from Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

Field identifier (fig. 1)	Area (square kilometers)	Land-use category (percentage of watershed area)				
		Urban	Sum of agriculture, range, and forest	Water	Wetland	Barren land
Lower West Fork Trinity River watershed						
BBC121	90.1	61.6	38.1	0.28	0	0
TRIBMD	1.27	96.5	3.54	0	0	0
TRIBEG	4.14	52.0	47.9	.13	0	0
OF25	2.82	89.0	11.0	0	0	0
OF19	2.70	87.1	12.9	0	0	0
LBC360	61.5	75.4	24.2	.18	.08	.16
TL	11.9	67.1	31.2	1.6	.10	0
BBC183	199	66.1	33.4	.30	.10	.10
Elm Fork Trinity River watershed						
CCTTR	3.26	77.9	22.2	0	0	0
CCBR	9.29	48.2	51.1	.25	.52	0
CCDTR	16.8	57.7	41.9	.14	.29	0
GCNAD	6.26	81.2	18.8	0	0	0
GCRR	9.22	67.2	32.7	0	0	.12
GCDTR	22.0	73.6	26.3	0	.05	.06
HCCER	2.40	85.8	14.2	0	0	0
HCMSC	4.35	70.2	29.8	0	0	0
MSC	8.16	67.0	32.9	.12	0	0
SHCBLR	2.92	52.2	47.8	0	0	0
SHCHPR	7.01	58.0	42.0	0	0	0
HCLR	34.7	72.4	27.5	.07	.05	0
EFT348	6,570	14.5	80.3	4.6	.50	.10

flow into the Elm Fork Trinity River. The contributing area upstream from the most downstream sampling sites on Cottonwood Creek (CCDTR), Grapevine Creek (GCDTR), and Hackberry Creek (HCLR) is about 74 km^2. Of all the sampling-site watersheds contributing to flow at EFT348, only the watershed upstream from CCBR on Cottonwood Creek is less than 50-percent urban (48 percent). DFW Airport discharge sites that contribute to flow at EFT348 are CCBR, GCNAD, GCRR, HCCER, HCMSC, MSC, and SHCBLR.

Acknowledgments

The authors thank DFW Airport Environmental Affairs Department staff for their interest in the study and assistance with site selection, access to sampling sites, and sampling logistics.

Methods

Data were collected in accordance with the USGS “National Field Manual for the Collection of Water Quality Data” (U.S. Geological Survey, variously dated) and the TCEQ “Surface Water Quality Monitoring Procedures, Volume 1—Physical and Chemical Monitoring Methods” (Texas Commission on Environmental Quality, 2009b).

Sample Collection

Samples for low-flow conditions were collected almost monthly (10 times) from each of the 21 sites (flow permitting) during February–December 2008 (appendix 1.1). Samples for stormflow conditions were collected at the most downstream (integrator) sites in the West Fork Trinity River watershed (BBC183) and the Elm Fork Trinity River watershed (EFT348) during three storms in March, April, and August 2008 (table 3). Eight samples were collected at each downstream site during the three storms (appendix 1.2). Sampled storms were different with respect to the total amounts of

Table 3. Summary information for storms during which samples were collected at integrator sites BBC183 and EFT348 on streams receiving discharge from Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

[Dry days prior to storm is number of days with less than 2.54 millimeters of precipitation prior to sampled storm; DFW, Dallas/Fort Worth International; >, greater than; NA, not available]

Storm	Total precipitation, DFW Airport (millimeters)	Dry days prior to storm	Peak stage (meters above datum)		Maximum discharge (cubic meters per second)	
			BBC183[1]	EFT348[2]	BBC183	EFT348
March 2008	67.8	7	>4.04	7.32	NA	200
April 2008	6.35	4	2.52	5.55	NA	114
August 2008	47.3	3	3.65	4.15	NA	40.0

[1] Datum is 146.3 meters above NGVD 29.

[2] Datum is 121.9 meters above NAVD 88.

precipitation and the period over which the storm occurred. The March 2008 storm had the most precipitation (67.8 millimeters [mm]) and occurred over a period of about 1 day. The April 2008 storm had the least amount of precipitation (6.35 mm) and occurred over a 4-hour period. The August 2008 storm had 47.3 mm of precipitation. During this storm, 23.9 mm of precipitation fell over a 7-hour period on August 15; after 2 days without appreciable precipitation, 15.0 mm fell on August 18 over a 12-hour period; and the remaining 8.38 mm of precipitation fell over the next 2 days.

All samples (low-flow and stormflow) were collected for analysis of total coliform, fecal coliform, *E. coli*, ammonia, TSS, and chloride. Instantaneous water-quality measurements were made at the time of sample collection for water temperature, DO, pH, and specific conductance using multiparameter water-quality monitors. Monitors were calibrated and operated according to USGS protocols (U.S. Geological Survey, variously dated). Post calibration also was done to comply with requirements of the TCEQ "Surface Water Quality Monitoring Procedures" (Texas Commission on Environmental Quality, 2009b). Salinity was estimated from specific conductance measurements (Wagner and others, 2006).

During low-flow sample collection, streamflow was estimated either as the product of surface-water velocity and cross-sectional flow area or using professional judgment. Estimates based on judgment were reported as less than a specified amount. The goal of estimating streamflow was to document that sampling was done during low-flow conditions and was indicative of periods following 72 hours without substantial precipitation. Site EFT348 is a USGS real-time streamflow-gaging station (08055560, Elm Fork Trinity River at Spur 348, Irving, Tex.) with an established stage-discharge relation (rating). At this site, stage was measured during sample collection for both low-flow and stormflow conditions, and streamflow was obtained from the rating.

Ancillary data collected at the time of all sampling included weather conditions, odor, bank vegetation, presence or absence of visible algae, upstream construction activities, water depth at sampling site, and sampling site description. Also, a photograph was taken of the sampling conditions.

All samples were collected as discrete grab samples at the estimated centroid of flow whenever possible. For water depths greater than 0.46 meter (m) (1.50 feet), samples were collected at 0.30 m (1.00 foot) below the water surface. For water depths less than 0.46 m, samples were collected at one-third of the water depth measured from the water surface. Samples were collected at or just below the water surface if the water depth was so shallow that bottom sediment would be disturbed if the sample were collected at one-third of the water depth. Every effort was made to not collect the sample from the surface, although some shallow sampling depths prevented collection below the water surface.

Fecal indicator bacteria samples were collected using sterile single-use Whirlpak® bags. The bags were not field-rinsed with native water. The bags were filled by submerging below the water surface with the top facing upstream and tilted slightly upward. The perforated top parts of the bags were removed before they were submerged, but the bags were held closed until they were at the depth of sample collection to prevent collection of surface water. When the stream velocity was low and water would not flow easily into the bags, they were held open at the proper depth and moved slowly upstream until full. Immediately after the bags were filled, some water was squeezed out to leave airspace to aid in mixing the water before decanting into separate sterile bottles for fecal coliform and *E. coli* analyses. The bags were shaken periodically while decanting into separate sterile bottles to keep the water well-mixed. Two sterile fecal coliform bottles (supplied by the analyzing laboratory) and one or two sterile IDEXX®-supplied bottles (depending on the number of dilutions to run) were filled to the 100-milliliter (mL) line immediately after collection in the sterile bags. All sample bottles for fecal coliform and *E. coli* analyses were pretreated with sodium thiosulfate in the event that residual chlorine was present. Bottles were put in coolers and placed on ice immediately after collection.

Ammonia, TSS, and chloride sample water was collected in two unused, 500-mL, clear polyethylene bottles supplied by the analyzing laboratory. One 500-mL bottle was collected for TSS and chloride analysis. Water for ammonia analysis was collected in a separate bottle. The bottles were dipped to the proper depth and filled but left with a small airspace. Sampling during low-flow conditions made the use of isokinetic samplers impractical. At most of the sampling sites during low-flow conditions, the depth of water was less than or equal to the unsampled zone of an isokinetic sampler. Water for ammonia analysis was preserved with 2.0 mL of concentrated sulfuric acid. After adding the acid, the bottle was inverted to mix the acid. All bottles were placed on ice immediately after collection.

The bottles were not field-rinsed with native water (as required by the USGS "National Field Manual for the Collection of Water Quality Data") before sample collection because they were identified as clean bottles by the analyzing laboratory, and because the TCEQ "Surface Water Quality Monitoring Procedures" require that bottles not be rinsed with native water. To account for both requirements, bottle lot numbers were recorded for all samples, and blank samples (deionized reagent-grade water from the USGS National Water Quality Laboratory [NWQL]) were put in the laboratory-supplied sample bottles and analyzed for ammonia, TSS, and chloride at the beginning of the study. Blank samples were handled in the same manner as environmental samples.

Sample bottles were labeled with field identifier, collection date and time, type of analysis requested, name of person collecting the sample, and preservation method. Samples for total coliform and *E. coli* were transported to the USGS Texas Water Science Center in Fort Worth for analysis by USGS staff. Samples for fecal coliform, ammonia, TSS, and chloride analyses were given to a courier for transport to the analyzing laboratory. Chain-of-custody forms were used to document the transport of samples.

Analytical Methods

Xenco Laboratories, Dallas, analyzed samples for ammonia, TSS, and chloride. Xenco also analyzed samples for fecal coliform, except for one suite of low-flow samples (December 2008) that was analyzed by Armstrong Forensic Laboratory, Inc., Arlington, Tex.

Total coliform and *E. coli* analyses were done by USGS staff using the IDEXX Colilert-24® method with the Quanti-Tray/2000 (Eaton and others, 2005; IDEXX Laboratories, 2009). This method is a 24-hour test that detects and quantifies total coliform and *E. coli* bacteria in water. After 24 hours of incubation at 35.0 (±0.5) degrees Celsius (°C), the sample should turn yellow if coliform bacteria are present. The sample also should fluoresce when exposed to ultraviolet light with a wavelength ranging from 365 to 366 nanometers if *E. coli* are present. Results (estimated values) are reported as most-probable number per 100 mL (MPN/100 mL). The range in reporting level for the method depends on sample dilutions. For an undiluted sample, the lowest reporting level is 1.0 MPN/100 mL, and the highest reporting level is 2,400 MPN/100 mL. Dilutions (1:10 and 1:100) were run to quantify results greater than 2,400 MPN/100 mL.

Fecal coliform analyses were done by the contract laboratories using the membrane filtration method with a 0.45-micrometer filter (Eaton and others, 2005). For this method, a 100-mL volume of sample water is passed through the filter. The fecal coliform bacteria present in the water remain on the filter. The filter is then placed in a petri dish containing the appropriate growth medium (M-FC) and incubated for 24 hours at 44.5 (±0.2) °C. During incubation the bacteria on the filter grow into separate colonies, which are then directly counted and reported as the number of colony-forming units per 100 mL (cfu/100 mL). Dilutions were run to try to achieve an ideal colony-counting range, as the range in reporting level for the method depends on sample dilutions. For an undiluted sample, the lowest reporting level is 1.00 cfu/100 mL, and the highest reporting level depends on the countability of the individual colonies after incubation; when it is not possible to count the colonies, results are reported as too numerous to count (TNTC).

The reporting units of most-probable number (for the IDEXX method in this report) are estimates, and the reporting units of colony-forming units (for the membrane filtration method in this report) are direct counts of cells on a plate. On the basis of the respective methods, total coliform and *E. coli* are reported here in terms of most-probable number, and fecal coliform are reported in terms of colony-forming units. Also, as noted in the section, "Occurrence and Distribution of Fecal Indicator Bacteria in Receiving Streams," the TCEQ *E. coli* criterion for classifying a stream segment as not fully supporting contact recreation is in colony-forming units. The units of most-probable number for the IDEXX method and colony-forming units are considered comparable.

Ammonia analyses were done using U.S. Environmental Protection Agency (1993) methods 350.1 and 350.3 with a lowest reporting level of 0.100 milligram per liter (mg/L). Total ammonia concentrations are reported as equivalent amounts of elemental nitrogen. TSS analyses were done using method SM2540D (Eaton and others, 2005) with lowest reporting levels of 4.00 and 5.00 mg/L. Chloride analyses were done using U.S. Environmental Protection Agency method 325.3 (National Environmental Methods Index, 2008) with a lowest reporting level of 5.00 mg/L.

Quality Assurance

Quality assurance was provided by blanks (laboratory and field), laboratory duplicates, split replicates, and field duplicates (*E. coli* samples collected from the same site using the same method). Blanks were analyzed to identify contamination, if any, during sample collection, transport, and analysis. Laboratory duplicate analyses for *E. coli* samples were done to test the reproducibility of analytical results for the IDEXX Colilert-24® method for *E. coli*. Split replicate analyses for ammonia, TSS, and chloride samples were done to assess the variability in results associated with sample preservation, handling, shipping, and analysis. Results of quality-assurance analyses of laboratory duplicates and split replicates are in appendixes 2.1 and 2.2, respectively. Field duplicate *E. coli* samples were analyzed for low-flow samples only to assess environmental variability in *E. coli* counts. Results of quality-assurance analyses of field duplicates are in appendix 1.1.

For fecal coliform bacteria blanks, IDEXX®-supplied sterile water was pipetted (with individually packaged sterile pipettes used to make dilutions) into a Whirlpack® bag. The water was transferred from the bag to the laboratory-supplied fecal coliform bacteria bottles used during environmental sample collection. The bottles were transported as environmental samples and analyzed for fecal coliform bacteria. Analytical results for fecal coliform bacteria blank samples were less than laboratory reporting levels.

Each new lot number of IDEXX®-supplied sterile water and IDEXX®-supplied sample bottles were tested for sterility. The sterile water was poured into a sample bottle and the sample was analyzed as an environmental sample. Analytical results for sterile water blank samples were less than reporting levels.

For other blank samples, deionized reagent-grade water from the NWQL was poured into a 1-liter (L) polyethylene bottle from the NWQL. This water was used to fill two of the 500-mL sample bottles supplied by the analyzing laboratory. Bottles were preserved and transported as environmental samples and analyzed for ammonia, TSS, and chloride. All analytical results for these samples were less than laboratory reporting levels.

Laboratory duplicate samples of *E. coli* samples were created by removing (using individually packaged sterile pipettes) a volume of water from a bottle of IDEXX®-supplied sterile water and replacing it with the same volume of environmental sample. This was done in duplicate to compare two results of the same dilution factor, typically 1:10 and 1:100, indicating 10 and 1.0 mL, respectively, of environmental sample water. Thirty-five laboratory duplicates were run on 31 samples (appendix 2.1), 12.7 percent of the 244 samples collected. Duplicate dilutions were analyzed for some samples, for example two 1:10-mL dilutions and two 1:100-mL dilutions. Laboratory duplicate results indicate that when the total number of cells that were yellow and fluoresced was within the recommended range of 30 to 80 (Texas Commission on Environmental Quality, 2009, p. 4–8), the average percentage difference between duplicate pairs for *E. coli* was 16.2.

Split replicates were collected by filling a 1-L polyethylene sample bottle from the NWQL in the field with stream water and decanting 500 mL into two sample bottles for ammonia analyses. The process was repeated to make replicates for TSS and chloride analyses. Split replicates were run on 24 samples (appendix 2.2), 9.8 percent of the 244 samples collected. For the split replicate samples, the average relative percentage difference is 10.6 for ammonia, 18.6 for TSS, and 10.3 for chloride.

Field duplicates were run on 11 samples for *E. coli* during low-flow conditions (appendix table 1.1), or 5.6 percent of the 196 low-flow samples collected. Average percentage difference between duplicate pairs was 27.3.

Reagent checks, positive control checks, and comparison count checks also were done. Reagent checks were done to test for *E. coli* contamination of the reagents. All sterility checks on sterile water and reagents were negative for presence of *E. coli*. Positive control checks were done to check the productivity of the reagent. Each new lot of reagent was tested for productivity with Quanti-cult® quality control test kits (U.S. Geological Survey, variously dated). All positive control checks yielded expected results for productivity of reagent. Comparison count checks were done on 36 different samples. Replicate counts between analysts averaged 7.8 percent.

Of the 244 samples analyzed for fecal coliform, 15 (6.1 percent) had holding times that exceeded 8 hours and 50 (20.5 percent) had holding times between 6 and 8 hours. The longest holding time for fecal coliform analysis was 9 hours 5 minutes. Of the 244 samples analyzed for *E. coli*, none had holding times that exceeded 8 hours, and five (2.0 percent) had holding times between 6 and 8 hours. USGS recommended holding times for total coliform, fecal coliform, and *E. coli* bacteria are 6 hours for nonpotable water collected for compliance purposes and 24 hours for noncompliance purposes (Myers and others, 2007). TCEQ recommends that bacteriological samples be analyzed within 8 hours of sample collection. The holding time for *E. coli* may be extended to 48 hours when samples are analyzed using the IDEXX Colilert Quanti-Tray/2000 (Texas Commission on Environmental Quality, 2008a).

Statistical Tests

Nonparametric methods were used to test for differences between groups (datasets) of analytical results for selected sampling sites. Comparisons between sites were made using the Mann-Whitney (Wilcoxon rank-sum) test. The Mann-Whitney test indicates whether one group tends to produce larger observations than a second group (Helsel and Hirsch, 1992). No assumptions are made about the distributions of the data in either group, and the two groups do not need to have the same distribution. For this report, differences between groups are considered significant at the .05 level (p-value less than or equal to .05).

Occurrence and Distribution of Fecal Indicator Bacteria in Receiving Streams

Results of analyses for fecal indicator bacteria (fecal coliform and *E. coli*) are listed in appendixes 1.1 and 1.2. All fecal coliform and *E. coli* data are included in the data analyses and graphical data presentation. *E. coli* counts are compared with contact recreation criteria. Water bodies are classified as fully supporting contact recreation if geometric mean *E. coli* counts are less than or equal to 126 cfu/100 mL (or MPN/100 mL) and 25 percent or less of the samples exceed the single-sample criterion of 394 cfu/100 mL (or MPN/100 mL). They are classified as not fully supporting contact recreation if either the geometric mean exceeds 126 cfu/100 mL or more than 25 percent of the samples exceed 394 cfu/100 mL (Texas Commission on Environmental Quality, 2008a).

Fecal Coliform and *Escherichia Coli* Counts During Low-Flow Conditions

Variability of fecal coliform and *E. coli* counts at all sampling sites during low-flow conditions is shown by boxplots (figs. 2–5). Boxplots for sites in the lower West Fork Trinity River watershed are shown in figures 2 and 3, and boxplots for sites in the Elm Fork Trinity River watershed are shown in figures 4 and 5.

West Fork Trinity River Watershed

At sampling sites in the lower West Fork Trinity River watershed during low-flow conditions, fecal coliform counts ranged from 4.00 to 8,500 cfu/100 mL (fig. 2), and *E. coli* counts ranged from 1.0 to 4,900 MPN/100 mL (fig. 3). Fecal coliform counts were reported by the laboratory as TNTC for five of the 70 West Fork Trinity River watershed low-flow samples; one for non-airport site BBC121 and two each for non-airport site TRIBMD and airport site OF25. Geometric mean *E. coli* counts[1] for five of the eight West Fork

[1]IDEXX analytical results (most-probable number) are reported to two significant figures. However, because the TCEQ criterion for contact recreation use based on *E. coli* counts (126 cfu/100 mL [or MPN/100 mL]) contains three significant figures (and geometric mean is a computed value), geometric mean *E. coli* counts are reported here to three significant figures.

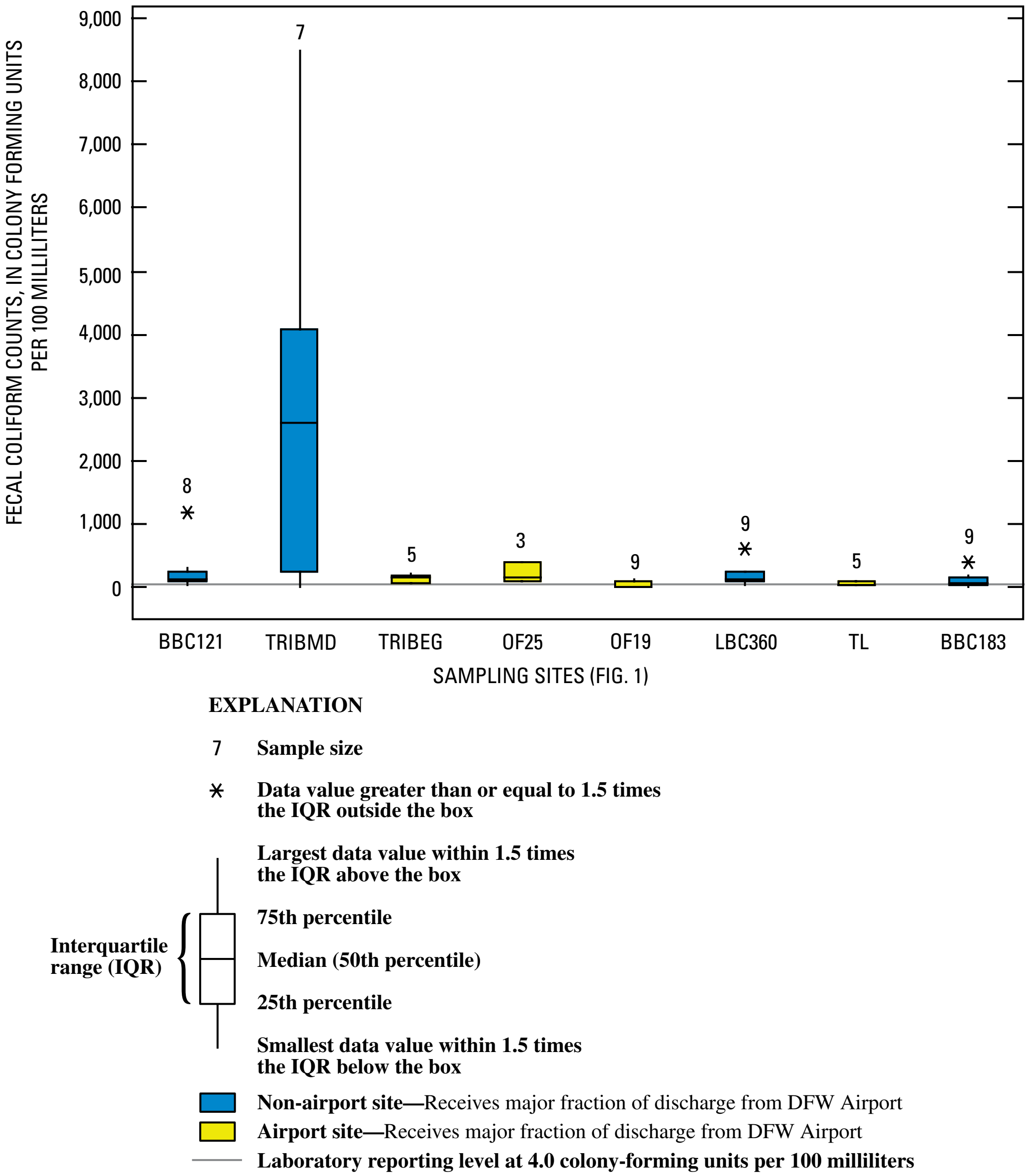


Figure 2. Boxplots showing variability of fecal coliform counts by site during low-flow conditions in streams in the lower West Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International (DFW) Airport and vicinity, north-central Texas, 2008.

Trinity River watershed sampling sites (BBC121 [non-airport], TRIBMD [non-airport], TRIBEG [airport], OF25 [airport], and LBC360 [non-airport]) were greater than 126 MPN/100 mL (fig. 6), thus not fully supporting contact recreation on the basis of the TCEQ criterion.

Maximum fecal indicator bacteria counts were measured at non-airport site TRIBMD, on the northwest side of DFW Airport property (fig. 1). It is the smallest sampled watershed at 1.3 km^2 and classified as 96.5-percent urban. The contributing area is mostly covered by office buildings and parking lots. The geometric mean *E. coli* count at TRIBMD (809 MPN/100 mL) exceeded the geometric mean criterion for support of contact recreation (fig. 6). Samples collected downstream from TRIBMD (after flow crosses DFW Airport property) at airport site TRIBEG had lower fecal indicator bacteria concentrations, but the geometric mean *E. coli* count (174 MPN/100 mL) still exceeded geometric mean criterion for support of contact recreation. Airport site OF25 represents a small watershed on DFW Airport property. The geometric mean *E. coli* count for OF25 was 209 MPN/100 mL, also greater than the geometric mean criterion for support of contact recreation. Sanitary sewer lines adjacent to the OF25 outfall creek and kennels for DFW Airport police dogs are in the watershed upstream from OF25. The sewer lines and kennels are potential sources of bacteria, but additional data from upstream of those potential sources would be needed for confirmation. Geometric mean

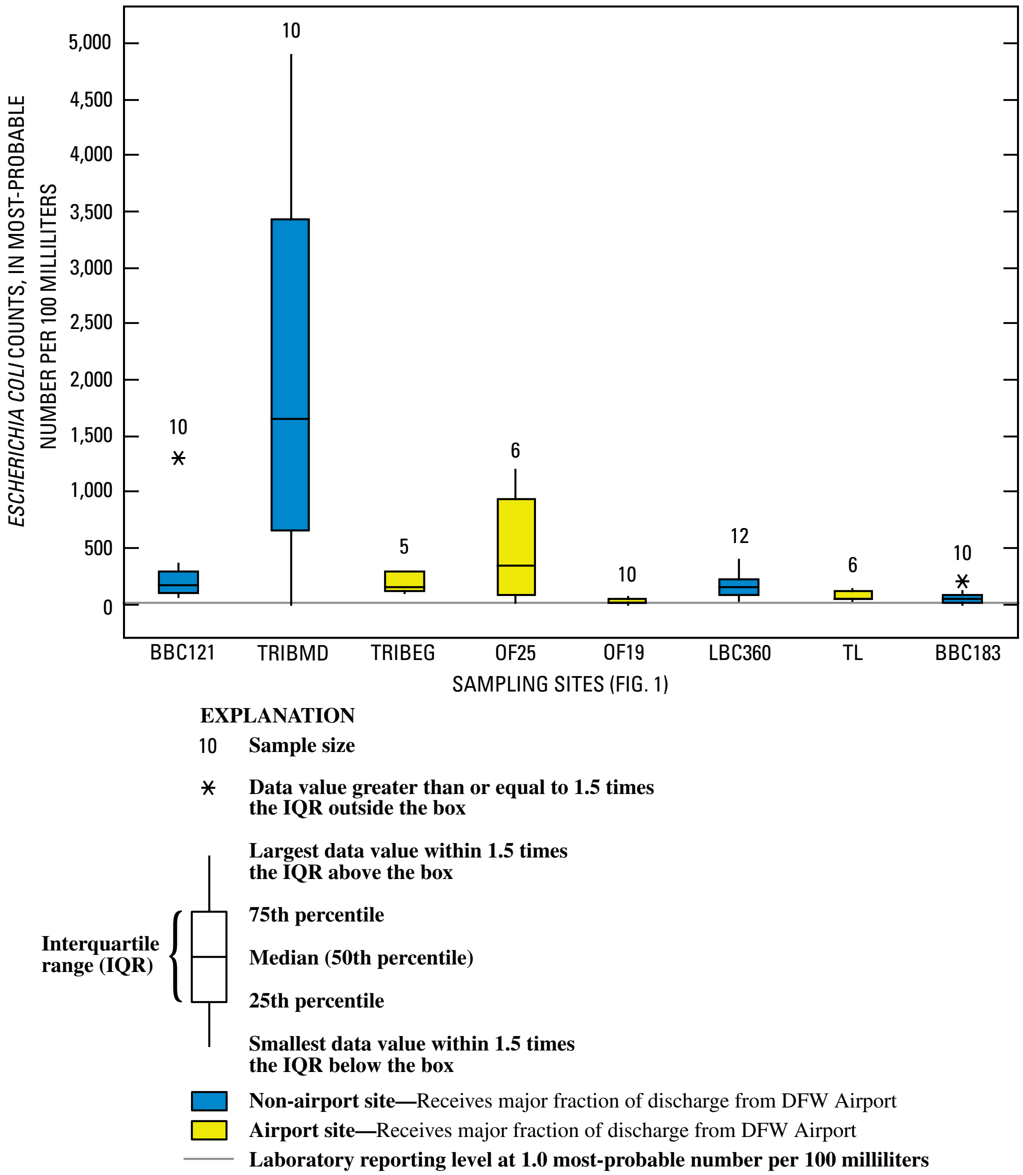


Figure 3. Boxplots showing variability of *Escherichia coli* counts by site during low-flow conditions in streams in the lower West Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International (DFW) Airport and vicinity, north-central Texas, 2008.

E. coli counts for airport sites OF19 and TL were less than the geometric mean criterion for support of contact recreation; and geometric mean *E. coli* counts for integrator site BBC183, the most downstream of the West Fork Trinity River watershed sites, also were less than the contact recreation criterion during low-flow conditions.

Non-airport sampling sites BBC121 and LBC360 represent relatively large urban watersheds (table 2) and no contributing area from DFW Airport property. Geometric mean *E. coli* counts for these two sites exceeded the criterion for support of contact recreation (fig. 6). Low-flow *E. coli* counts for these two sites were not significantly different from each other but were significantly different from counts at integrator site BBC183 on the basis of the Mann-Whitney test.

Elm Fork Trinity River Watershed

At sampling sites in the Elm Fork Trinity River watershed during low-flow conditions, fecal coliform counts ranged from 1.00 to 2,160 cfu/100 mL (fig. 4), and *E. coli* counts ranged from less than 1.0 to 2,000 MPN/100 mL (fig. 5). Fecal coliform counts were reported by the laboratory as TNTC for three of 126 Elm Fork Trinity River watershed low-flow samples; one each for non-airport site CCDTR, airport site GCNAD, and integrator site EFT348. Of the 13 sampling sites in the Elm Fork Trinity River watershed, geometric mean *E. coli* counts exceeded the geometric mean contact recreation criterion of 126 cfu/100 mL (or MPN/100 mL) for seven sites—non-airport CCTTR, airport CCBR, non-airport

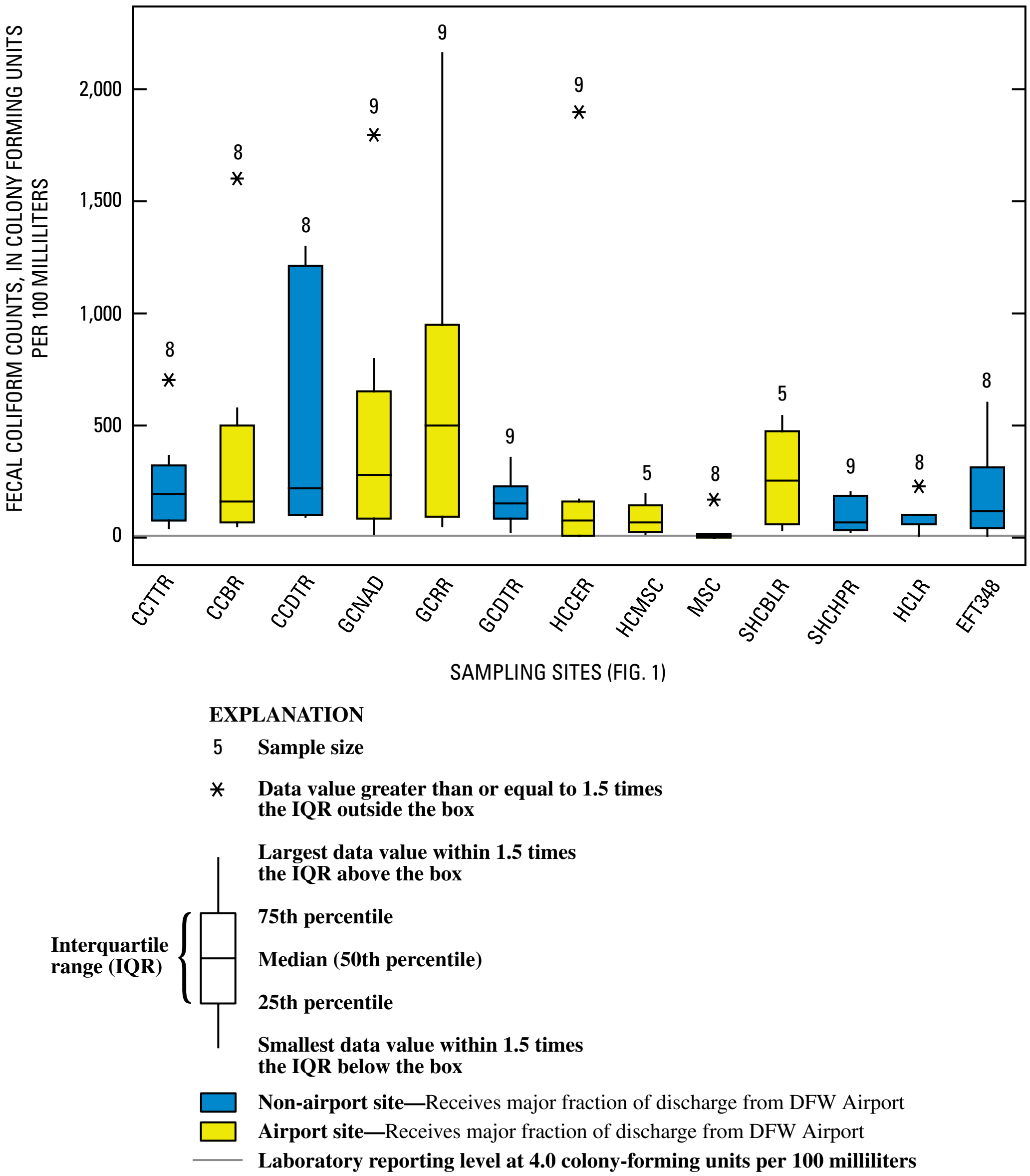


Figure 4. Boxplots showing variability of fecal coliform counts by site during low-flow conditions in streams in the Elm Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International (DFW) Airport and vicinity, north-central Texas, 2008.

CCDTR, airport GCNAD, airport GCRR, non-airport GCDTR, and airport SHCBLR (fig. 6). These seven sites include all of the sampling sites on Cottonwood Creek and Grapevine Creek and one site on South Hackberry Creek.

Fecal indicator bacteria counts at the three sampling sites on Cottonwood Creek (non-airport CCTTR, airport CCBR, and non-airport CCDTR) generally increase from upstream to downstream (figs. 4, 5). There were no statistically significant differences between counts at these three sites, despite the fact that the geometric mean *E. coli* count at the most downstream sampling site on Cottonwood Creek (non-airport CCDTR) was 1.6 to 1.8 times greater than geometric mean counts at the upstream sampling sites. However, small sample sizes (8–10 per site) likely reduced the power of the Mann-Whitney test to indicate differences. In general, small sample sizes reduce the power of a statistical test to indicate a difference, if one exists (Park, 2004).

Fecal indicator bacteria counts at the three sampling sites on Grapevine Creek (airport GCNAD, airport GCRR, and non-airport GCDTR) decrease from the two upstream sites to the most downstream site (figs. 4, 5). There were no statistically significant differences between counts at these sites, despite the fact that the geometric mean *E. coli* count at the most downstream sampling site on Grapevine Creek (non-airport GCDTR) was 1.6 to 1.7 times less than geometric mean counts at the upstream sampling sites; but again, small sample sizes

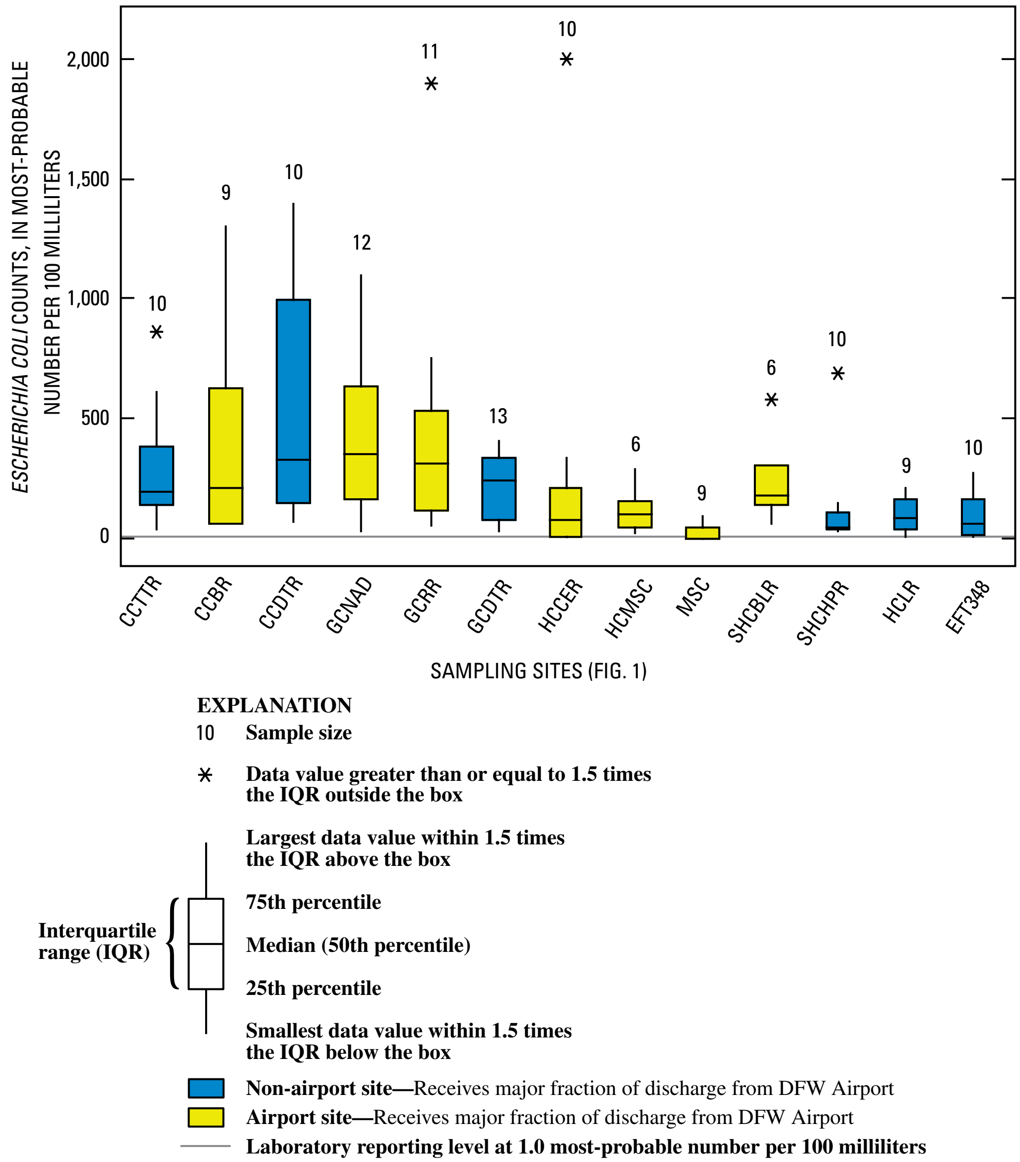
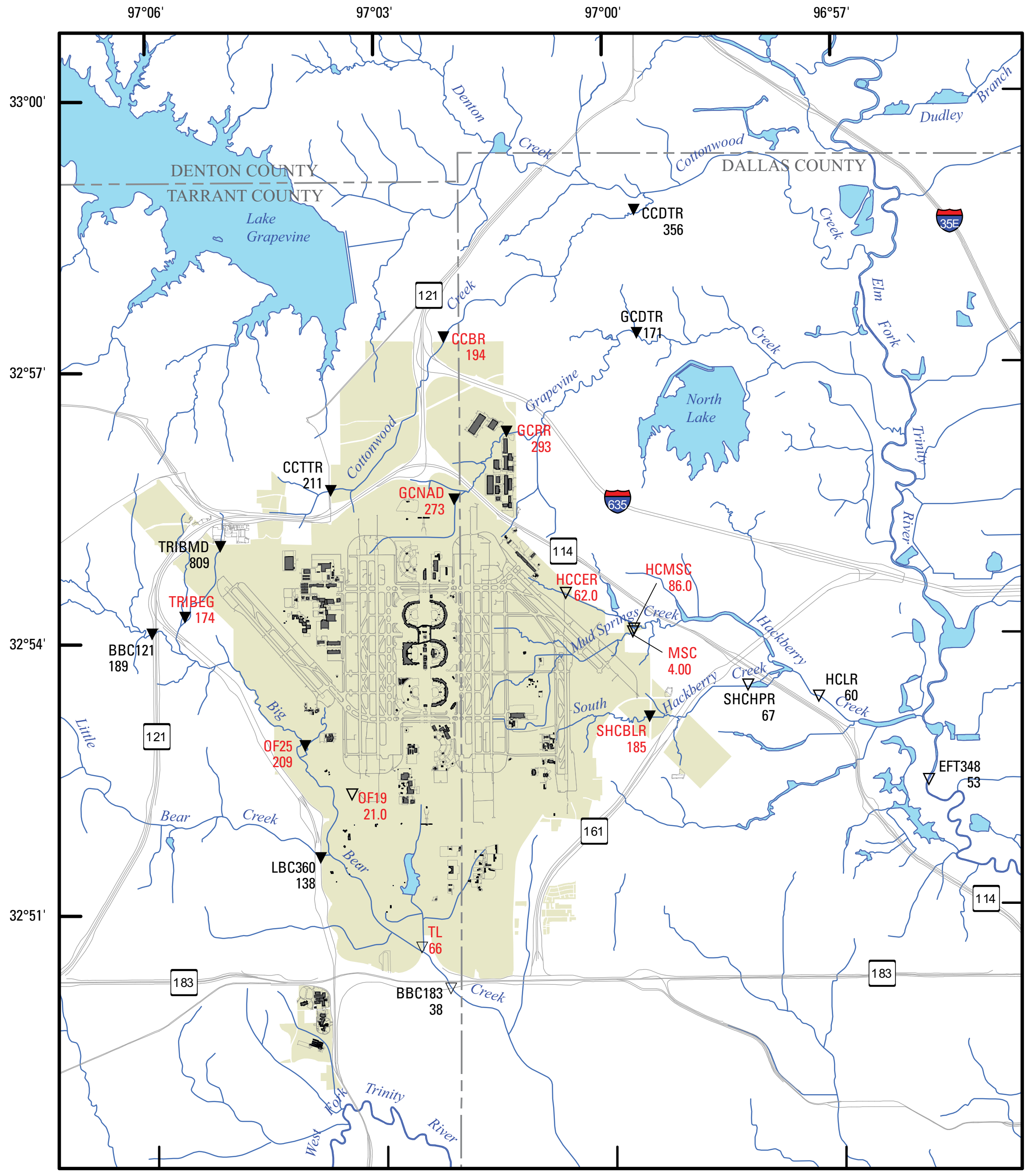


Figure 5. Boxplots showing variability of *Escherichia coli* counts by site during low-flow conditions in streams in the Elm Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International (DFW) Airport and vicinity, north-central Texas, 2008.

likely reduced the power of the Mann-Whitney test to indicate differences.

The differences in geometric mean *E. coli* counts between the upstream and downstream sites on Cottonwood Creek and Grapevine Creek results are relatively large; but the statistical tests indicate no significant differences in the counts, although the test results here are questionable because of small sample sizes. If sample sizes had been larger than 8–10 per site, 30–50 for example, the statistical tests would have been more definitive. In general, statistical tests using adequate sample sizes offer a more defensible basis for comparison of bacteria counts between sites than geometric mean values.

All sampling sites on Hackberry Creek, Mud Springs Creek, and South Fork Hackberry Creek (except airport site SHCBLR) and integrator site EFT348 on Elm Fork Trinity River had geometric mean *E. coli* counts less than the geometric mean contact recreation criterion (fig. 6). SHCBLR drains a small watershed (2.9 km^2) with about 52 percent of its area classified as urban and the remainder classified as agriculture, range, or forest (table 2). Airport site SHCBLR site is downstream from a forested area and park that provide habitat for small animals. *E. coli* counts at SHCBLR were significantly higher than those at the downstream sampling site on South Hackberry Creek (non-airport site SHCHPR).



Base from Dallas Fort Worth International Airport,
Texas Department of Transportation,
USGS National Hydrography Dataset,
Texas Natural Resources Information System

0 2.5 5 KILOMETERS

EXPLANATION

Dallas Fort Worth International (DFW) Airport property

CCBR 194

Sampling site and field identifier/geometric mean *Escherichia (E.) coli* count, in most-probable number per 100 milliliters—Red font indicates site receives major fraction of discharge from DFW Airport. Filled symbol indicates *E. coli* count greater than and open symbol indicates *E. coli* count less than or equal to Texas Commisssion on Environmental Quality (2008a) contact recreation criterion (126 colony-forming units [or most-probable number] per 100 milliliters)

Figure 6. Geometric mean *Escherichia coli* counts during low-flow conditions at all sampling sites that receive discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

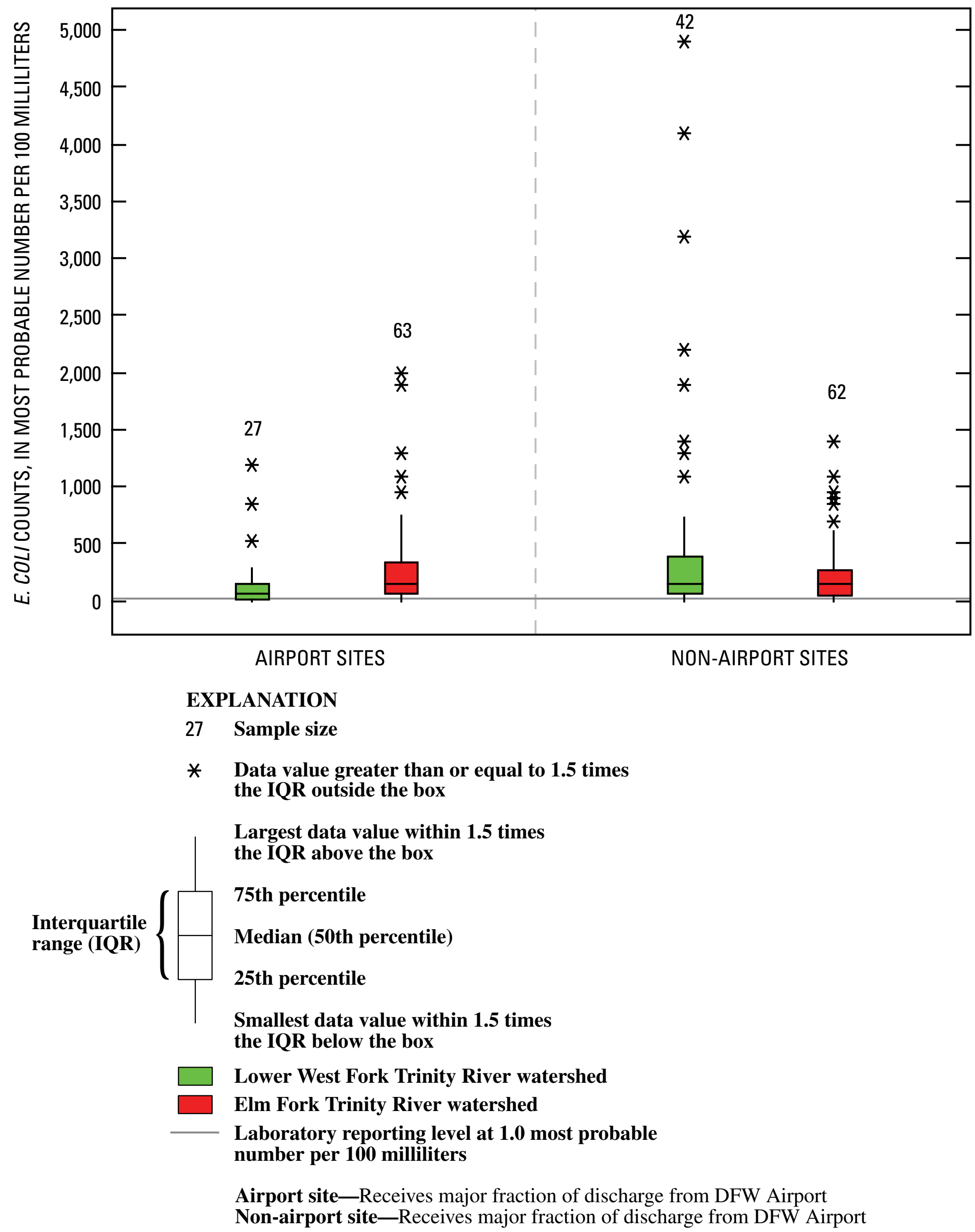


Figure 7. Variability of *Escherichia coli* counts by watershed under low-flow conditions for airport sampling sites and non-airport sampling sites in streams that receive discharge from the Dallas/Fort Worth International (DFW) Airport and vicinity, north-central Texas, 2008.

Comparison of *Escherichia Coli* Counts for Airport and Non-Airport Discharge Sites

E. coli counts under low-flow conditions for airport discharge sites in the lower West Fork Trinity River and Elm Fork Trinity River watersheds were compared with counts for non-airport discharge sites (fig. 7). *E. coli* counts for airport sites in the lower West Fork Trinity River watershed were significantly different from (lower than) *E. coli* counts for non-airport sites in the lower West Fork Trinity River watershed. There was no significant difference between *E. coli* counts for airport sites in the Elm Fork Trinity River watershed and *E. coli* counts for non-airport sites in the Elm Fork Trinity River watershed.

Fecal Coliform and *Escherichia Coli* Counts During Stormflow Conditions

Fecal indicator bacteria counts at downstream integrator sites BBC183 (fig. 8) and EFT348 (fig. 9) during stormflow conditions ranged from 20 to 39,800 cfu/100 mL for

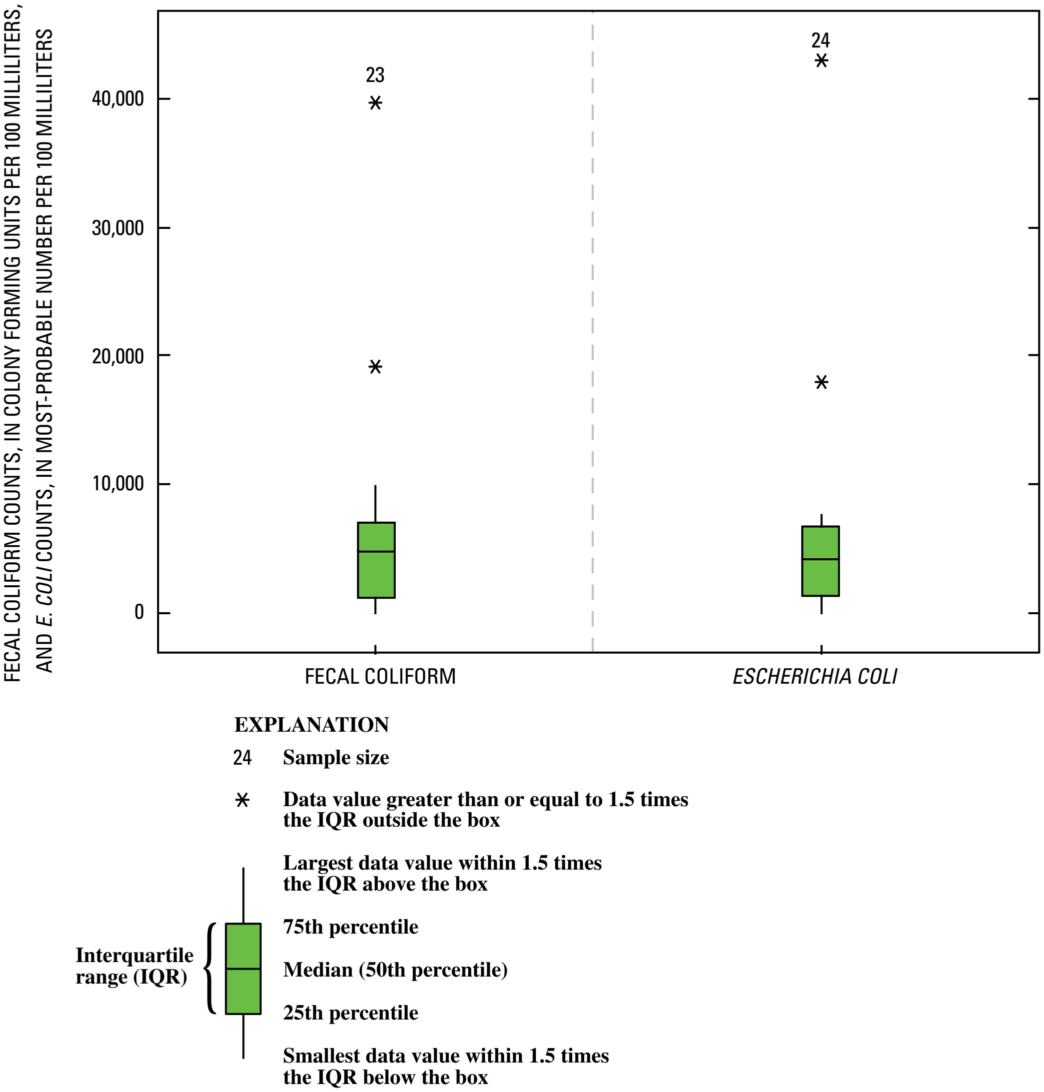


Figure 8. Variability of fecal coliform and *Escherichia coli* counts during stormflow conditions in 2008 at integrator site BBC183, the most downstream of sampling sites in the lower West Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas.

fecal coliform and 25 to 43,000 MPN/100 mL for *E. coli*. Maximum counts for both fecal coliform and *E. coli* were from samples collected at BBC183. For BBC183, median fecal coliform counts and *E. coli* counts were 4,800 cfu/100 mL and 4,250 MPN/100 mL, respectively. In contrast, during low-flow conditions median fecal coliform and *E. coli* counts were 58 cfu/100 mL and 57 MPN/100 mL, respectively. For EFT348, median fecal coliform and *E. coli* counts were 350 cfu/100 mL and 225 MPN/100 mL, respectively. During low-flow conditions, median fecal coliform and *E. coli* counts were 115 cfu/100 mL and 59 MPN/100 mL, respectively.

Counts of fecal indicator bacteria in stormflow samples can strongly influence descriptive statistics used to characterize counts in surface water. Geometric mean *E. coli* counts at integrator sites BBC183 and EFT348 during low-flow conditions were 38 and 53 MPN/100 mL, respectively (fig. 6). Geometric mean *E. coli* counts at these two sites were 645 and 203 MPN/100 mL, respectively, when stormflow samples were included, which changes the stream-segment classification from fully supporting to not fully supporting contact recreation.

The high counts of fecal indicator bacteria in stormflow samples at BBC183 and EFT348 are typical of counts at other urban sites in the Dallas/Fort Worth area. Stormflow samples analyzed for fecal coliform bacteria from small watersheds (less than 1.0 km^2) during February 1992–June 1993 had median counts of 20,000 cfu/100 mL in residential

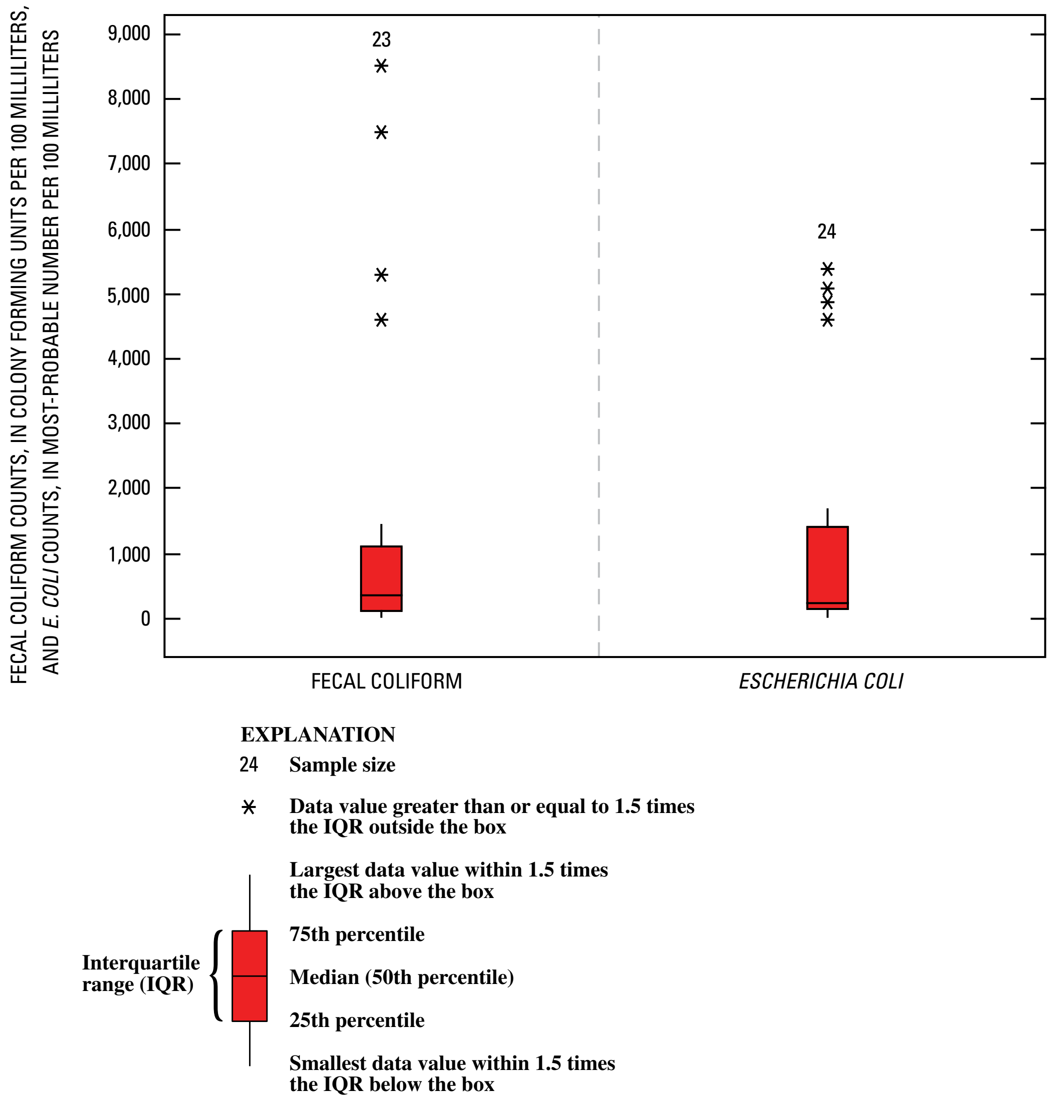


Figure 9. Variability of fecal coliform and *Escherichia coli* counts during stormflow conditions in 2008 at integrator site EFT348, the most downstream of sampling sites in the Elm Fork Trinity River watershed that receive discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas.

watersheds, 6,900 cfu/100 mL in commercial watersheds, and 9,700 cfu/100 mL in industrial watersheds (Baldys and others, 1998, table 3). Maximum fecal coliform bacteria counts in these watersheds were 600,000, 810,000, and 290,000 cfu/100 mL, respectively. At sites monitoring flow from two relatively large watersheds, 08048542 Sycamore Creek at Scott Avenue, Fort Worth, Tex. (88 km^2) and 08049240 Rush Creek at Woodland Park Boulevard, Arlington, Tex. (69 km^2), stormflow samples were collected during December 1997–May 2000 and analyzed for fecal coliform bacteria. Median counts were 17,000 and 13,000 cfu/100 mL, respectively, and maximums were as high as 150,000 cfu/100 mL (U.S. Geological Survey, 2008).

Physical and Chemical Indicators of Water Quality

The physical and chemical water-quality indicators, water temperature, DO, pH, specific conductance, ammonia, TSS, and chloride, for the classified segments on the lower West Fork Trinity River (0841) and the Elm Fork Trinity River (0822) were compared with numerical criteria for site-specific uses (if applicable) in the “2000 Texas Surface Water Quality Standards” (Texas Commission on Environmental Quality, 2008a). The stream segments sampled for this report (except segment 0822 that contains EFT348) are not segments

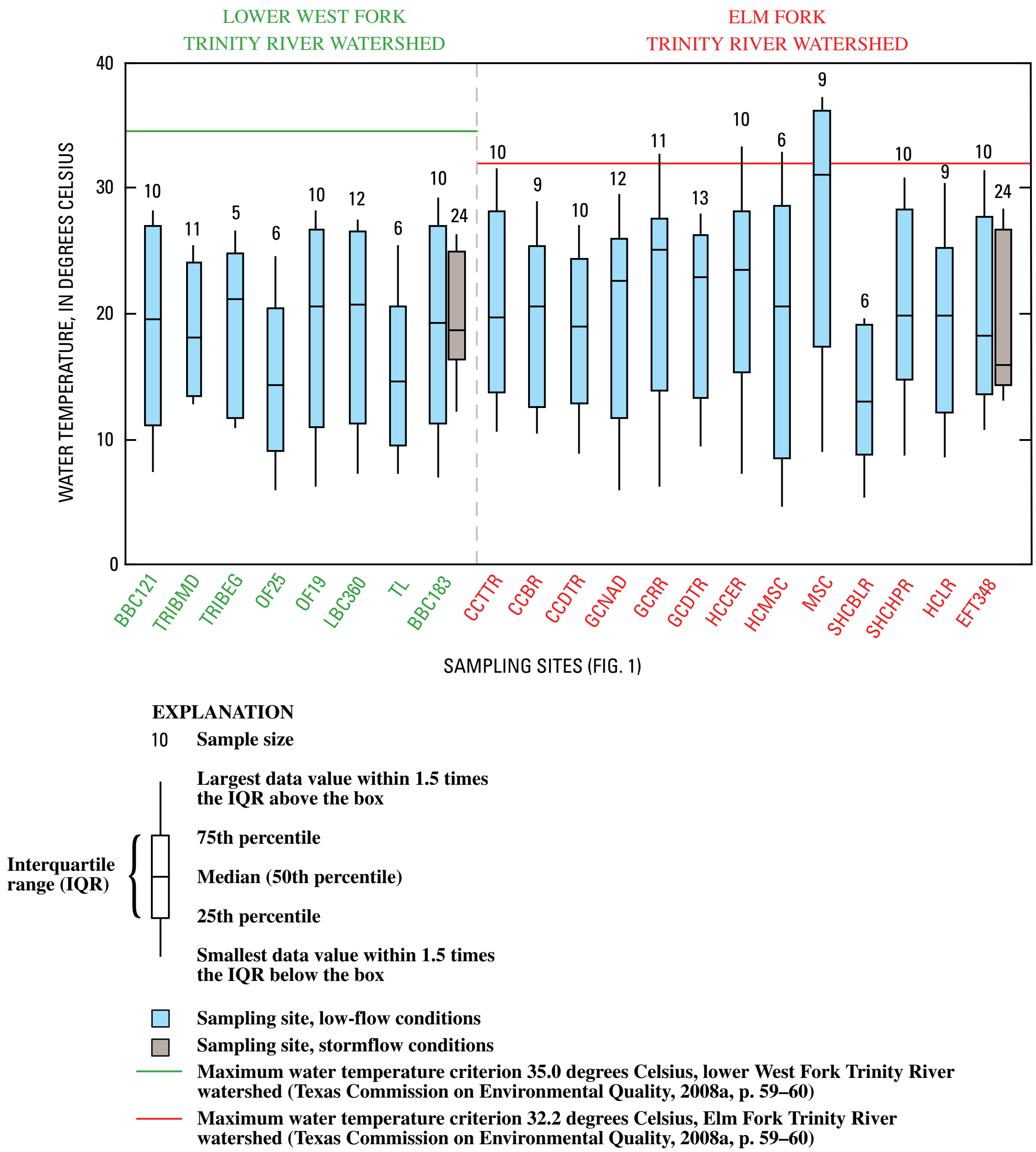


Figure 10. Variability of water temperature by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

classified by the TCEQ, but they discharge to either segment 0841 or 0822. Physical and chemical water-quality data are in appendixes 1.1 and 1.2.

Water Temperature

Water temperature at all sites ranged from 4.8 °C in December to 37.2 °C in July. The distributions and the wide interquartile ranges reflect the seasonal variability of water temperature measured at all sampling sites (fig. 10). The highest water temperature was at airport site MSC, which likely is because of channel conditions at this site. MSC has a relatively wide, exposed concrete trapezoidal channel. The tops of the right and left banks are covered with grasses that provide little or no shade. Some of the distributions are influenced by a lack of samples during summer. For example, at airport sites OF25, TL, and SHCBLR samples were not collected during some summer months because there was no flow at these sites at the time of sample collection.

Thus their distributions do not include the high temperatures that likely would have been measured had the streams been flowing.

Maximum water temperature criteria for the lower West Fork Trinity and the Elm Fork Trinity River segments are 35.0 and 32.2 °C, respectively (Texas Commission on Environmental Quality, 2008a, p. 59–60). All water temperature measurements at sampling sites in the lower West Fork Trinity River watershed were less than the maximum criterion. Of the water temperature measurements at sampling sites in the Elm Fork Trinity River watershed, 95 percent were less than the maximum criterion. Seven measurements were greater than 32.2 °C, and more than one-half of those were at airport site MSC during June–September 2008.

Dissolved Oxygen

DO concentrations ranged from 4.4 mg/L at non-airport site TRIBMD to 17.4 mg/L at non-airport site CCTTR (fig. 11). TRIBMD is on the northwest side of DFW Airport property, although the contributing area for this site does not include airport property (fig. 1). The TRIBMD watershed is the smallest sampled at 1.3 km^2. he watershed is 96.5-percent urban and comprises mostly office buildings and parking lots.

Although non-airport site CCTTR had the highest measured DO concentration at 17.4 mg/L, the boxplot (fig. 11) shows this value as an outlier. DO concentrations at airport site MSC frequently were higher than at other sites. Channel conditions at CCTTR and MSC likely are responsible for these elevated DO concentrations. The concrete trapezoidal channel at MSC usually was covered with a thin layer of algae. Samples were collected during daylight when photosynthesis was taking place and DO concentrations were elevated.

DO criteria for classified freshwater stream segments are given in terms of minimum averages over a 24-hour period and absolute minimums. For this report, point measurements were made at the time of sample collection, thus comparisons with minimum 24-hour average criteria are not relevant. All DO concentrations at all sampling sites during low-flow and stormflow conditions were greater than the minimum criterion of 4.0 mg/L for stream segments classified as exceptional aquatic life use (Texas Commission on Environmental Quality, 2008d, p. 3–5).

pH

Measurements of pH ranged from a low of 6.1 at integrator site BBC183 to a high of 10.1 at airport site MSC (fig. 12). Elevated pH at MSC is consistent with elevated temperature and DO. During photosynthesis, algae use sunlight to consume inorganic carbon (carbon dioxide, carbonate, and bicarbonate) from solution and increase the pH of the water (Snoeyink and Jenkins, 1980). MSC was characterized by the presence of algae, elevated temperatures, oxygen production during photosynthesis, and elevated pH.

The pH criterion listed in the “2000 Texas Surface Water Quality Standards” for the classified segments in the lower West Fork Trinity River and the Elm Fork Trinity River is the range 6.5–9.0 (Texas Commission on Environmental Quality, 2008a, p. 59–60). One pH measurement, at integrator site BBC183 during stormflow conditions, was less than the minimum of the criterion range. Most pH measurements at airport site MSC were greater than the maximum of the criterion range. All other pH measurements were within the criterion range. Ecological consequences can occur as a result of low pH (Baker and others, 1996): When pH is between 6.0 and 6.5, loss of sensitive benthic invertebrates can occur. Between 5.5 and 6.0, acid-sensitive fish can die or reproduce at reduced rates. When surface-water pH is greater than 6.5, there are no adverse effects due to acidity.

Specific Conductance and Dissolved Solids

Specific conductance measurements ranged from 251 microsiemens per centimeter (µS/cm) at integrator site BBC183 to 2,020 µS/cm at non-airport site CCTTR (fig. 13). Empirical data have demonstrated a strong linear relation between specific conductance and dissolved solids concentration, with coefficients mostly between 0.55 and 0.75 (Hem, 1985, p. 67). If dissolved solids concentration is not available, TCEQ currently (2009) uses a coefficient of 0.65 to estimate dissolved solids concentrations (in milligrams per liter) from specific conductance (in microsiemens per centimeter) (Texas Commission on Environmental Quality, 2008d, p. 3–33).

Boxplots of dissolved solids concentrations thus computed are shown in figure 14. The dissolved solids criteria for classified stream segments are given in terms of annual averages and are 850 mg/L for the lower West Fork Trinity River segment and 500 mg/L for the Elm Fork Trinity River segment (Texas Commission on Environmental Quality, 2008a, p. 59–60). For sampling sites in the lower West Fork Trinity River watershed, all annual averages were less than 850 mg/L. For the 13 sampling sites in the Elm Fork Trinity River watershed, nine sites (six airport, three non-airport) had annual averages that exceeded 500 mg/L; airport site GCNAD, non-airport site SHCHPR, non-airport site HCLR, and integrator site EFT348 had annual averages less than 500 mg/L. Specific conductance, and therefore dissolved solids concentration, typically is higher during low-flow conditions, which was more the case for BBC183 than for EFT348. Dissolved solids concentrations during low-flow conditions were significantly higher than concentrations during stormflow conditions on the basis of the Mann-Whitney test. For EFT348 there was no significant difference between low-flow and stormflow dissolved solids concentrations. Discharge at EFT348 depends on dam releases from two lakes. Dilution of stormflows through the lakes and lake releases likely account for no significant difference between the two groups.

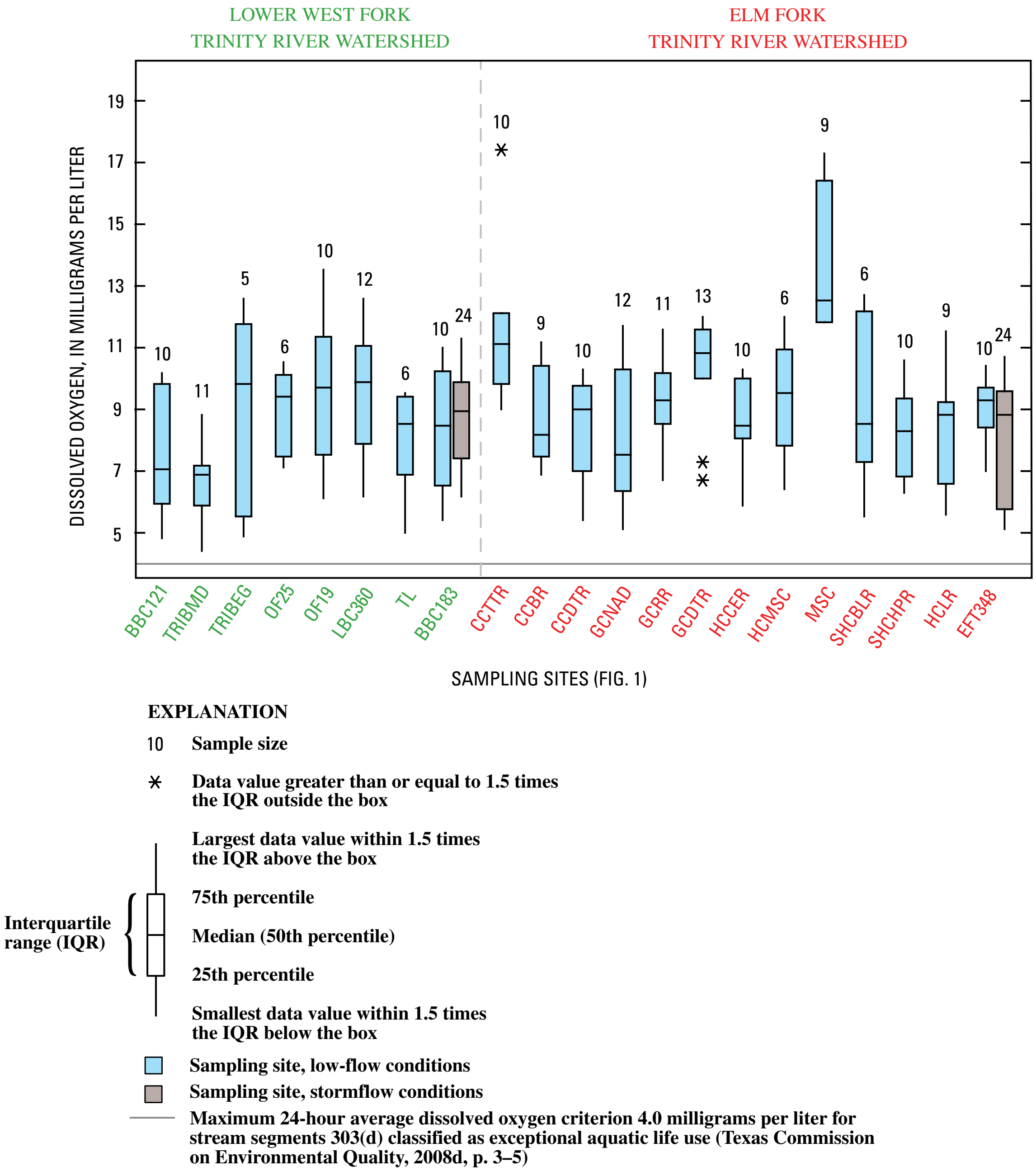


Figure 11. Variability of dissolved oxygen concentration by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

Ammonia

Ammonia is a common surface-water constituent. Sources of ammonia in surface water include industrial and municipal wastewater discharges, agricultural runoff of fertilizers, confined animal feeding operations, leaking septic systems, raw sewage spills, urban runoff of fertilizers and cleaners, and accidental spills (Texas Commission on Environmental Quality, 2005). Background ammonia concentrations are those that can be expected in the absence of substantial human influence and are usually less than 0.1 mg/L (Mueller and others, 1995). Ammonia concentrations in untreated sewage might exceed 30 mg/L and might approach 5 mg/L downstream from wastewater discharges in small streams (Maidment, 1993, p. 11.48–11.49). Ammonia toxicity depends on pH and water temperature. Its toxicity increases as pH and water temperature increase. In alkaline water at high temperatures, chronic-exposure criteria can be exceeded by

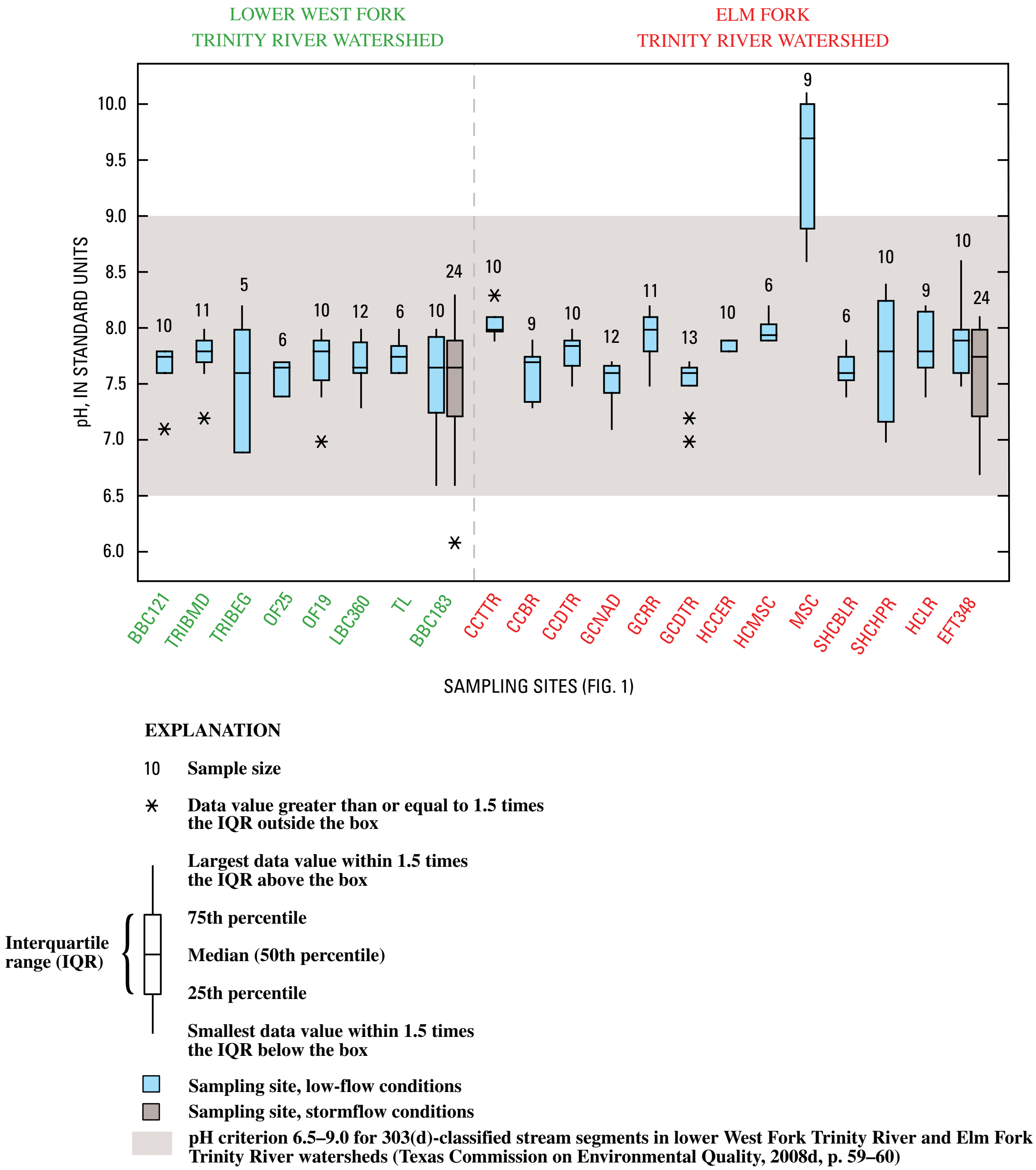


Figure 12. Variability of pH by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

total ammonia concentrations less than 0.1 mg/L (Mueller and others, 1995). The screening level for ammonia in freshwater streams to support the general uses for unclassified water bodies is 0.33 mg/L (Texas Commission on Environmental Quality, 2008d, table 3–10). A water-quality concern is identified if this screening level is exceeded more than 20 percent of the time using the binomial method, based on the number of exceedances for a given sample size (Texas Commission on Environmental Quality, 2008d, p. 3–33).

Ammonia concentrations ranged from less than 0.100 to 0.809 mg/L (fig. 15). For the boxplots in figure 15, all nondetections were set equal to values less than the laboratory reporting level so that detected values are represented correctly by the boxplot and no information is lost (Helsel, 2005). The proportion of the censored data is represented by the

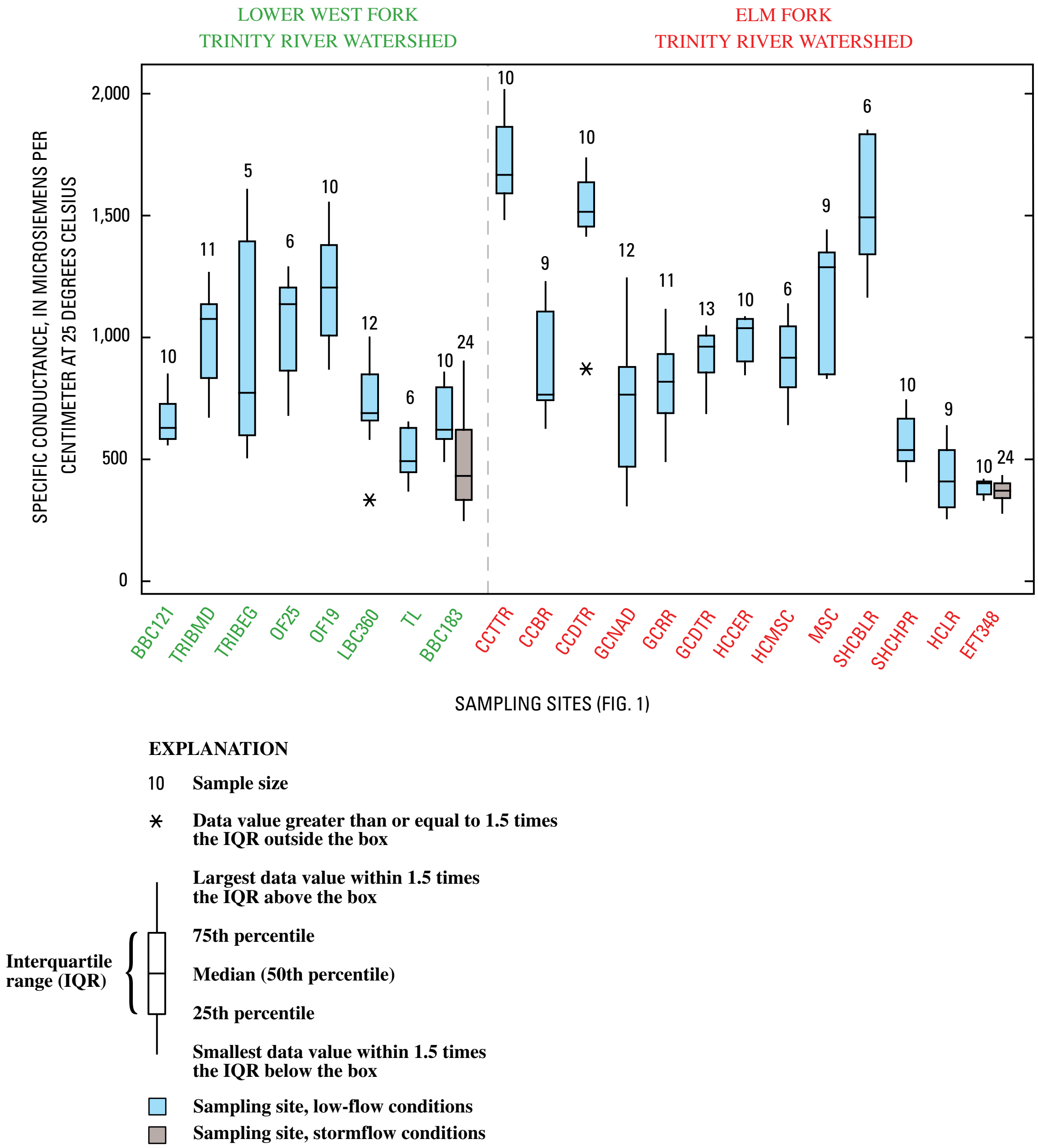


Figure 13. Variability of specific conductance by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

amount of data below the reference line. For example, the median line for airport site HCCER is not visible in the box; therefore, between 50 and 75 percent of the ammonia concentrations were less than 0.100 mg/L. Ammonia concentrations for one storm each at integrator sites BBC183 and EFT348 were all less than the laboratory reporting level of 1.00 mg/L (appendix 1.2); those data were not included in the boxplots.

Of 216 low-flow and stormflow samples, 23 samples from 12 different sites had concentrations that exceeded the screening level for ammonia of 0.33 mg/L. Of these 12 sites, only one (non-airport site TRIBMD) had more than the required number of exceedances to indicate a screening level concern. Nine of the 12 sites had only one sample that was greater than 0.33 mg/L.

For the integrator sites BBC183 and EFT348 at which stormflow samples were collected in addition to low-flow samples, variability of stormflow concentrations appears substantially greater than variability of low-flow concentrations (fig. 15); but Mann-Whitney tests indicated no

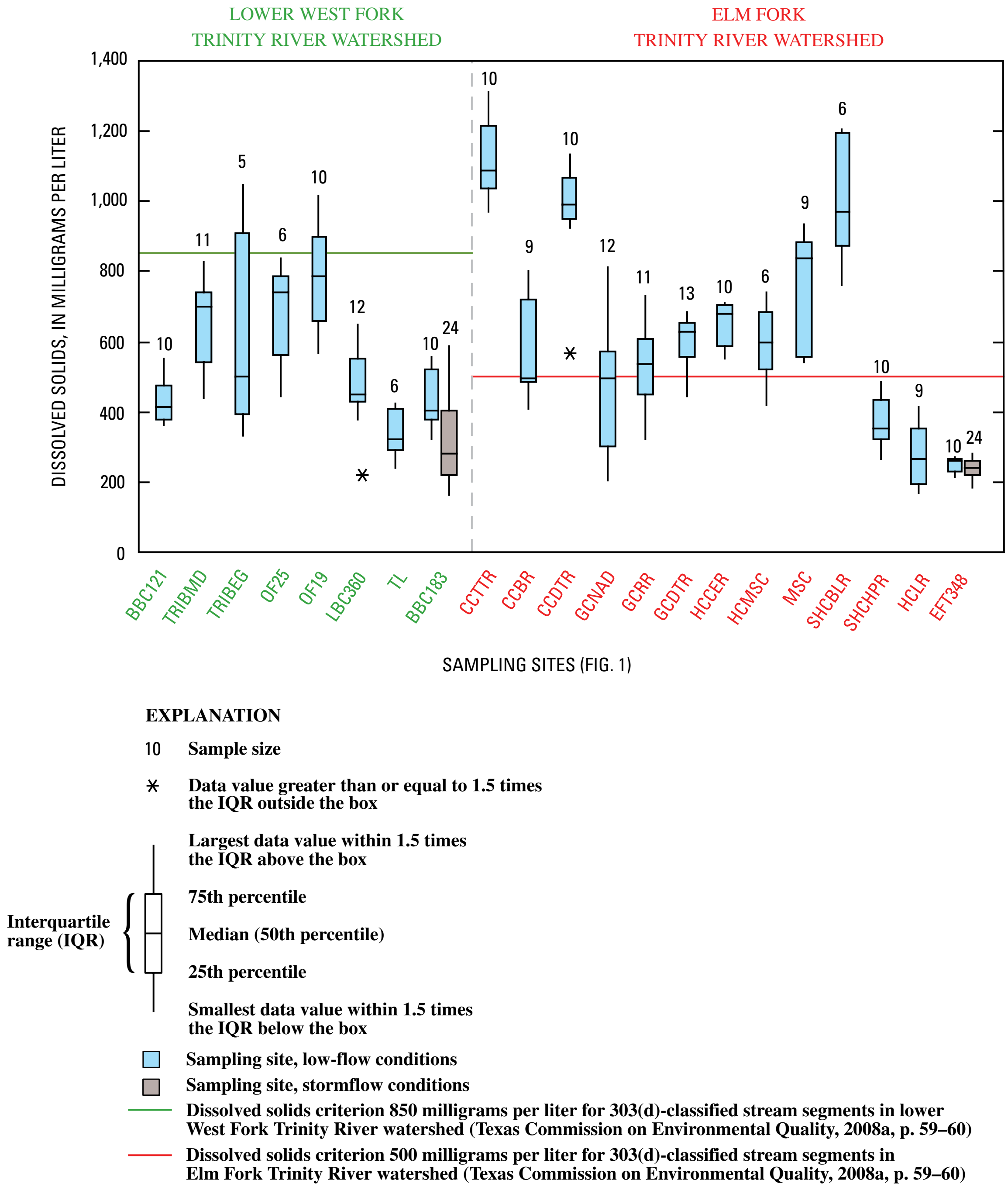


Figure 14. Variability of dissolved solids concentration (computed from specific conductance) by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

significant difference between low-flow and stormflow concentrations for either site.

Total Suspended Solids

Possible sources of elevated TSS concentrations include sewage bypasses, agricultural runoff, urban runoff, and construction runoff (Texas Commission on Environmental Quality, 2005). TSS concentrations ranged from less than 4.00 to 851 mg/L (fig. 16). There were two laboratory reporting levels for analysis of TSS samples for this report, 4.00 and 5.00 mg/L; the higher of the two is shown on the boxplots of figure 16, which is the reason some values are below the reporting-level line.

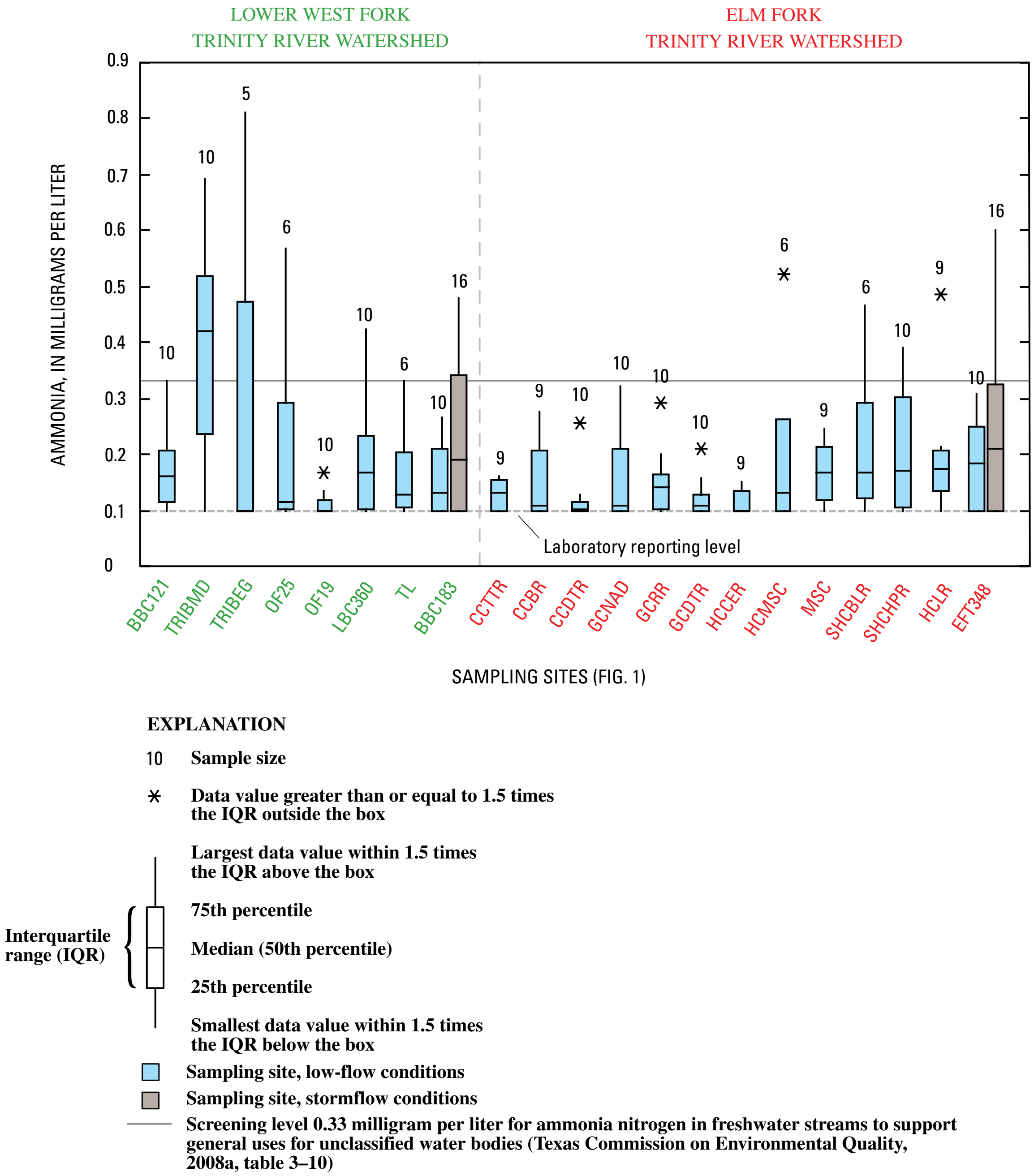
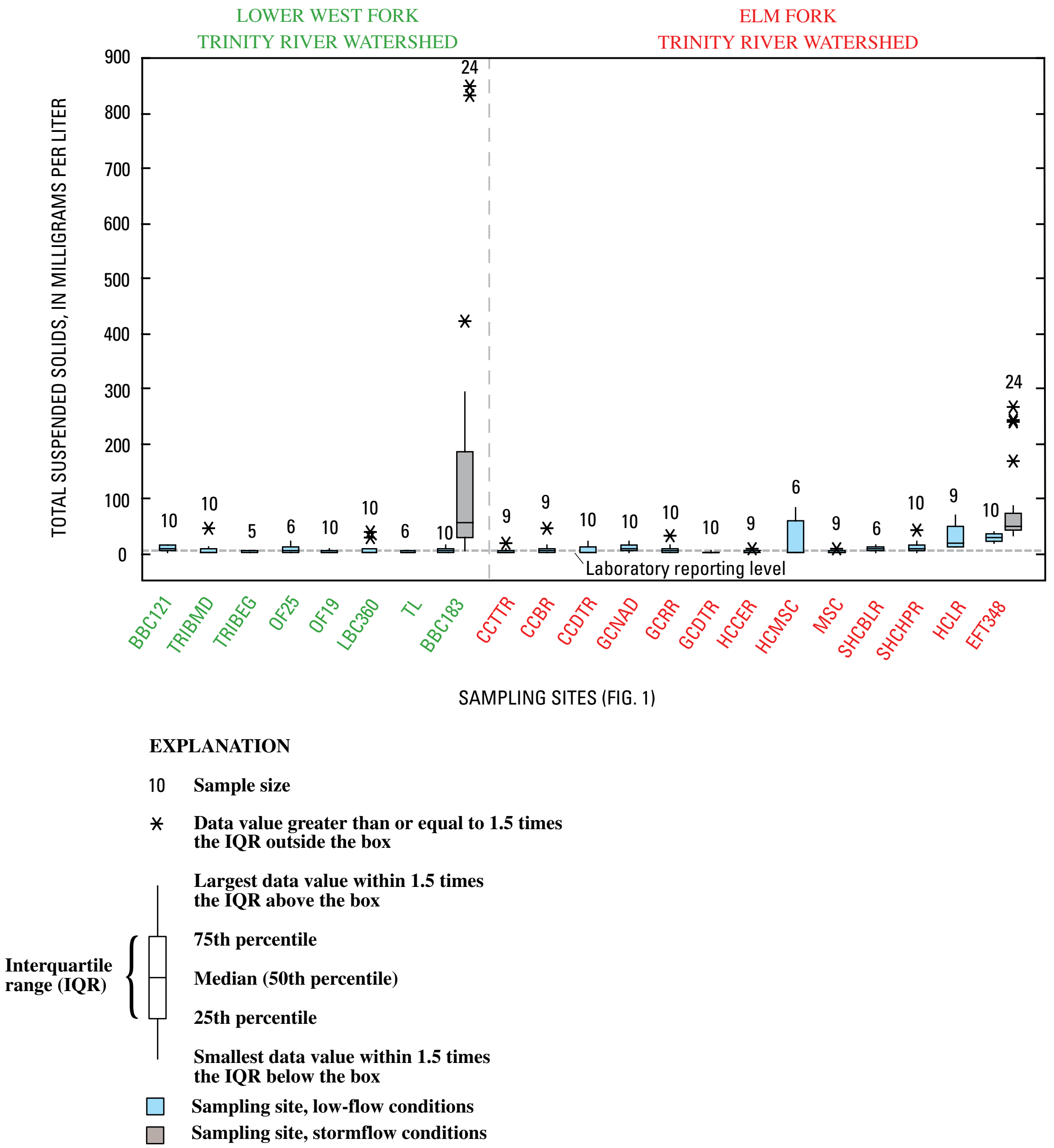


Figure 15. Variability of ammonia nitrogen concentration by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

All samples collected during low-flow conditions had TSS concentrations less than 86 mg/L, and 75 percent were less than or equal to 13 mg/L. At the scale of the graph in figure 16 (necessitated by a few anomalously large stormflow concentrations at integrator site BBC183), the low-flow distributions are not visible, but the main point of the boxplots in figure 16 is to show that TSS concentrations during low-flow conditions were lower than during stormflow conditions and typical of TSS concentrations in streams and rivers nationwide, which commonly range from 10 to 110 mg/L (Maidment, 1993, p. 11.13). Mann-Whitney tests indicated that stormflow TSS concentrations were significantly higher than low-flow concentrations at both BBC183 and EFT348.

Chloride

Chloride concentrations ranged from less than 5.00 to 154 mg/L (fig. 17). Chloride criteria for classified stream



Note: Laboratory reporting level 5.00 milligrams per liter; 4.00 milligrams per liter for some analyses

Figure 16. Variability of total suspended solids concentration by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

segments are given in terms of annual averages. Maximum annual average chloride concentration criteria for the lower West Fork Trinity and the Elm Fork Trinity River segments are 175 and 80 mg/L, respectively (Texas Commission on Environmental Quality, 2008a, p. 59–60). For sampling sites in the lower West Fork Trinity River watershed, all annual averages were below 175 mg/L. For sampling sites in the Elm Fork Trinity River watershed, one of the 13 (non-airport site CCDTR) had an annual average concentration that exceeded 80 mg/L.

Similar to specific conductance and dissolved solids concentrations, higher chloride concentrations are common during low-flow conditions. Chloride concentrations during low-flow conditions at BBC183 were significantly higher than concentrations during stormflow conditions. At EFT348, there was no significant difference between low-flow and stormflow chloride concentrations.

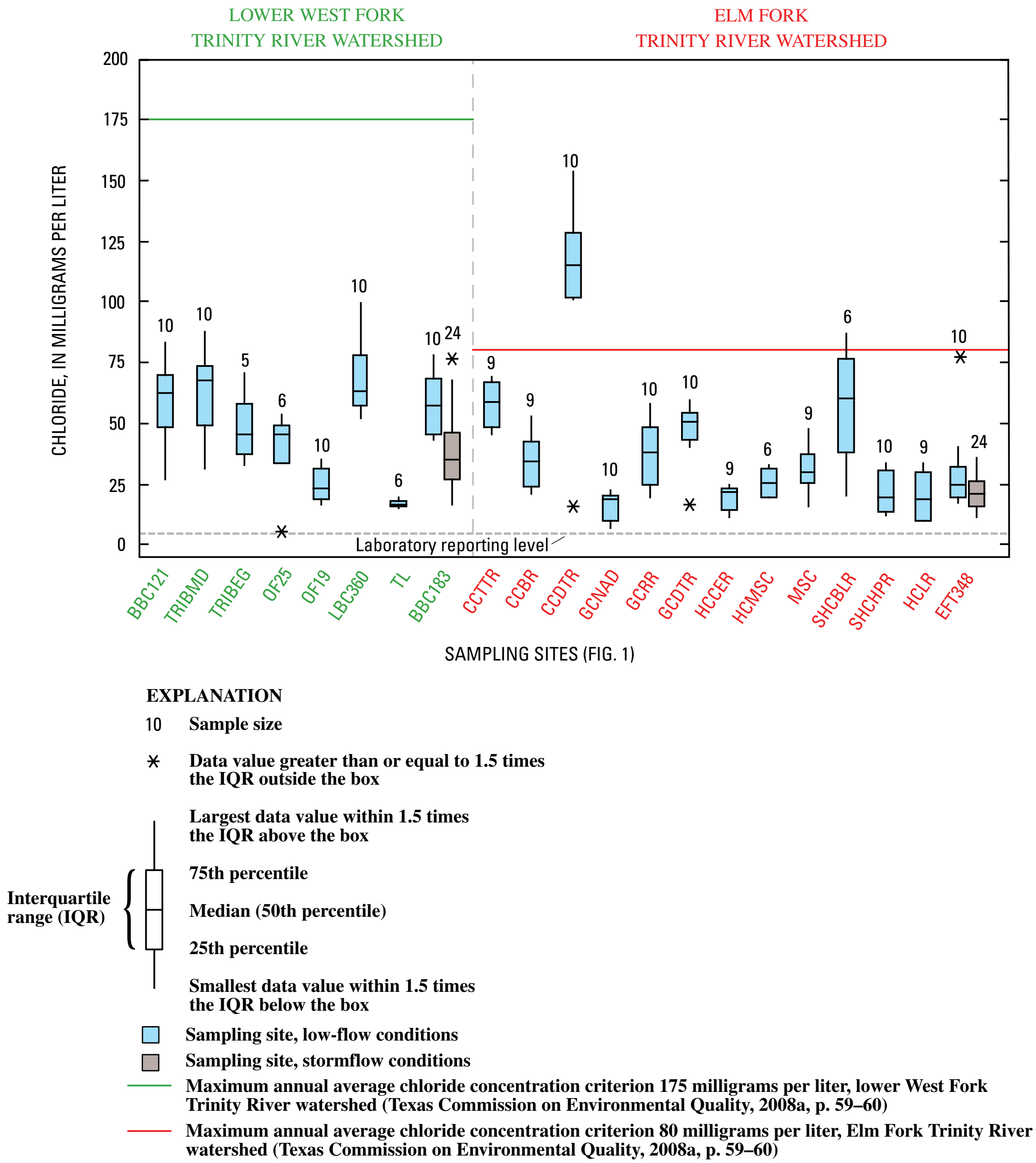


Figure 17. Variability of chloride concentration by site in streams receiving discharge from the Dallas/Fort Worth International Airport and vicinity, north-central Texas, 2008.

Summary

This report, done by the U.S. Geological Survey in cooperation with Dallas/Fort Worth International (DFW) Airport in 2008, describes the occurrence and distribution of fecal indicator bacteria (fecal coliform and *Escherichia* [*E.*] *coli*), and the physical and chemical indicators of water quality (relative to Texas Surface Water Quality Standards), in streams receiving discharge from DFW Airport and vicinity. The findings are intended to help DFW Airport management better understand the extent to which airport discharge is responsible for the State 303(d) listing for bacteria of two segments of the Trinity River downstream from the airport. Occurrence and distribution are described for low-flow conditions on the basis of analysis of samples collected at 21 sites, eight in the lower West Fork Trinity River watershed and 13 in the Elm Fork Trinity River watershed. Four of the eight lower West Fork

Trinity River watershed sites and seven of the 13 Elm Fork Trinity River watershed sites are airport discharge sites, or airport sites, which for this report means the major fraction of discharge at those sites is from DFW Airport. For stormflow conditions, occurrence and distribution are described on the basis of analysis of samples collected at the two most downstream (integrator) sites in each watershed, each downstream from DFW Airport property.

Samples for low-flow conditions were collected almost monthly from each of the 21 sites (flow permitting) during February–December 2008. Samples for stormflow conditions were collected from the two integrator sites during three storms in March, April, and August 2008, respectively. Eight samples were collected at each downstream site during the three storms. Physical and chemical water-quality data (water temperature, dissolved oxygen, pH, specific conductance, ammonia nitrogen, total suspended solids [TSS], and chloride) obtained from the low-flow and stormflow samples are compared with water-quality criteria supporting the uses for the 303(d)-classified segments on the lower West Fork Trinity River and the Elm Fork Trinity River.

At sampling sites in the lower West Fork Trinity River watershed during low-flow conditions, geometric mean *E. coli* counts for five of the eight West Fork Trinity River watershed sampling sites exceeded the TCEQ *E. coli* criterion (126 cfu/100 mL [or MPN/100 mL]), thus not fully supporting contact recreation. Two of the five sites with geometric means that exceeded the contact recreation criterion are airport discharge sites. Maximum fecal indicator bacteria counts were measured for non-airport site TRIBMD on the northwest side of DFW Airport property, the contributing area for which does not include DFW Airport property. Samples collected downstream (after flowing across DFW Airport property) from TRIBMD had lower fecal indicator bacteria counts, but geometric mean *E. coli* counts still exceeded the geometric mean contact recreation criterion. One airport site (OF25) on the western side of the airport with geometric mean *E. coli* counts that exceeded the geometric mean contact recreation criterion has sanitary sewer lines adjacent to the creek and kennels for DFW Airport police dogs. Geometric mean *E. coli* counts at three sites in the lower West Fork Trinity River watershed were less than the geometric mean contact recreation criterion during low-flow conditions. Two of the three are airport sites, and one is the most downstream (integrator) site.

At sampling sites in the Elm Fork Trinity River watershed during low-flow conditions, geometric mean *E. coli* counts exceeded the geometric mean contact recreation criterion for seven of the 13 sampling sites; of the seven, four were airport sites and three were non-airport sites. The seven exceedance sites include all sites on Cottonwood Creek (three) and Grapevine Creek (three) and one site on South Hackberry Creek.

Fecal indicator bacteria counts at the three sampling sites on Cottonwood Creek (non-airport, airport, non-airport in downstream order) generally increase from upstream to downstream; and fecal indicator bacteria counts at the three sampling sites on Grapevine Creek (two airport, one non-airport in downstream order) decrease from the two upstream sites to the most downstream site. For each creek, there were no statistically significant differences between counts at the three sites, despite the fact that the geometric mean *E. coli* count at the most downstream sampling site on each creek was substantially different from geometric mean counts at the upstream sampling sites. Small sample sizes (8–10 per site) likely reduced the power of the statistical test applied (Mann-Whitney) to indicate differences. In general, statistical tests using adequate sample sizes offer a more defensible basis for comparison of bacteria counts between sites than geometric mean values.

E. coli counts under low-flow conditions for airport discharge sites in the lower West Fork Trinity River and Elm Fork Trinity River watersheds were compared with counts for non-airport discharge sites. E. coli counts for airport sites in the lower West Fork Trinity River watershed were significantly different from (lower than) E. coli counts for non-airport sites in the lower West Fork Trinity River watershed. There was no significant difference between E. coli counts for airport sites in the Elm Fork Trinity River watershed and E. coli counts for non-airport sites in the Elm Fork Trinity River watershed.

During stormflow conditions, fecal indicator bacteria counts at the two downstream integrator sites (BBC183 and EFT348) were considerably higher than counts at those sites during low-flow conditions. When stormflow sample counts are included with low-flow sample counts to compute a geometric mean for each site, classification changes from fully supporting to not fully supporting contact recreation on the basis of the geometric mean contact recreation criterion.

All water temperature measurements at sampling sites in the lower West Fork Trinity River watershed were less than the maximum criterion for water temperature for the lower West Fork Trinity segment (35 °C). Of the measurements at sampling sites in the Elm Fork Trinity River watershed, 95 percent were less than the maximum criterion for water temperature for the Elm Fork Trinity River segment (32.2 °C). All measured DO concentrations were greater than the minimum criterion of 4.0 mg/L for stream segments classified as exceptional aquatic life use. One pH measurement, at integrator site BBC183 during stormflow conditions, was less than the minimum of the pH criterion range for the classified segments in both watersheds (6.5–9.0). Most pH measurements at airport site MSC were greater than the maximum of the criterion range; all other pH measurements were within the range. For sampling sites in the lower West Fork Trinity River watershed, all annual average dissolved solids concentrations were less than the maximum criterion for the lower West Fork Trinity segment (850 mg/L). For sampling sites in the Elm Fork Trinity River, nine of the 13 (six airport, three non-airport) had annual average dissolved solids concentrations that exceeded the maximum criterion for the Elm Fork Trinity segment (500 mg/L). For ammonia, 23 samples from 12 different sites had concentrations that exceeded the screening level for ammonia (0.33 mg/L). Of these 12 sites, only one (non-airport site TRIBMD) had more than the required number of exceedances to indicate a screening level concern. Nine of the 12 sites had only one sample that exceeded the screening level. Mann-Whitney tests indicated that stormflow TSS concentrations were significantly higher than low-flow concentrations at the two integrator sites (BBC183 and EFT348) where both low-flow and stormflow samples were collected. For sampling sites in the lower West Fork Trinity River watershed, all annual average chloride concentrations were less than the maximum annual average chloride concentration criterion for the lower West Fork Trinity segment (175 mg/L). For sampling sites in the Elm Fork Trinity River watershed, one of the 13 (non-airport site CCDTR) had an annual average concentration that exceeded the maximum annual average chloride concentration criterion for the Elm Fork Trinity segment (80 mg/L).

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Appendix 1—Fecal Indicator Bacteria and Water-Quality Data Collected at Sampling Sites on Streams Receiving Discharge from Dallas/Fort Worth International Airport and Vicinity, North-Central Texas, 2008

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Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions.

[Bold font indicates field duplicate; MPN/100 mL, most-probable number per 100 milliliters; cfu/100 mL, colony-forming units per 100 milliliters; E., Escherichia; mg/L, milligrams per liter; TSS, total suspended solids; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; psu, practical salinity units; ft³/s, cubic feet per second; ft, feet; >, greater than; TNTC, too numerous to count; E, estimated; NA, not available; <, less than laboratory reporting level]

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft³/s)	Stage (ft)
					Lower West Fork Trinity River watershed									
BBC121	2/20/2008 11:05	>2,400	TNTC	370	0.170	11.0	26.5	10.6	9.9	7.6	560	0.253	E20	NA
BBC121	4/7/2008 15:15	>2,400	80.0	140	.139	14.0	83.0	19.5	10.2	7.8	826	.383	E20	NA
BBC121	5/1/2008 12:25	>2,400	E1,200	1,300	.210	18.0	74.5	19.7	7.9	7.8	852	.396	E15	NA
BBC121	6/2/2008 12:30	16,000	144	220	.120	10.0	61.5	26.9	6.0	7.8	669	.306	E15	NA
BBC121	7/7/2008 9:45	8,400	E100	66	.194	17.0	68.0	27.4	4.8	7.6	697	.320	E1.5	NA
BBC121	8/5/2008 9:10	>2,400	E300	260	<.100	18.0	68.5	28.1	6.2	7.8	668	.305	E1	NA
BBC121	9/22/2008 10:30	>2,400	E100	130	.155	10.0	63.0	21.7	5.8	7.6	587	.266	E10	NA
BBC121	10/29/2008 10:25	1,700	50.0	72	.333	6.00	52.0	12.0	6.0	7.1	594	.270	E8	NA
BBC121	11/18/2008 10:35	>2,400	NA	120	.206	9.00	52.0	11.3	9.4	7.7	579	.262	E13	NA
BBC121	12/2/2008 10:55	>2,400	E160	200	<.100	5.00	36.0	7.5	9.8	7.8	603	.274	E13	NA
TRIBMD	2/20/2008 11:30	1,600	8.00	1.0	.622	48.0	31.0	12.9	6.9	7.7	890	.415	<.3	NA
TRIBMD	4/7/2008 17:20	>2,400	TNTC	1,100	.691	<5.00	65.5	18.1	7.3	7.6	747	.344	<.2	NA
TRIBMD	5/1/2008 12:55	>2,400	TNTC	>2,400	.484	6.50	70.8	19.8	6.8	7.8	1,130	.535	E1	NA
TRIBMD	6/2/2008 13:05	31,000	3,000	4,100	.274	7.00	71.3	24.1	5.9	7.7	1,200	.570	E1	NA
TRIBMD	7/7/2008 10:15	79,000	8,500	4,900	.459	11.0	87.5	24.3	4.4	7.9	1,270	.605	<1	NA
TRIBMD	8/5/2008 9:35	120,000	4,100	3,200	<.100	<4.00	69.5	25.4	5.8	7.7	1,140	.540	<1	NA
TRIBMD	9/22/2008 11:05	73,000	E2,600	1,400	.133	5.00	55.0	22.6	6.4	8.0	836	.388	<1	NA
TRIBMD	10/29/2008 10:45	460	2,600	740	.354	<4.00	64.5	13.4	7.2	7.2	914	.427	<1	NA
TRIBMD	11/18/2008 11:00	39,000	NA	1,900	.384	4.00	81.5	13.6	7.0	7.8	1,080	.509	<1	NA
TRIBMD	**11/18/2008 11:01**	**55,000**	**NA**	**2,200**	**NA**	**NA**	**NA**	**13.6**	**7.0**	**7.8**	**1,080**	**.509**	**<1**	**NA**
TRIBMD	12/2/2008 11:25	2,200	260	390	.457	14.5	31.5	12.9	8.8	7.9	681	.312	<1	NA
TRIBEG	2/20/2008 10:45	1,600	68.0	100	<.100	<5.00	33.0	12.4	12.6	8.2	510	.229	E.3	NA
TRIBEG	4/7/2008 14:58	>2,400	79.0	120	.136	7.00	41.0	23.0	10.9	7.8	699	.321	E4	NA
TRIBEG	5/1/2008 12:03	>2,400	E216	290	<.100	<5.00	45.0	21.1	9.8	7.6	773	.357	E2	NA
TRIBEG	6/2/2008 12:05	>2,400	180	160	.809	7.00	70.5	26.5	6.1	6.9	1,610	.779	<1	NA
TRIBEG	12/2/2008 10:35	>2,400	E150	290	<.100	9.00	45.0	11.0	4.9	6.9	1,180	.560	E1.5	NA
OF25	2/20/2008 10:20	>2,400	172	150	.202	23.0	53.5	10.1	9.3	7.4	925	.432	<1	NA
OF25	4/7/2008 14:20	>2,400	TNTC	530	.104	9.50	42.8	19.0	9.5	7.6	1,170	.555	E3	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Lower West Fork Trinity River watershed—Continued														
OF25	5/1/2008 11:25	>2,400	TNTC	1,200	0.131	5.00	45.8	18.7	7.6	7.4	1,290	0.616	E4	NA
OF25	6/2/2008 11:35	18,000	416	860	.103	<5.00	47.0	24.5	7.1	7.7	1,180	.560	E2	NA
OF25	11/18/2008 10:05	920	NA	8.5	.568	9.00	45.0	10.1	10.0	7.7	1,110	.525	<1	NA
OF25	12/2/2008 10:15	2,400	E110	120	<.100	<4.00	<5.00	6.1	10.5	7.7	684	.313	E2	NA
OF19	2/20/2008 9:15	1,400	E20.0	9.8	.137	<5.00	17.0	11.1	11.4	8.0	1,230	.585	<1	NA
OF19	4/7/2008 13:00	>2,400	22.0	18	<.100	<5.00	19.0	21.0	13.5	7.9	1,170	.555	E3	NA
OF19	5/1/2008 9:57	>2,400	E26.0	19	<.100	<5.00	21.0	20.3	9.3	7.8	1,190	.565	E3	NA
OF19	6/2/2008 10:20	2,000	8.00	18	.113	<5.00	27.5	26.6	8.4	7.9	1,380	.661	E1	NA
OF19	7/7/2008 8:15	8,100	E120	58	.106	8.00	30.0	27.0	6.1	7.6	1,350	.646	<1	NA
OF19	8/5/2008 7:45	>2,400	E56.0	74	<.100	8.00	23.5	28.2	6.5	7.4	1,040	.489	<1	NA
OF19	9/22/2008 9:15	>2,400	20.0	9.8	<.100	<4.00	35.0	21.6	7.9	7.7	877	.408	E1	NA
OF19	10/29/2008 9:10	>2,400	4.00	5.2	.168	<4.00	33.5	11.4	11.3	7.0	1,560	.754	<1	NA
OF19	11/18/2008 8:50	>2,400	NA	40	<.100	5.00	21.8	10.5	10.1	7.8	1,390	.667	<1	NA
OF19	12/2/2008 9:00	>2,400	E140	37	<.100	12.0	16.0	6.3	10.6	7.8	935	.437	<1	NA
LBC360	2/20/2008 10:00	>2,400	218	240	.202	6.00	56.5	11.0	10.6	7.6	659	.301	E8	NA
LBC360	4/7/2008 13:58	>2,400	88.0	67	.151	5.00	99.5	21.2	12.6	8.0	1,000	.469	E17	NA
LBC360	5/1/2008 10:50	>2,400	E148	140	.298	32.0	79.5	20.2	10.1	7.8	875	.407	E10	NA
LBC360	6/2/2008 11:10	>2,400	144	200	.152	<5.00	62.5	26.6	9.3	7.9	681	.312	E10	NA
LBC360	7/7/2008 8:55	>2,400	E260	250	.105	5.00	63.5	26.3	7.4	7.7	671	.307	<1	NA
LBC360	8/5/2008 8:20	11,000	E134	130	<.100	<4.00	57.5	27.4	6.2	7.6	692	.317	E1	NA
LBC360	**8/5/2008 8:24**	**6,800**	**NA**	**140**	**NA**	**NA**	**NA**	**27.4**	**6.2**	**7.6**	**692**	**.317**	**E1**	**NA**
LBC360	9/22/2008 9:50	>2,400	600	390	.186	<4.00	57.0	22.4	9.6	7.9	338	.148	E8	NA
LBC360	10/29/2008 9:45	1,500	44.0	52	.213	42.0	70.0	11.3	11.2	7.3	853	.396	E5	NA
LBC360	**10/29/2008 9:46**	**1,600**	**NA**	**38**	**NA**	**NA**	**NA**	**11.3**	**11.2**	**7.3**	**853**	**.396**	**E5**	**NA**
LBC360	11/18/2008 9:45	>2,400	NA	200	.423	4.00	77.0	11.5	9.5	7.6	737	.339	E7	NA
LBC360	12/2/2008 9:50	>2,400	E100	150	<.100	4.00	52.0	7.4	10.5	7.7	585	.265	E7	NA
TL	2/20/2008 9:45	2,400	48.0	50	.123	<5.00	19.5	10.3	9.5	7.6	515	.232	<1	NA
TL	4/7/2008 13:28	>2,400	105	120	.135	9.00	17.5	18.4	8.4	7.7	619	.282	E2	NA
TL	5/1/2008 10:25	>2,400	E44.0	53	.111	6.00	16.0	19.0	7.5	7.6	657	.300	E2	NA
TL	6/2/2008 10:45	>2,400	68.0	140	.164	<5.00	16.0	25.4	5.0	7.8	478	.214	E1	NA
TL	11/18/2008 9:20	>2,400	NA	32	.332	8.00	17.0	10.9	8.6	8.0	371	.163	<1	NA
TL	12/2/2008 9:25	2,000	E30	60	<.100	<4.00	15.0	7.4	9.4	7.8	482	.216	E1.5	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Lower West Fork Trinity River watershed—Continued														
BBC183	2/20/2008 8:40	>2,400	E400	210	0.266	8.00	60.0	9.8	10.4	7.7	601	0.273	E20	6.22
BBC183	4/7/2008 12:25	>2,400	67.0	64	.146	9.00	78.0	18.9	10.2	8.0	860	.400	E45	6.07
BBC183	5/1/2008 9:30	>2,400	E58.0	71	<.100	5.00	65.5	19.6	8.6	8.0	858	.399	E15	6.26
BBC183	6/2/2008 9:45	>2,400	E40.0	120	.118	11.0	57.0	26.7	6.7	7.9	649	.296	E15	5.80
BBC183	7/7/2008 7:45	>2,400	E38.0	19	.111	12.0	75.5	28.0	5.4	7.4	780	.360	E3	5.41
BBC183	8/5/2008 7:10	>2,400	E98.0	19	<.100	5.00	48.5	29.2	6.0	6.8	581	.263	E1	NA
BBC183	9/22/2008 8:40	>2,400	10.0	13	.173	16.0	46.0	23.5	7.4	7.8	497	.223	E12	NA
BBC183	10/29/2008 8:45	550	7.00	3.1	.203	<4.00	43.0	12.7	8.3	6.6	587	.266	E4	5.50
BBC183	11/18/2008 8:20	>2,400	NA	50	.234	12.0	44.0	11.7	9.6	7.6	596	.271	E8	5.06
BBC183	12/2/2008 8:30	>2,400	E200	81	<.100	4.00	58.0	7.1	11.0	7.4	688	.315	E11	5.71
Elm Fork Trinity River watershed														
CCTTR	2/20/2008 12:00	>2,400	66.0	42	.147	6.00	45.5	16.9	17.4	8.3	1,580	.764	<1	NA
CCTTR	4/7/2008 16:50	>2,400	192	200	.134	<5.00	66.0	22.4	10.4	8.1	1,870	.914	<.2	NA
CCTTR	5/1/2008 15:44	>2,400	38.0	150	.130	22.0	50.5	23.5	9.2	8.0	1,610	.779	E.8	NA
CCTTR	6/2/2008 13:30	>2,400	116	250	.160	8.00	68.0	31.5	9.0	8.0	2,020	.992	<.2	NA
CCTTR	7/7/2008 10:47	17,000	700	860	<.100	10.0	59.0	31.4	11.2	8.0	1,660	.805	<.2	NA
CCTTR	9/22/2008 13:28	18,000	200	610	<.100	<4.00	46.0	27.0	10.0	7.9	1,680	.816	<.2	NA
CCTTR	10/29/2008 12:35	5,000	218	190	.161	4.00	69.0	15.4	11.0	7.9	1,490	.718	<.2	NA
CCTTR	11/18/2008 14:00	4,100	NA	310	.154	<4.00	60.0	13.7	12.1	8.0	1,870	.914	<.2	NA
CCTTR	**11/18/2008 14:02**	**1,100**	**NA**	**140**	**NA**	**NA**	**NA**	**13.7**	**12.1**	**8.0**	**1,870**	**.914**	**<.2**	**NA**
CCTTR	12/2/2008 14:15	3,300	360	130	<.100	<4.00	52.0	10.7	E11.9	8.1	1,600	.774	<.2	NA
CCBR	2/20/2008 13:30	>2,400	50.0	96	.111	6.00	21.0	13.0	11.2	7.4	745	.343	E.2	NA
CCBR	4/7/2008 15:06	>2,400	57.0	62	<.100	5.00	35.0	21.8	10.3	7.7	990	.464	<.2	NA
CCBR	5/1/2008 13:19	>2,400	100	210	.276	49.0	34.5	20.6	9.4	7.8	1,200	.570	E.2	NA
CCBR	6/2/2008 13:00	>2,400	572	1,300	.164	9.00	49.5	28.9	10.5	7.3	1,230	.585	<.2	NA
CCBR	7/7/2008 10:22	46,000	282	300	.183	16.0	52.5	28.1	7.8	7.3	1,020	.479	<.2	NA
CCBR	9/22/2008 11:17	6,200	E120	60	<.100	<4.00	35.0	22.7	7.1	7.9	751	.346	<.2	NA
CCBR	10/29/2008 13:05	6,400	196	230	.111	<4.00	28.8	12.9	7.8	7.7	767	.354	<.2	NA
CCBR	11/18/2008 13:40	1,100	NA	61	.230	<4.00	25.0	12.3	6.9	7.6	747	.344	<.2	NA
CCBR	12/2/2008 13:50	11,000	1,600	960	<.100	6.00	22.0	10.5	E8.2	7.7	634	.289	<.2	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Elm Fork Trinity River watershed—Continued														
CCDTR	2/20/2008 14:00	>2,400	98.0	73	<.100	5.00	102	14.1	10.3	7.8	1,470	0.707	E4	NA
CCDTR	4/7/2008 14:05	>2,400	TNTC	1,400	.256	<5.00	15.5	18.8	9.7	7.9	1,620	.785	E5	NA
CCDTR	5/1/2008 12:47	>2,400	1,300	1,100	.129	25.0	115	19.2	8.5	7.9	1,570	.759	E6	NA
CCDTR	6/2/2008 12:15	31,000	1,000	910	.113	13.0	108	24.0	7.3	7.9	1,490	.718	E2.5	NA
CCDTR	7/7/2008 9:43	5,500	E264	310	.104	8.50	131	25.2	6.0	7.6	1,700	.826	E3	NA
CCDTR	8/5/2008 9:38	5,000	178	260	<.100	<4.00	154	27.0	5.4	7.5	1,740	.847	E1	NA
CCDTR	9/22/2008 10:50	7,600	E100	170	<.100	<4.00	115	22.6	7.4	7.8	872	.406	E2	NA
CCDTR	10/29/2008 10:40	5,300	96.0	70	.113	<4.00	128	13.0	9.5	7.7	1,520	.733	E2	NA
CCDTR	11/18/2008 13:15	920	NA	350	<.100	5.00	119	12.7	9.5	8.0	1,520	.733	E2	NA
CCDTR	12/2/2008 13:25	4,900	1,280	960	<.100	13.0	101	8.9	E10.0	7.9	1,420	.682	E5	NA
GCNAD	2/20/2008 12:20	>2,400	17.0	31	.115	<5.00	19.0	14.3	11.7	7.7	944	.441	E2	NA
GCNAD	4/7/2008 15:45	>2,400	TNTC	170	.103	20.0	18.0	24.2	10.9	7.7	879	.409	E2	NA
GCNAD	**4/7/2008 15:46**	**>2,400**	**136**	**160**	**NA**	**NA**	**NA**	**24.2**	**10.9**	**7.7**	**879**	**.409**	**E2**	**NA**
GCNAD	5/1/2008 13:30	>2,400	280	550	.253	8.00	21.5	21.2	8.2	7.5	860	.400	E5	NA
GCNAD	6/2/2008 13:40	16,000	100	190	<.100	11.0	19.5	29.5	5.5	7.4	1,250	.595	<1	NA
GCNAD	7/7/2008 10:50	7,000	64.0	61	.107	15.0	10.0	26.6	5.1	7.4	673	.308	<.5	NA
GCNAD	8/5/2008 10:15	14,000	800	540	<.100	23.0	7.50	28.7	7.0	7.5	574	.260	<1	NA
GCNAD	9/22/2008 11:37	17,000	E1,800	660	.130	<4.00	22.5	22.6	6.6	7.6	316	.138	<1	NA
GCNAD	**9/22/2008 11:40**	**14,000**	**NA**	**690**	**NA**	**NA**	**NA**	**22.6**	**6.6**	**7.6**	**316**	**.138**	**<1**	**NA**
GCNAD	10/29/2008 11:15	2,900	500	280	.324	11.0	6.50	10.8	6.3	7.1	443	.197	<1	NA
GCNAD	11/18/2008 11:35	5,300	NA	1,100	.199	15.0	20.0	10.5	8.0	7.6	868	.404	<1	NA
GCNAD	12/2/2008 11:55	16,000	460	420	<.100	12.0	12.0	6.0	8.4	7.6	547	.247	E1	NA
GCRR	2/20/2008 13:05	>2,400	E52.0	50	.106	8.00	25.5	17.4	11.6	8.1	716	.329	E.6	NA
GCRR	4/7/2008 15:34	>2,400	73.0	110	.203	5.50	28.5	27.6	8.5	8.1	692	.317	E.2	NA
GCRR	5/1/2008 15:06	>2,400	112	260	.145	35.0	21.5	26.3	9.1	8.2	739	.340	E1	NA
GCRR	6/2/2008 15:22	>2,400	116	120	.142	6.00	28.5	32.7	8.7	8.1	498	.223	E.2	NA
GCRR	7/7/2008 12:18	11,000	1,300	750	.155	11.0	47.5	29.4	8.5	7.7	871	.405	E.2	NA
GCRR	8/5/2008 10:10	19,000	600	290	<.100	4.00	51.5	27.4	6.7	7.5	824	.382	E.2	NA
GCRR	9/22/2008 14:05	8,600	500	340	.294	11.0	46.5	25.1	9.3	8.0	933	.436	<.2	NA
GCRR	**9/22/2008 14:07**	**15,000**	**NA**	**340**	**NA**	**NA**	**NA**	**25.1**	**9.3**	**8.0**	**933**	**.436**	**<.2**	**NA**
GCRR	10/29/2008 13:30	14,000	500	530	.131	<4.00	58.0	13.9	9.7	7.8	1,120	.530	<.2	NA
GCRR	11/18/2008 14:30	8,100	NA	310	.147	4.00	47.0	12.5	10.3	7.9	890	.415	<.2	NA
GCRR	12/2/2008 11:10	20,000	2,160	1,900	<.100	16.0	19.0	6.3	E10.2	7.8	661	.302	E.5	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
						Elm Fork Trinity River watershed—Continued								
GCDTR	2/20/2008 14:25	2,000	56.0	63	0.110	<5.00	16.0	16.2	12.0	7.6	875	0.407	E4	NA
GCDTR	4/7/2008 14:43	>2,400	21.0	390	.158	<5.00	49.0	23.3	10.9	7.7	1,040	.489	E5	NA
GCDTR	5/1/2008 12:11	9,700	357	370	.210	<5.00	53.3	21.6	10.8	7.6	1,050	.494	E4	NA
GCDTR	6/2/2008 11:38	>2,400	180	300	.102	<5.00	59.5	27.9	10.0	7.7	1,010	.474	E2	NA
GCDTR	**6/2/2008 11:39**	**11,000**	**NA**	**240**	**NA**	**NA**	**NA**	**27.9**	**10.0**	**7.7**	**1,010**	**.474**	**E2**	**NA**
GCDTR	7/7/2008 9:12	8,100	E174	250	.121	5.00	45.5	25.5	7.3	7.2	855	.397	E2	NA
GCDTR	8/5/2008 9:15	10,000	E144	68	<.100	<4.00	44.5	27.1	6.7	7.0	815	.378	E2	NA
GCDTR	9/22/2008 10:20	7,000	E104	92	<.100	6.00	54.0	22.9	10.1	7.5	999	.469	E2	NA
GCDTR	**9/22/2008 10:22**	**5,900**	**NA**	**34**	**NA**	**NA**	**NA**	**22.9**	**10.1**	**7.5**	**999**	**.469**	**E2**	**NA**
GCDTR	10/29/2008 10:15	3,900	280	410	.107	<4.00	56.0	13.0	11.8	7.5	966	.452	E3	NA
GCDTR	**10/29/2008 10:17**	**1,400**	**NA**	**310**	**NA**	**NA**	**NA**	**13.0**	**11.8**	**7.5**	**966**	**.452**	**E3**	**NA**
GCDTR	11/18/2008 12:55	3,300	NA	110	.117	<4.00	52.0	13.5	11.4	7.6	689	.316	E5	NA
GCDTR	12/2/2008 13:00	1,300	150	220	<.100	<4.00	40.0	9.6	E11.4	7.6	857	.398	E5	NA
HCCER	2/20/2008 15:00	1,400	4.00	6.3	<.100	<5.00	14.5	15.8	10.3	7.8	1,000	.469	E1	NA
HCCER	4/7/2008 17:50	2,000	10.0	9.7	<.100	<5.00	21.5	23.2	8.7	7.8	1,080	.509	E.2	NA
HCCER	5/1/2008 17:12	>2,400	74.0	91	.152	<5.00	16.5	23.9	8.1	7.9	1,070	.504	E.2	NA
HCCER	**5/1/2008 17:14**	**>2,400**	**68.0**	**110**	**NA**	**NA**	**NA**	**23.9**	**8.1**	**7.9**	**1,070**	**.504**	**E.2**	**NA**
HCCER	6/2/2008 15:56	>2,400	1,900	2,000	.147	<5.00	23.5	33.2	5.9	7.8	1,090	.514	E.2	NA
HCCER	7/7/2008 12:44	7,100	10.0	10	.125	<4.00	24.5	31.9	9.9	7.9	1,090	.514	<.2	NA
HCCER	9/22/2008 14:35	13,000	150	340	<.100	<4.00	13.0	26.8	8.0	7.9	850	.395	<.2	NA
HCCER	10/29/2008 13:55	>2,400	168	170	.107	7.00	22.0	16.4	8.2	7.8	926	.432	<.2	NA
HCCER	11/18/2008 11:10	2,400	NA	60	<.100	<4.00	23.0	14.2	9.4	7.9	1,020	.479	<.2	NA
HCCER	12/2/2008 10:45	>2,400	E90	20	<.100	12.0	11.5	7.3	E10.3	7.9	849	.394	<.2	NA
HCMSC	2/20/2008 15:25	2,400	14.0	22	<.100	6.00	30.5	16.1	10.5	7.9	952	.445	E2	NA
HCMSC	4/7/2008 18:23	>2,400	42.0	54	.179	5.00	19.0	25.2	8.6	8.0	1,020	.479	<.2	NA
HCMSC	5/1/2008 16:20	>2,400	104	110	.165	52.0	19.5	27.2	8.3	8.0	888	.414	E.8	NA
HCMSC	6/2/2008 16:40	>2,400	68.0	110	.521	86.0	33.0	32.8	6.4	8.2	648	.296	E.2	NA
HCMSC	11/18/2008 10:30	>2,400	NA	96	<.100	<4.00	31.0	9.7	10.6	7.9	1,140	.540	<.2	NA
HCMSC	12/2/2008 10:00	>2,400	E190	290	<.100	<4.00	19.0	4.8	E12.0	7.9	853	.396	<.2	NA
MSC	2/20/2008 15:45	>2,400	8.00	9.8	.141	12.0	15.5	20.1	15.7	9.0	945	.442	E.5	NA
MSC	4/7/2008 18:38	1,300	15.0	16	.217	<5.00	29.5	26.6	12.3	10.0	1,290	.616	E1.5	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft³/s)	Stage (ft)
					Elm Fork Trinity River watershed—Continued									
MSC	5/1/2008 16:40	370	<2.00	1.0	.177	<5.00	23.0	31.0	11.8	10.1	1,300	.621	E2	NA
MSC	6/2/2008 16:50	310	<4.00	<1.0	0.212	<5.00	34.5	35.6	11.8	10.0	1,410	0.677	E.2	NA
MSC	7/7/2008 13:20	46	<2.00	<1.0	.248	6.00	40.0	37.2	11.8	9.7	834	.387	E.2	NA
MSC	8/5/2008 12:12	>2,400	<2.00	<1.0	<.100	4.00	47.5	36.6	12.5	9.4	1,440	.692	E.2	NA
MSC	9/22/2008 15:00	980	1.00	1.0	.157	8.00	28.0	33.0	13.3	9.9	1,290	.616	<.2	NA
MSC	10/29/2008 14:30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	E14	NA
MSC	11/18/2008 10:40	2,400	NA	82	.170	<4.00	33.5	14.6	17.3	8.8	838	.389	<.3	NA
MSC	12/2/2008 10:15	>2,400	E170	96	<.100	<4.00	28.0	9.1	E17.1	8.6	873	.406	<.2	NA
SHCBLR	2/20/2008 16:20	>2,400	30.0	60	.467	8.00	20.0	15.3	12.0	7.9	1,560	.754	E.2	NA
SHCBLR	4/7/2008 12:22	>2,400	89.0	180	.190	18.0	52.5	18.9	8.4	7.6	1,830	.893	<.2	NA
SHCBLR	5/1/2008 9:40	>2,400	E250	180	.150	12.0	87.0	19.6	8.6	7.6	1,400	.672	<.2	NA
SHCBLR	10/29/2008 8:35	>2,400	400	210	.129	9.00	44.0	10.6	5.5	7.4	1,170	.555	<.2	NA
SHCBLR	11/18/2008 8:35	>2,400	NA	170	.233	10.5	67.5	9.9	7.9	7.6	1,430	.687	<.2	NA
SHCBLR	12/2/2008 8:22	>2,400	E540	580	<.100	<4.00	73.0	5.4	E12.7	7.7	1,850	.904	<.2	NA
SHCHPR	2/25/2008 14:20	2,600	29.0	36	.296	25.0	19.5	16.8	8.5	7.2	706	.324	E.2	NA
SHCHPR	4/7/2008 12:45	2,400	169	41	.151	15.0	21.5	18.9	9.9	8.2	749	.345	<.5	NA
SHCHPR	5/1/2008 10:24	>2,400	E21.7	38	.324	15.0	13.8	20.8	9.2	8.4	527	.237	<.2	NA
SHCHPR	6/2/2008 9:42	>2,400	E72.0	150	.179	12.0	17.5	28.0	8.1	8.4	526	.237	<.2	NA
SHCHPR	7/7/2008 7:55	>2,400	E42.0	33	.168	11.0	30.5	29.1	6.3	7.0	644	.294	E.2	NA
SHCHPR	8/5/2008 7:18	2,000	E200	99	<.100	5.00	33.5	30.8	7.3	7.1	659	.301	<.2	NA
SHCHPR	9/22/2008 8:55	>2,400	E200	53	.236	<4.00	31.5	24.7	6.9	7.6	559	.253	<.2	NA
SHCHPR	10/29/2008 9:00	1,600	70.0	45	.111	7.00	18.5	15.3	8.6	7.9	482	.216	<.5	NA
SHCHPR	11/18/2008 9:00	>2,400	NA	690	.392	46.0	12.0	13.2	6.6	7.7	412	.183	<.5	NA
SHCHPR	12/2/2008 8:45	2,400	E30	41	<.100	13.0	13.0	8.8	E10.6	8.0	504	.226	<.2	NA
HCLR	2/20/2008 17:10	>2,400	230	160	.199	52.0	18.5	10.7	9.1	7.6	318	.139	E6	NA
HCLR	4/7/2008 13:10	>2,400	102	170	.164	30.0	9.50	19.9	9.1	8.1	426	.189	E1	NA
HCLR	5/1/2008 10:48	>2,400	E100	73	.487	71.0	10.5	20.6	7.7	7.7	412	.183	E1	NA
HCLR	6/2/2008 10:14	>2,400	76.0	210	.145	14.0	19.0	25.8	5.6	7.8	292	.127	<.2	NA
HCLR	8/5/2008 7:57	>2,400	E6.00	4.1	<.100	14.0	33.5	30.3	5.8	7.4	637	.290	E1.3	NA
HCLR	9/22/2008 9:18	>2,400	E100	5.2	.127	14.0	33.0	24.6	7.4	8.2	543	.245	E.5	NA
HCLR	10/29/2008 9:20	2,400	54.0	76	.174	22.0	26.0	15.1	8.8	7.8	541	.244	E5	NA

Appendix 1.1. Fecal indicator bacteria and water-quality data for samples collected during low-flow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Elm Fork Trinity River watershed—Continued														
HCLR	11/18/2008 9:33	>2,400	NA	160	.181	51.0	10.0	13.6	9.4	8.1	264	.114	E5	NA
HCLR	12/2/2008 9:10	13,000	E100	89	.216	13.0	10.0	8.6	E11.5	8.2	363	.160	E3	NA
EFT348	2/20/2008 17:35	>2,400	350	140	0.190	37.0	77.5	10.8	9.4	7.6	399	0.176	123	11.70
EFT348	4/7/2008 13:35	>2,400	TNTC	44	.250	37.0	19.5	16.6	9.6	8.0	365	.160	3,279	17.00
EFT348	5/1/2008 11:20	>2,400	E100	68	.257	42.0	18.0	19.4	9.2	8.0	362	.159	3,445	17.27
EFT348	6/2/2008 11:00	>2,400	48.0	50	.198	34.0	25.0	27.5	8.7	8.0	411	.182	286	12.09
EFT348	7/7/2008 8:38	>2,400	E10.0	11	.179	27.0	26.5	28.5	7.0	7.5	403	.178	172	11.83
EFT348	8/5/2008 8:27	>2,400	E42.0	7.3	<.100	27.0	24.5	31.3	10.4	7.6	354	.155	197	11.89
EFT348	9/22/2008 9:42	>2,400	E200	17	<.100	29.0	40.0	25.5	10.0	8.6	422	.187	232	11.97
EFT348	10/29/2008 9:45	2,400	600	270	.181	23.0	29.5	17.2	8.8	7.9	410	.182	156	11.79
EFT348	11/18/2008 10:00	>2,400	NA	240	.310	33.0	17.0	14.5	7.5	7.9	334	.146	35.5	11.39
EFT348	12/2/2008 9:30	>2,400	E130	100	<.100	22.0	21.0	10.9	E9.6	7.8	422	.187	255	12.02

[1] Estimated if holding time greater than 6 hours.

[2] Estimated if rated as fair (+0.5 to 0.8 mg/L) or poor (>+0.8 mg/L).

[3] Calculated from specific conductance.

Appendix 1.2. Fecal indicator bacteria and water-quality data for samples collected during stormflow conditions.

[MPN/100 mL, most-probable number per 100 milliliters; cfu/100 mL, colony-forming units per 100 milliliters; E., Escherichia; mg/L, milligrams per liter; TSS, total suspended solids; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; psu, practical salinity units; ft^3/s, cubic feet per second; ft, feet; <, less than laboratory reporting level; NA, not available; E, estimated; >, greater than; TNTC, too numerous to count]

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Lower West Fork Trinity River watershed														
BBC183	3/17/2008 14:20	2,400	20.0	48	<1.00	9.00	76.5	18.6	11.3	8.1	902	0.421	NA	6.27
BBC183	3/18/2008 9:54	E15,000	E1,200	E1,400	<1.00	149	65.5	17.7	8.4	7.8	774	.357	NA	7.00
BBC183	3/18/2008 11:52	92,000	4,800	4,900	<1.00	426	20.0	16.3	9.0	7.8	306	.133	NA	13.24
BBC183	3/19/2008 10:00	130,000	E6,200	5,200	<1.00	296	16.5	12.3	9.7	7.6	259	.111	NA	12.92
BBC183	3/19/2008 12:00	46,000	6,400	4,600	<1.00	226	17.5	12.7	9.9	7.7	272	.117	NA	11.71
BBC183	3/19/2008 13:46	120,000	6,100	4,600	<1.00	132	19.5	13.2	10.0	7.4	287	.124	NA	10.80
BBC183	3/20/2008 9:28	58,000	2,350	2,100	<1.00	54.0	30.5	12.5	10.1	7.5	444	.198	NA	7.41
BBC183	3/20/2008 11:16	44,000	1,900	1,400	<1.00	74.0	29.5	13.3	10.2	7.5	458	.204	NA	7.33
BBC183	4/3/2008 18:23	>2,400	TNTC	55	.481	22.0	58.0	20.8	10.4	8.3	728	.335	NA	6.29
BBC183	4/4/2008 8:11	120,000	E7,000	7,600	.349	106	49.5	17.8	9.0	7.7	625	.285	NA	7.96
BBC183	4/4/2008 10:12	200,000	E9,900	7,600	.415	56.0	45.5	17.5	8.9	7.9	597	.271	NA	7.30
BBC183	4/4/2008 10:34	200,000	E7,400	6,500	.350	57.0	46.5	17.6	8.5	7.9	630	.287	NA	7.28
BBC183	4/4/2008 14:00	E>240,000	6,900	E6,500	.239	43.0	42.0	18.9	9.9	7.9	576	.261	NA	7.15
BBC183	4/4/2008 15:30	240,000	8,200	6,900	.269	45.0	44.5	19.4	9.6	8.0	601	.273	NA	7.10
BBC183	4/4/2008 16:55	>240,000	6,900	6,900	.237	42.0	43.5	19.3	9.6	8.0	623	.284	NA	7.10
BBC183	4/5/2008 10:15	61,000	1,140	1,300	.315	22.0	67.5	16.4	E8.6	8.0	710	.326	NA	6.69
BBC183	8/15/2008 10:43	>240,000	E19,200	18,000	.147	834	26.0	24.5	E6.3	6.1	317	.138	NA	11.45
BBC183	8/15/2008 12:44	>240,000	39,800	43,000	.125	851	23.8	24.6	E6.2	7.0	251	.108	NA	11.46
BBC183	8/18/2008 13:07	130,000	2,250	1,700	.129	200	30.5	25.3	7.4	6.6	419	.186	NA	7.57
BBC183	8/19/2008 11:30	140,000	4,100	3,900	<.100	100	34.5	25.1	7.4	7.0	406	.180	NA	6.98
BBC183	8/19/2008 13:38	98,000	2,700	2,300	<.100	61.0	35.0	25.7	7.5	7.3	408	.181	NA	6.84
BBC183	8/20/2008 10:30	17,000	E400	220	<.100	29.0	34.5	25.1	E6.6	6.8	420	.186	NA	6.38
BBC183	8/20/2008 11:55	22,000	100	130	<.100	27.0	34.5	25.6	E6.9	7.2	425	.189	NA	6.35
BBC183	8/20/2008 13:26	14,000	200	170	<.100	27.0	35.5	26.3	E7.0	7.3	430	.191	NA	6.27
Elm Fork Trinity River watershed														
EFT348	3/17/2008 15:30	2,000	27.0	37	<1.00	37.0	17.5	13.2	10.7	7.8	358	.157	2,881	16.35
EFT348	3/18/2008 10:55	E4,100	E90.0	E230	<1.00	73.0	16.5	14.2	9.7	7.9	347	.152	3,180	16.84
EFT348	3/18/2008 13:40	87,000	1,120	1,600	<1.00	268	13.5	14.8	9.4	7.9	343	.150	5,458	20.92
EFT348	3/18/2008 14:34	52,000	1,450	1,700	<1.00	242	15.0	14.5	9.6	8.0	337	.147	5,853	21.63
EFT348	3/19/2008 11:00	E100,000	E8,550	E5,400	<1.00	170	11.5	13.7	8.8	7.7	285	.123	6,918	23.53

Appendix 1.2. Fecal indicator bacteria and water-quality data for samples collected during stormflow conditions—Continued.

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)	Fecal coliforms[1] (cfu/100 mL)	*E. coli*[1] (MPN/100 mL)	Ammonia, as nitrogen (mg/L)	Residue (TSS) (mg/L)	Total chloride (mg/L)	Water temperature (°C)	Dissolved oxygen[2] (mg/L)	pH (standard units)	Specific conductance (µS/cm)	Salinity[3] (psu)	Discharge (ft^3/s)	Stage (ft)
Elm Fork Trinity River watershed—Continued														
EFT348	3/19/2008 12:57	130,000	7,500	5,100	<1.00	246	12.0	13.7	9.0	7.5	284	.123	6,828	23.37
EFT348	3/20/2008 10:18	77,000	5,300	4,600	<1.00	65.0	13.0	13.7	8.7	7.4	330	.144	3,236	16.93
EFT348	3/20/2008 12:13	87,000	4,600	4,900	<1.00	78.0	14.5	13.8	8.8	7.3	336	.147	2,791	16.20
EFT348	4/3/2008 19:07	>2,400	TNTC	64	.600	43.0	20.0	16.2	9.6	8.0	367	.161	3,340	17.10
EFT348	4/4/2008 9:23	6,100	E110	93	.301	45.0	20.0	16.0	9.4	8.1	364	.160	3,606	17.53
EFT348	4/4/2008 11:26	5,600	240	130	.379	47.0	19.0	15.9	9.8	8.1	370	.163	3,750	17.76
EFT348	4/4/2008 12:07	14,000	100	190	.327	52.0	20.5	16.0	8.7	8.1	373	.164	3,794	17.83
EFT348	4/4/2008 14:43	E46,000	760	E580	.347	63.0	24.0	16.3	10.1	8.0	393	.174	3,932	18.06
EFT348	4/4/2008 16:10	19,000	940	580	.327	88.0	23.5	16.4	10.1	8.0	401	.177	3,970	18.13
EFT348	4/5/2008 9:30	21,000	760	830	.295	44.0	21.0	15.8	E9.1	8.0	377	.166	3,819	17.87
EFT348	4/5/2008 10:52	25,000	640	720	.308	47.0	20.5	15.9	E8.7	8.0	376	.166	3,794	17.83
EFT348	8/15/2008 11:27	9,900	173	25	.125	38.0	26.0	28.1	E6.2	7.4	386	.170	933	13.20
EFT348	8/15/2008 13:31	12,000	200	26	.130	44.0	25.0	28.3	E6.0	7.3	388	.171	1,134	13.51
EFT348	8/19/2008 10:45	19,000	200	250	<.100	39.0	26.5	26.7	5.1	6.7	405	.179	503	12.49
EFT348	8/19/2008 12:55	18,000	300	200	<.100	39.0	24.5	26.8	5.4	6.8	404	.179	450	12.40
EFT348	8/19/2008 14:20	20,000	800	170	<.100	35.0	26.5	26.9	5.5	7.2	401	.177	421	12.35
EFT348	8/20/2008 11:15	16,000	350	220	<.100	55.0	32.5	26.6	E5.2	7.0	433	.193	576	12.61
EFT348	8/20/2008 12:35	13,000	100	200	<.100	49.0	35.5	26.7	E5.4	7.1	429	.191	545	12.56
EFT348	8/20/2008 14:05	15,000	100	160	<.100	53.0	26.5	27.0	E5.7	7.2	426	.189	515	12.51

[1] Estimated if holding time greater than 6 hours.

[2] Estimated if rated as fair (+0.5 to 0.8 mg/L) or poor (>+0.8 mg/L).

[3] Calculated from specific conductance.

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Appendix 2—Quality Assurance Data for Samples Collected at Sites on Streams Receiving Discharge from Dallas/Fort Worth International Airport and Vicinity, North-Central Texas, 2008

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Appendix 2.1. Total coliform and *Escherichia coli* laboratory duplicates.

[MPN/100 mL, most-probable number per 100 milliliters; *E., Escherichia*; >, greater than; <, less than]

Field identifier (fig. 1)	Sample date and time	Total coliforms[1] (MPN/100 mL)		*E. coli*[1] (MPN/100 mL)		*E. coli* laboratory duplicates (percentage difference[2])
		Duplicate 1	Duplicate 2	Duplicate 1	Duplicate 2	
		Lower West Fork Trinity River watershed				
BBC121	7/7/08 9:45	**9,200**	**11,000**	**120**	**98**	
TRIBMD	5/1/08 12:55	**>2,400**	**>2,400**	**>2,400**	**>2,400**	
TRIBMD	11/18/08 11:01	**>24,000**	**>24,000**	2,100	2,200	4.7
TRIBMD	12/2/08 11:25	2,200	**7,300**	**280**	**270**	
OF25	4/7/08 14:20	**>2,400**	**>2,400**	520	550	5.6
OF25	5/1/08 11:25	**>2,400**	**>2,400**	**1,200**	**1,100**	
OF19	7/7/08 8:15	**10,000**	**14,000**	**52**	**63**	
LBC360	8/5/08 8:20	**20,000**	**17,000**	**135**	**109**	
LBC360	8/5/08 8:24	**8,200**	6,100	**75**	**63**	
LBC360	10/29/08 9:45	1,200	1,700	**41**	**52**	
BBC183	3/18/08 11:52	**>24,000**	**>24,000**	4,600	5,200	12.2
BBC183	4/4/08 8:11	**>48,000**	**>48,000**	9,800	6,300	43.5
BBC183	8/15/08 12:44	**>24,000**	**>24,000**	**>24,000**	**>24,000**	
BBC183	8/15/08 12:44	**>240,000**	**>240,000**	49,000	37,000	27.9
		Elm Fork Trinity River watershed				
CCTTR	11/18/08 14:00	4,400	3,700	**350**	**250**	
CCDTR	7/7/08 9:43	**12,000**	2,000	**290**	**110**	
GCNAD	9/22/08 11:37	**14,000**	**20,000**	730	580	22.9
GCNAD	9/22/08 11:40	**20,000**	**24,000**	710	650	8.8
GCNAD	9/22/08 11:40	**7,700**	**11,000**	690	720	4.3
GCRR	4/7/08 15:34	**>2,400**	**>2,400**	81	130	46.4
GCRR	9/22/08 14:05	**12,000**	**8,700**	410	**330**	
GCRR	9/22/08 14:07	**17,000**	**20,000**	**290**	**340**	
GCRR	9/22/08 14:07	**17,000**	**14,000**	**300**	**390**	
GCDTR	5/1/08 12:11	**>9,700**	**9,700**	430	420	2.4
GCDTR	9/22/08 10:20	6,100	**7,700**	**97**	**31**	
GCDTR	9/22/08 10:22	6,500	**6,900**	**41**	**31**	
GCDTR	10/29/08 10:15	3,900	400	**290**	**230**	
HCCER	12/2/08 10:45	**>2,400**	**>2,400**	**24**	**16**	
SHCHPR	2/25/08 14:20	**2,600**	**2,600**	**34**	**43**	
SHCHPR	5/1/08 10:24	**>2,400**	**>2,400**	**40**	**37**	
HCLR	12/2/08 9:10	**7,300**	**11,200**	**31**	**160**	
EFT348	3/18/08 13:40	**>24,000**	**>24,000**	1,600	1,600	0
EFT348	4/4/08 9:23	5,000	8,700	**62**	**150**	
EFT348	8/15/08 13:31	**16,000**	**16,000**	**31**	**30**	
EFT348	8/15/08 13:31	15,000	10,000	**100**	**<100**	
Average percentage difference						**16.2**

[1] Normal font indicates counts with number of cells that were yellow and fluoresced within recommended 30 to 80 range (Texas Commission on Environmental Quality, 2009, p. 4–8); bold font indicates counts not within recommended 30 to 80 range.

[2] Percentage difference listed for counts within recommended 30 to 80 range (Texas Commission on Environmental Quality, 2009, p. 4–8).

Appendix 2.2. Ammonia, residue (total suspended solids), and total chloride split replicates.

[mg/L, milligrams per liter; TSS, total suspended solids; <, less than laboratory reporting level; NA, not applicable]

Field identifier (fig. 1)	Sample date	Ammonia, as nitrogen, (mg/L)		Ammonia replicates (relative percentage difference[1])	Residue (TSS) (mg/L)		TSS replicates (relative percentage difference[1])	Total chloride (mg/L)		Chloride replicates (relative percentage difference[1])
		Replicate 1	Replicate 2		Replicate 1	Replicate 2		Replicate 1	Replicate 2	
Lower West Fork Trinity River watershed										
BBC121	7/7/2008	0.180	0.207	14.0	16.0	18.0	11.8	73.5	62.5	16.2
TRIBMD	5/1/2008	.470	.497	5.6	7.00	6.00	15.4	70.5	71.0	.7
TRIBMD	6/2/2008	.267	.280	4.8	<5.00	7.00	NA	71.5	71.0	.7
TRIBMD	12/2/2008	.462	.452	2.2	13.0	16.0	20.7	31.0	32.0	3.2
OF25	4/7/2008	.104	<.100	NA	11.0	8.00	31.6	43.5	42.0	3.5
OF25	5/1/2008	<.100	.131	NA	<5.00	5.00	NA	44.5	47.0	5.5
OF19	11/18/2008	<.100	<.100	NA	5.00	<4.00	NA	22.5	21.0	6.9
LBC360	8/5/2008	<.100	<.100	NA	<4.00	<4.00	NA	57.5	57.5	0
BBC183	4/4/2008	.302	.315	4.2	101	105	3.9	50.5	48.5	4.0
BBC183	8/15/2008	.128	.121	5.6	840	862	2.6	25.5	22.0	14.7
Elm Fork Trinity River watershed										
CCBR	10/29/2008	.116	.105	10.0	<4.00	<4.00	NA	25.5	32.0	22.6
CCDTR	6/2/2008	<.100	.113	NA	10.0	16.0	46.2	106	109	2.8
CCDTR	7/7/2008	.100	.108	7.7	8.00	9.00	11.8	127	135	6.1
GCNAD	9/22/2008	<.100	.130	NA	<4.00	<4.00	NA	17.0	28.0	48.9
GCRR	4/7/2008	.200	.205	2.5	5.00	6.00	18.2	27.5	29.5	7.0
GCRR	9/22/2008	.291	.297	2.0	<4.00	11.0	NA	43.0	50.0	15.1
GCDTR	5/1/2008	.210	<.100	NA	<5.00	<5.00	NA	53.5	53.0	.9
GCDTR	9/22/2008	<.100	<.100	NA	6.00	<4.00	NA	60.0	48.0	22.2
HCCER	10/29/2008	.107	<.100	NA	7.00	<4.00	NA	21.0	23.0	9.1
HCCER	12/2/2008	<.100	<.100	NA	12.0	<4.00	NA	12.0	11.0	8.7
SHCBLR	11/18/2008	.158	.308	64.4	7.00	14.0	66.7	54.0	81.0	40.0
SHCHPR	5/1/2008	.353	.295	17.9	15.0	15.0	0	14.0	13.5	3.6
EFT348	4/4/2008	.337	.346	2.6	48.0	44.0	8.7	19.0	19.0	0
EFT348	8/15/2008	.133	.127	4.6	43.0	45.0	4.5	25.5	24.5	4.0
Average relative percentage difference				**10.6**			**18.6**			**10.3**

[1] Relative percentage difference between replicate sample concentrations (C) computed as $\frac{C_1 - C_2}{(C_1 + C_2)/2}$ X 100 .

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