Prepared in cooperation with the Urban Drainage and Flood Control District

Summary and Evaluation of the Quality of Stormwater in Denver, Colorado, 2006–2010

By Michael R. Stevens and Cecil B. Slaughter

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Contents

Abstract.....	1
Introduction.....	2
Purpose and Scope.....	4
Description of Stations	4
Previous Investigations	8
Methods of Study.....	8
Streamflow Data Collection.....	9
Sample Collection and Analysis	10
Stormwater Samples	16
Bacteriological Samples	18
Quality Assurance and Quality Control.....	18
Summary of Stormwater Quality	23
Water Quality of Stormwater Samples	24
Comparison to Colorado Water-Quality Standards	52
Evaluation of Stormwater Quality between 2002–2005 and 2006–2010.....	55
Statistics.....	55
Comparison to Previous Results	61
Summary	61
References Cited	64
Appendix.....	67

Figures

Figure 1. Map showing location of stations.....	3
Figure 2. Explanation for boxplots shown in this report	17
Figure 3. Graphs showing daily values for streamflow and precipitation and dates of sample collection (2006–2010) at South Platte River below Union Avenue at Englewood, South Platte River at Denver, Toll Gate Creek above 6th Avenue at Aurora, Sand Creek at mouth near Commerce City, and South Platte River at Henderson.....	23
Figure 4. Boxplots showing distribution of water-quality properties and constituents at South Platte River below Union Avenue at Englewood, South Platte River at Denver, Toll Gate Creek above 6th Avenue at Aurora, Sand Creek at mouth near Commerce City, and South Platte River at Henderson, calendar years 1998–2001, 2002–2005, and 2006–2010	32

Tables

Table 1. Station characteristics.....	5
Table 2. Land-cover characteristics	7
Table 3. Streamflow statistics for 2006–2010 water years and calendar years.....	9
Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010	11
Table 5. Analytical results for quality-assurance blanks, 2006–2010.....	19
Table 6. Relative percentage difference statistics for duplicate samples collected during 2006–2010	22
Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010	27
Table 8. Summary of Colorado water-quality standards and properties and constituents that exceeded Colorado standards for this study, 2006–2010	55
Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.	58

Appendix

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood by year, 2006–2010	70
Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.....	75
Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010	80
Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.....	85
Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010	90

Conversion Factors and Abbreviations

Multiply	By	To obtain
Area		
square mile (mi ²)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
Volume		
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233	cubic meter (m ³)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm ³)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

ALERT	Automated Local Evaluation in Real Time
CODWR	Colorado Division of Water Resources
CDPHE	Colorado Department of Public Health and Environment
QA/QC	Quality assurance and quality control
MWRD	Metropolitan Wastewater Reclamation District
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
RPD	Relative percent difference
UBL	Universal blank water
UDFCD	Urban Drainage and Flood Control District
USGS	U.S. Geological Survey

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

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

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

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83)

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Water year is defined in this report as the 12-month period October 1 through September 30, designated by the calendar year in which it ends.

Summary and Evaluation of the Quality of Stormwater in Denver, Colorado, 2006–2010

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Abstract

Stormwater in the Denver area was sampled by the U.S. Geological Survey, in cooperation with the Urban Drainage and Flood Control District, in a network of 5 monitoring stations—3 on the South Platte River and 2 on streams tributary to the South Platte River, Sand Creek, and Toll Gate Creek beginning in January 2006 and continuing through December 2010. Stormwater samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory during 2006–2010 for water-quality properties such as pH, specific conductance, hardness, and residue on evaporation at 105 degrees Celsius; for constituents such as major ions (calcium, magnesium), organic carbon and nutrients, including ammonia plus organic nitrogen, ammonia, dissolved nitrite plus nitrate, total phosphorus, and orthophosphate; and for metals, including total recoverable and dissolved phases of copper, lead, manganese, and zinc. Samples collected during selected storms were also analyzed for bacteriological indicators such as *Escherichia coli* and fecal coliform at the Metro Wastewater Reclamation Laboratory.

About 200 stormwater samples collected during storms characterize the quality of storm runoff during 2006–2010. In general, the quality of stormwater (2006–2010) has improved for many water-quality constituents, many of which had lower values and concentrations than those in stormwater collected in 2002–2005. However, the physical basis, processes, and the role of dilution that account for these changes are complex and beyond the scope of this report.

The water-quality sampling results indicate few exceptions to standards except for dissolved manganese, dissolved zinc, and *Escherichia coli*. Stormwater collected at the South Platte River below Union Avenue station had about 10 percent acute or chronic dissolved manganese exceedances in samples; samples collected at the South Platte River at Denver station had less than 5 percent acute or chronic dissolved manganese exceedances. In contrast, samples collected at Toll Gate Creek above 6th Avenue at Aurora station, Sand Creek at mouth near Commerce City station, and the South Platte River at Henderson station, each had about 30 to 50 percent exceedances of both acute and chronic dissolved manganese standards. Of the samples collected at Sand Creek at mouth near Commerce City, 1 sample exceeded the acute standard and 4 samples exceeded the chronic standard for dissolved zinc, but no samples collected from the other sites exceeded either standard for zinc. Almost all samples of stormwater analyzed for *Escherichia coli* exceeded Colorado numeric standards. A numerical standard for fecal coliform is no longer applicable as of 2004.

Results from the 2002–2005 study indicated that the general quality of stormwater had improved during 2002–2005 compared to 1998–2001, having fewer exceedances of Colorado standards, and showing downward trends for many water-quality values and concentrations. These trends coincided with general downward or relatively similar mean streamflows for the 2002–2005

compared to 1998–2001, which indicates that dilution may be a smaller influence on values and concentrations than other factors. For this report, downward trends were indicated for many constituents at each station during 2006–2010 compared to 2002–2005. The trends for mean streamflow for 2006–2010 compared to 2002–2005 are upward at all sites except for the South Platte River at Henderson, indicating that dilution by larger flows could be a factor in the downward concentration trends. At the South Platte River below Union Avenue station, downward trends were indicated for hardness, dissolved ammonia, dissolved orthophosphate, and dissolved copper. Upward trends at South Platte River below Union Avenue were indicated for pH. At the South Platte River at Denver station, downward trends were indicated for total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved organic carbon, and dissolved lead, manganese, and zinc, and total recoverable zinc. An upward trend in properties and constituents at South Platte River at Denver was indicated for pH. At Toll Gate Creek above 6th Avenue at Aurora, downward trends were indicated for residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved orthophosphate, total phosphorus, and total recoverable copper, lead, manganese, and zinc. Upward trends in properties and constituents at Toll Gate Creek above 6th Avenue at Aurora were indicated for pH, specific conductance, and dissolved nitrite plus nitrate. At Sand Creek at mouth near Commerce City, downward trends were indicated for hardness, dissolved calcium, total ammonia plus organic nitrogen, and dissolved ammonia, orthophosphate, manganese, and zinc. An upward trend in properties and constituents at Sand Creek at mouth near Commerce City was indicated for pH. Downward trends at South Platte River at Henderson were indicated for specific conductance, hardness, dissolved magnesium, residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved lead and manganese, and total recoverable copper, lead, manganese, and zinc.

Introduction

The quality of stormwater runoff and trend of water quality in stormwater runoff is of interest to many management and regulatory agencies as well as scientists, recreational stream users, and the general public. The basic character of stormwater runoff is of general interest to all, and more detailed information concerning spatial and temporal variations in stormwater quality may be of interest to management and regulatory agencies. In response to these interests, the U.S. Geological Survey (USGS), in cooperation with the Urban Drainage and Flood Control District (UDFCD), collected stormwater samples during wet weather from a monitoring network of five stations in and around metropolitan Denver, Colorado. The monitoring network is the basis for evaluation of stormwater conditions in Aurora, Denver, and Lakewood, and consists of three stations on the South Platte River, the principal stream draining the area and two stations on streams that are tributary to the South Platte River, Sand Creek and Toll Gate Creek (fig. 1). Reaches of each of these streams have use classifications and associated numeric standards for some water-quality properties and constituents and bacteriological indicators included in this study, such as pH, dissolved nitrite plus nitrate, dissolved copper, lead, manganese, zinc, and *Escherichia coli*, (Colorado Department of Public Health and Environment, 2011a, 2011b).

Figure 1. Map showing location of stations.

Purpose and Scope

The purpose of this report is to present summaries and an evaluation of laboratory analyses for water-quality properties and constituents and bacteriological indicators in stormwater samples that characterize the quality of stormwater in and around metropolitan Denver, Colo., from January 2006 through December 2010. Specifically, the summaries and evaluation in this report include

- characterizations that summarize streamflow associated with stormwater samples,
- descriptive statistics that summarize stormwater quality,
- comparisons of stormwater quality with numeric standards for use classifications established by the CDPHE, and
- comparison of previous characterizations of stormwater quality, based on data collected during 2002–2005 to the stormwater quality characterized in this report (2006–2010).

The summary presented in this report (2006–2010) provides a basis for comparison to similar data (1998–2001 and 2002–2005); however, the physical basis and processes responsible for changes between the two periods are complex and are beyond the scope of this report.

Description of Stations

The five stations in the monitoring network include three stations on the main stem of the South Platte River (fig. 1; table 1). These three stations, South Platte River below Union Avenue at Englewood, South Platte River at Denver, and South Platte River at Henderson, will be referred to in this report as “Union,” “Denver,” and “Henderson.” The stations on the South Platte River receive streamflow from several tributaries, and the South Platte River is sometimes referred to as a “receiving stream.” The two additional stations, Sand Creek at mouth near Commerce City and Toll Gate Creek above 6th Avenue at Aurora, represent tributaries and are referred to in this report as “Sand Creek” and “Toll Gate.” Sand Creek is tributary to the South Platte River, and Toll Gate is tributary to Sand Creek. Collectively, these five stations define a drainage system that drains most of the area in and around metropolitan Denver.

Table 1. Station characteristics.

[Station number and name from the U.S. Geological Survey (USGS) National Water Inventory System. Latitude and Longitude (North American Datum of 1927), geographic coordinates in degrees minutes seconds; Operating agency indicates agency responsible for streamflow records: CODWR, Colorado Division of Water Resources; UDFCD, Urban Drainage and Flood Control District. RF location, location of precipitation gage associated with station, the source for all precipitation records is UDFCD]

Station number	Station name	Station location		Operating agency	RF location	
		Latitude	Longitude		Latitude	Longitude
06710247	South Platte River below Union Avenue at Englewood	39°37'57"	105°00'52"	USGS	39°37'57"	105°00'52"
06714000	South Platte River at Denver	39°45'35"	105°00'10"	CODWR	39°44'32"	104°59'58"
394329104490101	Toll Gate Creek above 6th Avenue at Aurora	39°43'29"	104°49'01"	UDFCD	39°43'30"	104°49'06"
394839104570300	Sand Creek at mouth near Commerce City	39°48'36"	104°57'00"	USGS/ UDFCD	39°48'39"	104°57'03"
06720500	South Platte River at Henderson	39°55'10"	104°52'04"	CODWR	39°55'19"	104°52'00"

The South Platte River originates in central Colorado and has a contributing drainage area of 3,860 square miles (mi²) at the Denver station (U.S. Geological Survey, 2006–2010). Snowmelt from mountainous areas of central Colorado is a principal source of spring streamflow in the South Platte River; however, reservoirs and diversions along the South Platte River regulate streamflow. Chatfield Lake, which is just upstream from Denver, contains the vast majority of storm runoff generated upstream from the reservoir, essentially truncating the contributing drainage area for the stations used in this study (fig. 1). Consequently, most stormwater runoff in the South Platte River in the Denver area is derived from a local contributing drainage area that does not extend upstream from Chatfield Lake.

Land-cover characteristics used in this report (table 2) represent percentages of the local contributing drainage areas for four aggregated categories developed on the basis of USGS National Land Cover data from 1992 (U.S. Geological Survey, 2003). In the aggregated classification, areas related to crops are classified as “agricultural”; areas identified as commercial, industrial, or transportation and areas related to mining, such as sand and gravel operations, are classified as “urban”; areas identified as residential or recreational are classified as “residential”; and all remaining areas are classified as “undeveloped.” The local contributing drainage areas are less than 10 percent urban and consist mostly of undeveloped land (ranging from 41.6 to 76.0 percent in individual basins) and residential areas (17.8 to 50.4 percent). The agricultural land-cover classification shows a tendency to increase with local contributing drainage area (from 0.7 to 3.2 percent in the South Platte main-stem stations (Union, Denver and Henderson). In the Sand Creek drainage area, agricultural land cover increases from 5.0 to 8.7 percent from Toll Gate to Sand Creek at mouth (table 2). Undeveloped and urban land cover also increases from Toll Gate to Sand Creek.

Table 2. Land-cover characteristics.

[Station number and name from the U.S. Geological Survey (USGS) National Water Inventory System; Operating agency indicates agency responsible for streamflow records: USGS, U.S. Geological Survey; CODWR, Colorado Division of Water Resources; UDFCD, Urban Drainage and Flood Control District; CDA, contributing drainage area in square miles; LCDA, local contributing drainage area in square miles adjusted for regulation (excludes CDA upstream from Chatfield Lake for South Platte River stations). Land cover indicates percentage of LCDA on basis of National Land Cover data from 1992 (U.S. Geological Survey, 2003) for undeveloped areas (Und), agricultural areas (Ag), residential areas (Res), and urban areas (Urb); land-cover percentages may not sum to 100 percent due to rounding; comments provide important historical operational events]

Station number	CDA	LCDA	Land cover, in percentage of local contributing drainage area				Comments
			Ag	Urb	Res	Und	
06710247	3,090	76	0.7	5.8	50.4	43.1	Gage operated by USGS as described in Sauer and Turnipseed (2010).
06714000	3,860	841	1.2	3.4	19.4	76.0	Gage operated by CODWR as described in Sauer and Turnipseed (2010).
394329104490101	35	35	5.0	5.5	48.0	41.6	Gage operated as part of flood warning network (UDFCD).
394839104570300	184	184	8.7	6.3	22.4	62.6	Gage operated by USGS as described in Sauer and Turnipseed (2010) from 2006 to 2009. Gage operated as part of flood warning network in 2010 (UDFCD).
06720500	4,770	1,740	3.2	3.7	17.8	75.3	Gage operated by CODWR as described in Sauer and Turnipseed (2010).

Previous Investigations

Several previous investigations of stormwater quality have been completed in the Denver area. From 1979 through 1983, annual data reports were issued summarizing stormwater-monitoring activities by the USGS for various stations in the Denver metropolitan area (Ellis, 1978; Ellis and Alley, 1979; Hall and Duncan, 1980, 1981; Gibbs, 1981; Gibbs and Doerfer, 1982; Gibbs and others, 1983). Although these activities included some sampling in the South Platte River, most of the activities focused on tributaries to the South Platte River. Blakely and others (1983) reported on washoff characteristics from two experimental plots, and Ellis and others (1984), Ellis and Mustard (1985), and Mustard and others (1985) provided additional stormwater information on the basis of the USGS stormwater-monitoring activities. The Denver Regional Council of Governments (1983) also summarized their stormwater-monitoring activities in the Denver metropolitan area.

More recently, Bossong and others (2005) summarized stormwater quality in the Denver area on the basis of samples collected during October 1997 through September 2001. The conclusions from the 2005 report indicated that concentrations in stormwater tended to increase in a downstream direction along the South Platte River, that concentrations for many water-quality properties and constituents in stormwater were relatively smaller compared to concentrations in base flow, that exceptions to CDPHE numeric standards (measured concentrations that did not meet standards) for some metals occurred in as many as 10 to 25 percent of samples, and that there were consistent exceedances of numeric standards for bacteriological indicators such as *Escherichia coli* and fecal coliform. In previously published USGS reports, data were grouped by water years (October 1 through September 30 of the following year). In this report, data are grouped and analyzed by calendar year.

A second report (Bossong and Fleming, 2008) summarized stormwater quality for water years 2002–2005 using methods similar to those in Bossong and others (2005). The 2002–2005 report indicated that statistically significant downward trends in concentrations were identified for the combined means of all stations for dissolved copper, manganese, and zinc, and total recoverable zinc. Downward trends between 1998–2001 means and 2002–2005 means were also relatively widespread for many constituents including hardness, ammonia plus organic nitrogen, total phosphorus, most dissolved metals (lead, manganese, and zinc), and all total recoverable metals (copper, lead, manganese, and zinc). Some trends were indicated only at individual stations. Downward trends were identified for ammonia as nitrogen at Union, Denver, and Henderson, for orthophosphate at Sand Creek, and for dissolved nitrite plus nitrate at Denver and Henderson. Only dissolved nitrite plus nitrate at Union and total recoverable copper and lead at Sand Creek showed consistent upward trends. There were many more exceedances to water-quality standards in the 1998–2001 study than in the 2002–2005 study. *Escherichia coli* and fecal coliform consistently exceeded bacteria standards in the 1998–2001 and the 2002–2005 reports.

Methods of Study

The methods used to collect and process streamflow data, collect and process stormwater samples, and perform laboratory analyses are described in this section. The section also describes quality-assurance and quality-control (QA/QC) methods and results.

Streamflow Data Collection

Streamflow records are maintained for each station by various operating agencies (table 3). Union is operated by the USGS in accordance with methods described by (Turnipseed and Sauer, 2010; Sauer and Turnipseed, 2010). The streamflow data for Union is maintained in the USGS National Water Information System (NWIS; <http://waterdata.usgs.gov/nwis/>). Daily data, which represent various statistics for a 24-hour period, and subdaily data that are instantaneous values used to develop daily values, are available from NWIS. In addition, the records were published in USGS annual data reports for 2006–2010 (U.S. Geological Survey, 2006–2010).

Table 3. Streamflow statistics for 2006–2010 water years and calendar years.

[Station number and name from the U.S. Geological Survey National Water Inventory System; ft³/s, cubic foot per second; Toll Gate Creek is not included in streamflow statistics because the gage is only operated seasonally; water year, the 12-month period from October 1 through September 30, and designated by the calendar year in which it ends and which includes 9 of the 12 months; calendar year, 12-month period from January 1 through December 31]

Descriptor	Station name (number)			
	Union (06710247)	Denver (06714000)	Sand Creek (394839104570300)	Henderson (06720500)
Water-year statistics ¹				
Period, in water years	2006–2010	2006–2010	2006–2010	2006–2010
Annual mean, in ft ³ /s	209	382	33	541
Highest annual mean, in ft ³ /s	411	684	42	813
Year it occurred	2007	2007	2009	2007
Lowest annual mean, in ft ³ /s	105	219	21	333
Year it occurred	2006	2006	2006	2006
Highest daily mean, in ft ³ /s	2,388	3,610	1,035	4,570
Date it occurred	May 2, 2007	April 24, 2007	April 24, 2007	June 2, 2009
Lowest daily mean, in ft ³ /s	5.84	80	0.74	44.6
Date it occurred	June 23, 2006	June 14, 2006	March 6, 2009	January 18, 2010
Calendar-year statistics				
Period, in calendar years	2006–2010	2006–2010	2006–2010	2006–2010
Annual mean, in ft ³ /s	209	386	33	531
Highest annual mean, in ft ³ /s	412	685	45	813
Year it occurred	2007	2007	2009	2007
Lowest annual mean, in ft ³ /s	112	228	21	333
Year it occurred	2006	2006	2006	2006
Highest daily mean, in ft ³ /s	2,388	3,610	1,035	4,570
Date it occurred	May 2, 2007	April 24, 2007	April 24, 2007	June 2, 2009
Lowest daily mean, in ft ³ /s	5.84	80	0.74	44.6
Date it occurred	June 23, 2006	June 14, 2006	March 6, 2009	January 18, 2010

¹Previous reports (Bossong and others, 2005; Bossong and Fleming, 2008) grouped and analyzed data by water years, but this report groups and analyzes data by calendar year

Denver and Henderson are operated by the Colorado Division of Water Resources (CODWR). The CODWR streamflow records at Denver and Henderson were reviewed and published by USGS for 1998–2008, but have not been reviewed and published by USGS since 2009. Daily values for 2006–2010 and instantaneous values for the most recent year are maintained on a publicly available CODWR Web-based system

<http://www.dwr.state.co.us/SurfaceWater/Default.aspx>. All instantaneous values from Denver and Henderson are available on a UDFCD Web-based system (<http://alert.udfcd.org>).

Toll Gate and Sand Creek currently are operated by UDFCD using systematic but undocumented methods that involve theoretical stage and streamflow relations developed on the basis of channel geometry (Sand Creek was operated by the USGS 1998–2009 until the USGS gage location was moved). The Toll Gate and Sand Creek data are used as part of an Automated Local Evaluation in Real Time (ALERT) system operated by UDFCD to assess field conditions in a real-time mode in order to facilitate flood forecasting. Because the UDFCD data are focused on real-time information, data may be available only for periods of storm runoff. The UDFCD records consist only of instantaneous values that are archived but do not receive additional processing or review.

Sample Collection and Analysis

During 2006–2010, composite stormwater samples were collected for water-quality analysis. Composite samples integrate several aliquots of water collected over a period of time as described in the following “Stormwater Samples” section. All composite samples were collected using refrigerated automatic pumping samplers that withdraw water from a fixed point in the channel cross section. Bacteriological samples were manually collected during selected storms. The composite and bacteriological samples are collectively referred to as “stormwater samples.”

Stormwater samples collected during 2006–2010 were analyzed by the USGS National Water Quality Laboratory (NWQL) in Denver, and bacteriological samples were analyzed at Metropolitan Wastewater Reclamation District (MWRD) in Denver. The results of all laboratory analyses obtained as part of this study are available in the NWIS database and can be accessed using the USGS Web interface to water data at <http://waterdata.usgs.gov/co/nwis/qw/>. Table 4 describes the laboratory analytical methods used in this study. Results referred to as “dissolved” are from water that has been passed through a filter that removes all particles greater than 0.45 micrometer (μm) in their smallest diameter. Results referred to as “total recoverable” are from unfiltered water that has undergone an in-bottle digestion procedure (Hoffman and others, 1996). Results referred to as “whole water” are from water that has not been filtered or digested. Table 4 also lists the reporting levels. The general term “reporting level” specifies the level at which laboratory results are censored, or reported as “less than” (Helsel, 2005). The reporting level is generally twice the long-term method detection level (Childress, 1999). The long-term method detection level is determined by the NWQL based on long-term quality control performance (Childress, 1999). Laboratory quantifications of values below the reporting level are sometimes made by the laboratory on a particular analysis and are qualified as estimated.

Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06710247 South Platte River below Union Avenue at Englewood, Colorado										
Streamflow, mean, ft³/s	410	312	131	346	632.	38	0	33	1,490	--
Streamflow, volume, acre-feet	378	282	136	322	574	38	0	30	1,360	--
pH, standard units	7.7	0.2	7.6	7.7	7.8	38	0	6.9	8.4	--
Specific conductance, µS/cm	490	210	345	409	585	38	0	226	993	--
Hardness, total, mg/L as CaCO₃	145	47.4	113	133	164	38	0	81.5	290	--
Calcium, mg/L	43	13	33	39	47	38	0	24	84	--
Magnesium, mg/L	9.3	3.6	6.8	7.9	11	38	0	5.1	20	--
Suspended solids, residue on evaporation at 105 °C, mg/L	226	183	77	196	326	37	1	16	670	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.4	0.72	0.83	1.4	1.7	8	0	0.46	4.00	--
Nitrogen, dissolved, ammonia as N, mg/L	0.06	0.06	0.02	0.05	0.08	38	6	0.01	6.00	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.82	0.56	0.42	0.59	1.03	38	0	0.17	2.71	--
Orthophosphate, dissolved as P, mg/L	0.059	0.051	0.024	0.043	0.068	38	0	0.004	0.237	--
Phosphorus, total as P, mg/L	0.38	0.24	0.22	0.35	0.49	38	0	0.07	0.98	--
Carbon, dissolved, organic as C, mg/L	6.7	3.0	4.8	6.1	7.5	38	0	2.9	18.6	--
<i>Escherichia coli</i> , MPN/100 mL	5,380	5,620	--	5,380	--	4	0	20	11,000	--
Fecal coliform, MPN/100 mL	6,180	6,200	--	6,180	--	4	0	20	12,000	--
Copper, dissolved, µg/L	2.1	0.8	1.6	1.9	2.6	38	0	1.1	4.6	--
Copper, total recoverable, µg/L	11	7.9	5.4	11	14	36	0	2.9	34	--
Lead, dissolved, µg/L	0.08	0.06	0.04	0.06	0.07	38	6	0.03	0.27	0.04, 0.06
Lead, total recoverable, µg/L	8.3	7.2	2.6	7.4	10.3	36	0	0.62	26.9	--
Manganese, dissolved, µg/L	19.5	26.0	6.4	11.6	20.6	38	0	0.2	119	--
Manganese, total recoverable, µg/L	304	242	143	263	379	36	0	42.2	884	--
Zinc, dissolved, µg/L	5.3	3.0	2.8	4.8	6.9	38	0	1.8	13.6	--
Zinc, total recoverable, µg/L	40	29	19	34	53	36	0	7	134	--

Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06714000 South Platte River at Denver, Colorado										
Streamflow, mean, ft³/s	1,480	1,370	656.	1,090	1,790	49	0	184	8,083	--
Streamflow, volume, acre-feet	1,410	1,280	667	1,010	1,630	49	0	168	7,350	--
pH, standard units	7.5	0.3	7.5	7.5	7.7	48	0	6.6	8.0	--
Specific conductance, µS/cm	522	225	384	491	597	46	0	260	1,390	--
Hardness, total, mg/L as CaCO₃	141	43	108	138	160	48	0	74.4	251	--
Calcium, mg/L	42	12	32	42	49	48	0	22	76	--
Magnesium, mg/L	8.6	3.1	6.2	8	9.8	48	0	4.3	18	--
Suspended solids, residue on evaporation at 105 °C, mg/L	202	125	122	180	258	47	0	20.0	660	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.8	0.82	1.2	1.5	2.2	7	0	0.51	4.2	--
Nitrogen, dissolved, ammonia as N, mg/L	0.12	0.13	0.03	0.07	0.13	47	4	0.01	0.60	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.21	0.65	0.80	0.98	1.38	46	0	0.55	3.69	--
Orthophosphate, dissolved as P, mg/L	0.150	0.087	0.098	0.122	0.167	47	0	0.046	0.487	--
Phosphorus, total as P, mg/L	0.54	0.24	0.39	0.47	0.65	47	0	0.14	1.33	--
Carbon, dissolved, organic as C, mg/L	6.3	2.0	5.0	5.8	7.2	48	0	4.1	12.2	--
<i>Escherichia coli</i> , MPN/100 mL	8,900	9,926	--	6,250	--	4	0	110	23,000	--
Fecal coliform, MPN/100 mL	10,520	9,486	--	9,450	--	4	0	170	23,000	--
Copper, dissolved, µg/L	2.9	1.2	2.2	2.5	3.3	48	1	1.5	7.0	1
Copper, total recoverable, µg/L	17	11	9.1	15	21	45	0	3.8	67	--
Lead, dissolved, µg/L	0.118	0.062	0.075	0.1	0.155	48	0	0.04	0.31	--
Lead, total recoverable, µg/L	15.2	13.7	6.72	13.1	18	45	0	2.13	79.5	--
Manganese, dissolved, µg/L	11	25	1.1	3.3	9.7	48	0	0.1	156	--
Manganese, total recoverable, µg/L	333	182	215	288	412	45	0	77.9	873	--
Zinc, dissolved, µg/L	8.3	4.5	5.0	6.8	10.6	48	0	3.3	21.3	--
Zinc, total recoverable, µg/L	71	51	33	60	91	45	0	13	287	--

Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
394329104490101 Toll Gate Creek above 6th Avenue near Aurora, Colorado										
Streamflow, mean, ft³/s	261	289	73	182	345	30	0	4	1,400	--
Streamflow, volume, acre-feet	242	241	67	156	313	30	0	4	921	--
pH, standard units	7.7	0.2	7.5	7.6	7.8	33	0	7.4	8.0	--
Specific conductance, µS/cm	1,112	506	720	957	1,500	31	0	363	2,230	--
Hardness, total, mg/L as CaCO₃	316	167	193	251	418	33	0	84.6	746	--
Calcium, mg/L	95	50	60	77	129	33	0	26	226	--
Magnesium, mg/L	19	10	11	15	24	33	0	4.6	44	--
Suspended solids, residue on evaporation at 105 °C, mg/L	180	186	46	97	254	31	0	10	695	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.6	0.78	1.1	1.4	2.0	32	0	0.63	3.5	--
Nitrogen, dissolved, ammonia as N, mg/L	0.14	0.15	0.04	0.09	0.20	32	3	0.01	0.66	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.64	0.21	0.49	0.59	0.77	32	0	0.36	1.28	--
Orthophosphate, dissolved as P, mg/L	0.022	0.020	0.007	0.013	0.035	32	1	0.003	0.077	0.003
Phosphorus, total as P, mg/L	0.33	0.32	0.12	0.22	0.44	32	0	0.04	1.38	--
Carbon, dissolved, organic as C, mg/L	10.4	3.7	8.5	10.4	11.7	33	0	5.3	20.9	--
<i>Escherichia coli</i> , MPN/100 mL	2,310	1,715	--	3,300	--	3	0	330	3,300	--
Fecal coliform, MPN/100 mL	2,310	1,715	--	3,300	--	3	0	330	3,300	--
Copper, dissolved, µg/L	2.5	1.1	1.8	2.2	2.8	33	0	1.0	4.9	--
Copper, total recoverable, µg/L	12	8.8	5.8	8.3	15	33	0	2.9	33	--
Lead, dissolved, µg/L	0.097	0.07	0.053	0.08	0.12	33	4	0.04	0.34	0.04, 0.06
Lead, total recoverable, µg/L	7.18	7.67	2.35	3.45	9.18	33	0	0.71	28.3	--
Manganese, dissolved, µg/L	75.29	78.83	20.3	50.9	105	33	0	2.8	330	--
Manganese, total recoverable, µg/L	381	269	192	244	480	33	0	103	1,120	--
Zinc, dissolved, µg/L	8.8	5.4	4.7	8.0	11	33	0	1.5	26.1	--
Zinc, total recoverable, µg/L	47	35	24	33	59	33	0	9	132	--

Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
394839104570300 Sand Creek at mouth near Commerce City, Colorado										
Streamflow, mean, ft ³ /s	285	275	100	229	374	47	0	21	1,620	--
Streamflow, volume, acre-feet	255	249	95	205	348	47	0	19	1,473	--
pH, standard units	7.6	0.2	7.4	7.6	7.8	47	0	7.3	8.0	--
Specific conductance, µS/cm	811	392	575	684	908	45	0	330	2,020	--
Hardness, total, mg/L as CaCO ₃	195	79	153	171	210	47	0	74.8	455	--
Calcium, mg/L	59	22	47	52	64	47	0	23	131	--
Magnesium, mg/L	12	5.6	8.4	10	13	47	0	4.1	31	--
Suspended solids, residue on evaporation at 105 °C, mg/L	351	306	128	236	470	47	0	56.0	1,360	--
Nitrogen, total, ammonia plus organic as N, mg/L	2.6	1.6	1.6	2.0	3.2	45	0	1.1	9.5	--
Nitrogen, dissolved, ammonia as N, mg/L	0.11	0.11	0.02	0.09	0.18	45	8	0.01	0.47	0.005, 0.01, 0.02
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.88	0.43	0.59	0.78	0.95	45	0	0.41	2.55	--
Orthophosphate, dissolved as P, mg/L	0.121	0.113	0.059	0.089	0.141	45	0	0.017	0.627	--
Phosphorus, total as P, mg/L	0.79	0.47	0.49	0.63	0.90	45	0	0.27	2.36	--
Carbon, dissolved, organic as C, mg/L	10.8	4.2	7.8	9.3	13.2	46	0	5.8	23.6	--
<i>Escherichia coli</i> , MPN/100 mL	3,530	2,370	--	2,950	--	3	0	790	4,900	--
Fecal coliform, MPN/100 mL	2,630	2,090	--	2,140	--	3	0	790	4,900	--
Copper, dissolved, µg/L	3.0	2.0	1.6	2.4	3.6	47	0	1.2	12.5	--
Copper, total recoverable, µg/L	22	14	11	17	28	47	0	6.5	55	--
Lead, dissolved, µg/L	0.19	0.14	0.10	0.14	0.25	47	0	0.04	0.74	--
Lead, total recoverable, µg/L	21.0	17.3	6.16	14.5	31.6	47	0	3.67	60.5	--
Manganese, dissolved, µg/L	45	78	2.5	11	59	47	0	0.5	391	--
Manganese, total recoverable, µg/L	678	661	283	466	640	47	0	144	3,210	--
Zinc, dissolved, µg/L	67.2	191	7.8	10.9	21.0	47	0	2.8	1,170	--
Zinc, total recoverable, µg/L	524	1205.4	44	75	241	47	0	22	5,230	--

Table 4. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06720500 South Platte River at Henderson, Colorado										
Streamflow, mean, ft³/s	2,260	3,290	754	1,470	2,390	33	0	218	19,000	--
Streamflow, volume, acre-feet	1,720	1,570	663	1,340	2,040	33	0	198	6,920	--
pH, standard units	7.3	0.2	7.2	7.4	7.5	34	0	6.6	7.7	--
Specific conductance, µS/cm	557	196	454	528	601	34	0	205	1,260	--
Hardness, total, mg/L as CaCO₃	141	31	119	133	154	34	0	95	226	--
Calcium, mg/L	42	9	36	41	47	34	0	28	64	--
Magnesium, mg/L	8.9	2.5	7.3	8.3	10	34	0	6.0	17	--
Suspended solids, residue on evaporation at 105 °C, mg/L	174	112	94	133	242	32	0	44	545	--
Nitrogen, total, ammonia plus organic as N, mg/L	2.9	1.7	2.0	2.6	3.4	3	0	0.96	9.4	--
Nitrogen, dissolved, ammonia as N, mg/L	0.80	0.88	0.24	0.58	0.73	33	1	0.11	3.38	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	2.08	0.81	1.53	1.87	2.24	33	0	0.96	4.64	--
Orthophosphate, dissolved as P, mg/L	0.461	0.279	0.262	0.367	0.621	33	0	0.152	1.15	--
Phosphorus, total as P, mg/L	1.02	0.46	0.72	0.96	1.18	33	0	0.37	2.85	--
Carbon, dissolved, organic as C, mg/L	9.1	5.3	6.2	7.5	10.6	34	0	4.8	34.4	--
<i>Escherichia coli</i> , MPN/100 mL	10,400	11,550	--	7,900	--	3	0	310	23,000	--
Fecal coliform, MPN/100 mL	12,100	11,370	--	13,000	--	3	0	310	23,000	--
Copper, dissolved, µg/L	3.04	0.92	2.4	2.75	3.4	34	0	1.7	5.5	--
Copper, total recoverable, µg/L	24	13	13	22	28	32	0	9.1	63	--
Lead, dissolved, µg/L	0.22	0.08	0.17	0.21	0.29	34	0	0.07	0.41	--
Lead, total recoverable, µg/L	22.6	15.9	10.2	17.3	32.4	32	0	5.09	70.9	--
Manganese, dissolved, µg/L	62	127	18	33	62	34	0	0.6	757	--
Manganese, total recoverable, µg/L	408	305	243	359	472	32	0	138	1,840	--
Zinc, dissolved, µg/L	18.3	7.5	13.1	17.3	22.1	34	0	6.7	45.8	--
Zinc, total recoverable, µg/L	114	68	68	91	148	32	0	32	308	--

For statistical summaries and boxplots, the number of censored values in the data are considered in the computations, but the values of statistics (in the tables and boxplots) that are affected by the presence of censored data (such as mean, standard deviation, and the lower percentiles) are predicted based on log-probability regression on the uncensored values (Helsel and Hirsch, 1992). If more than 25 percent of the data are censored, statistics were not computed for the types affected by censored values. In this report, generally only the 25th percentile and the mean statistics on a few water-quality constituents required the log-probability regression methods. For Mann-Whitney rank sum testing in this report, no groups of water-quality constituents for a period had more than 50-percent censored values, which is the limit for successful use of the test to determine differences (Helsel and Hirsch, 1992).

Stormwater Samples

About 200 stormwater samples were collected by using refrigerated, automatic pumping samplers that were manually activated when stormwater runoff began. Once activated, the samplers obtained aliquots, or sample portions, by withdrawing fixed volumes of water from the stream every 60 minutes. The samplers were equipped with eight 2-liter (L) bottles and were programmed to add three aliquots to each bottle. Time-weighted composite stormwater samples were collected by compositing individual aliquots of stormwater that were obtained at fixed-time increments typically during 12-hour intervals; bacteriological samples were collected manually from streams during some storms (see Bacteriological Samples section). Each station was visited by USGS project staff every 12 to 24 hours during storm events. As the stations were visited, the contents of four sequential bottles were composited into a single time-weighted composite sample covering about 12 hours of the storm hydrograph, and individual sample bottles were filled by using a churn splitter for subsequent laboratory analysis. The churn splitter is a plastic container for compositing samples that allows mixing of raw sample water while bottles are filled using a spigot on the churn (U.S. Geological Survey, variously dated). The compositing, filtration, bottling, and preservation of samples submitted to NWQL took place in the field using procedures described in the USGS National Field Manual (U.S. Geological Survey, variously dated). If individual sample bottles were found to contain different volumes of water, it was assumed that individual aliquot volumes varied, and the aliquot sample volumes were adjusted, if possible, or the samples were discarded. The samples were analyzed by the NWQL for physical properties such as pH, specific conductance, hardness, and residue on evaporation at 105°C; for major ions such as calcium and magnesium, and organic carbon, and nutrients including ammonia, total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, orthophosphate, and total phosphorus; and for metals, including total recoverable and dissolved phases of copper, lead, manganese, and zinc (table 4).

The composite samples integrate concentrations over time and are appropriate for evaluating water-quality criteria developed for aquatic life (Colorado Department of Public Health and Environment, 2011a, 2011b). Generally, the most stringent criteria in place are the acute standards, which specify a maximum allowable concentration for a period of time, usually 24 hours. The acute criteria, like the composite samples, describe concentration over a period of time.

Decisions to activate samplers in this study were made by USGS project staff on the basis of local weather and streamflow conditions, which were monitored continuously through a variety of sources, including data available in near real-time from the World Wide Web (<http://alert.udfcd.org/>). The ALERT system, operated by UDFCD, provides data in near real-time from an extensive network of precipitation gages and information from many UDFCD streamflow-gaging stations (Urban Drainage and Flood Control District, 2012). It also integrates streamflow

data from USGS and CODWR streamflow-gaging stations into Web-based reports in near real-time. The ALERT data typically are available within a few minutes of measurement.

Boxplots were constructed for values and concentrations at all sites. The data from each site are displayed side-by-side for selected water-quality measurements and constituents. The explanation for the boxplots is shown in figure 2. The boxplot shows the quartiles (25th, 50th or median, and 75th percentiles). The whiskers on the boxplot extend to the maximum and minimum values. An open circle is plotted for the mean value. The number of values used in the boxplot, the number of values that were censored, and the highest censoring level that was applied to the data for a particular boxplot are shown at the top of the boxplot. A line representing one-half of the censoring level, essentially the long-term method detection level, is drawn on the boxplot corresponding to the y-axis value of that long-term method detection level. Any boxplot that has a censoring level greater than the 25th percentile is drawn with a dashed line for the box below that level. The dashed box indicates that statistical methods were used to estimate the 25th percentile (same as methods used to compute the statistics for this report). Boxplots provide a visual representation of basic site statistics and are useful for interpreting differences among the 1998–2001, 2002–2005, and 2006–2010 periods.

Figure 2. Explanation for boxplots shown in this report.

The Mann-Whitney rank-sum test (Iman and Conover, 1983) was used to test for statistically significant temporal differences in streamflow and water-quality data collected from the 2002–2005 and the 2006–2010 periods at the same monitoring station. The Mann-Whitney rank-sum test is a nonparametric procedure in which data for the two populations (data for both monitoring periods) are ranked; a two-sample t-test is then performed on the ranks of the data. The advantages of the Mann-Whitney rank-sum test over a simple two-sample t-test (Iman and Conover, 1983) are that (1) the data need not be normally distributed (and hydrologic data often are not normally distributed), and (2) the Mann-Whitney rank-sum test is less sensitive to the

assumption of equal variances compared to other tests. The null hypothesis states that samples from both stations are from the same population; for example, the samples are not statistically different (Helsel and Hirsch, 1992). The Mann-Whitney rank-sum tests used in this report are two-tailed tests, and the probability of error (p-value) was used in this report to determine the significance of statistical tests for all statistical methods. In this report, p-values less than 0.10 are considered to be statistically significant. The use of the word “significant” herein only applies to the p-value of the statistical test to reduce any confusion of descriptive terms. The median values for both periods tested are presented in a table with the p-values to provide the reader a frame of reference for the data periods. The test assesses the probability of the two datasets belonging to the same population, not necessarily just the difference in the medians.

Bacteriological Samples

A total of 17 bacteriological samples were collected during selected storms. The samples were collected manually as grab samples by filling bottles at the streambank and transporting them directly to MWRD for analysis, generally within an hour of sample collection. The bacteriological samples were analyzed for *Escherichia coli* and fecal coliform (table 4).

Quality Assurance and Quality Control

Quality-control (QC) samples (blanks and duplicates) were collected to characterize contamination and precision resulting from sampling equipment or ambient field conditions. Approximately 10 percent of all samples collected were QC samples. No blanks or duplicates were collected during 2006-2010 for bacteriological samples.

Blank samples were processed in the field using universal blank water (UBL), obtained from the NWQL and certified to have very low concentrations of inorganic and organic constituents. The UBL water was poured directly into autosampler bottles in the field, processed through churn splitters and filters, and transported to the NWQL for analysis. The results for blanks in table 5 indicate no substantial contamination to analyzed concentrations from ambient field conditions or from the use of sampling and processing equipment in the field or in the laboratory.

Table 5. Analytical results for quality-assurance blanks, 2006–2010.

[SPRU, South Platte River below Union Avenue; SPRD, South Platte River at Denver; TGC6, Toll Gate Creek above 6th Avenue; SCRM, Sand Creek at mouth near Commerce City; SPRH, South Platte River at Henderson; Samples consist of universal blank water (UBL) passed through automated sampler bottles and all processing equipment; $\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25°C , Celsius; mg/L , milligrams per liter; N, nitrogen; P, phosphorus; CaCO_3 , calcium carbonate; $\mu\text{g}/\text{L}$, micrograms per liter; E, estimated value less than reporting level; na, not applicable; <, less than]

Station name	SPRU	TGC6	TGC6	SPRH	SPRU	SCRM	SPRH	SCRM	SPRH	SPRD	SPRD	TGC6	SPRD
Date (yyyymmdd)	20060709	20070329	20070425	20070516	20070530	20080806	20080808	20080810	20080913	20090418	20090527	20090720	20100704
Time (hhmm)	1432	0700	1340	1415	1220	1030	1100	1111	1245	1630	159	2256	1900
pH, in standard units	7.6	6.0	8.2	7.8	8	8.5	7.9	8	8.1	6.2	8.1	7.2	7.9
Specific conductance, in $\mu\text{S}/\text{cm}$ at 25°C	na	na	na	na	na	na	na	na	na	na	na	1	1
Hardness, total as CaCO_3 , in mg/L	1.09	na	na	na	na	na	na	na	na	na	na	na	< .18
Calcium, in mg/L	0.41	0.04	0.05	<.02	0.02	E.03	0.09	0.04	E.04	0.05	0.04	< .02	< .04
Magnesium, in mg/L	0.014	<.014	<.014	E.008	<.014	<.020	<.020	<.020	<.020	< .012	< .012	< .012	< .016
Residue on evaporation at 105°C , in mg/L	<10	na	na	<10	<10	na	na	na	na	na	< 15	< 15	< 15
Nitrogen, Ammonia + organic, total as N, in mg/L	<.10	na	<.10	<.10	<.10	<.14	<.14	<.14	E.10	< .10	E .06	< .10	< .10
Nitrogen, ammonia, dissolved as N, in mg/L	E.008	na	<.020	<.020	<.020	<.020	<.020	<.020	<.020	< .020	< .020	< .020	< .020
Nitrogen, nitrite + nitrate, dissolved as N, in mg/L	<.06	na	<.06	<.06	<.06	<.04	E.02	<.04	<.04	< .04	< .04	< .04	< .04
Orthophosphate, dissolved as P, in mg/L	E.003	na	<.006	E.003	<.006	E.003	E.004	E.003	<.006	< .008	0.017	< .008	< .008
Phosphorus, total as P, in mg/L	<.04	na	<.04	<.04	<.04	E.02	<.04	<.04	<.04	< .04	< .04	< .04	<.04

Table 5. Analytical results for quality-assurance blanks, 2006–2010.—Continued

[SPRU, South Platte River below Union Avenue; SPRD, South Platte River at Denver; TGC6, Toll Gate Creek above 6th Avenue; SCRM, Sand Creek at mouth near Commerce City; SPRH, South Platte River at Henderson; Samples consist of universal blank water (UBL) passed through automated sampler bottles and all processing equipment; $\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25°C , Celsius; mg/L , milligrams per liter; N, nitrogen; P, phosphorus; CaCO_3 , calcium carbonate; $\mu\text{g}/\text{L}$, micrograms per liter; E, estimated value less than reporting level; na, not applicable; <, less than]

Station name	SPRU	TGC6	TGC6	SPRH	SPRU	SCRM	SPRH	SCRM	SPRH	SPRD	SPRD	TGC6	SPRD
Date (yyyymmdd)	20060709	20070329	20070425	20070516	20070530	20080806	20080808	20080810	20080913	20090418	20090527	20090720	20100704
Time (hhmm)	1432	0700	1340	1415	1220	1030	1100	1111	1245	1630	159	2256	1900
Carbon, organic, dissolved as C, in mg/L	0.8	<.4	0.4	E.3	<.4	0.5	E.3	E.3	na	E .2	< .4	0.5	< .7
Copper, dissolved, in $\mu\text{g}/\text{L}$	<.4	<.40	<.40	<.40	<.40	<1.0	<1.0	<1.0	<1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper, total recoverable, in $\mu\text{g}/\text{L}$	<.6	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	< 4.0	< 4.0	< 4.0	< 1.4
Lead, dissolved, in $\mu\text{g}/\text{L}$	<.08	<.12	<.12	<.12	<.12	<.08	<.08	<.08	<.08	< .06	E .05	< .06	< .03
Lead, total recoverable, in $\mu\text{g}/\text{L}$	E.05	<.06	<.06	0.07	<.06	0.09	E.04	E.04	<.06	< .10	0.13	< .10	< .06
Manganese, dissolved, in $\mu\text{g}/\text{L}$	<.2	<.2	E.1	<.2	<.2	<.2	0.9	<.2	<.2	< .2	0.9	< .2	< .3
Manganese, total recoverable, in $\mu\text{g}/\text{L}$	1.5	<.6	<.6	E.4	<.6	<.8	E.7	E.6	E.6	< .4	2.6	< .4	< .8
Zinc, dissolved, in $\mu\text{g}/\text{L}$	<.6	2.4	<.60	<.60	1.1	<1.8	<1.8	<1.8	<1.8	E 1.8	< 2.0	< 2.0	< 2.8
Zinc, total recoverable, in $\mu\text{g}/\text{L}$	<2	<2	<2.0	<2.0	E1.0	<2.0	<2.0	<2.0	<2.0	< 2.0	E 1.1	< 2.0	2.1

Duplicate samples were used to evaluate the reproducibility (precision) of analytical results. The duplicate samples consisted of stormwater split into two separate samples and sent to the NWQL for analysis. The relative percent difference (RPD) for two values (a and b) is calculated according to the following equation:

$$\text{RPD} = |\{(a - b) \div [(a + b) \div 2]\} \times 100| \quad (1)$$

For example, if the environmental sample (a) result is 18, and the duplicate (b) is 20, the RPD (absolute value) is 10.52 percent. If censored values were reported for both results in a comparison, they were counted as a “zero” RPD. If one result was censored and the other result was not, the RPD was not computed. For small concentrations, small differences in analytical results near the reporting level can result in large RPDs. Some constituents showed this tendency, but analysis of the distribution of the RPDs and the associated concentration or measured value seemed to indicate mostly random distribution of RPD values. For the 151 duplicate analyses, the median RPD was 1.9 percent, and RPDs ranged from 0 to 115 percent (table 6). For the 151 duplicate analyses, the 90th-percentile RPDs ranged from 0.4 to 45 percent. Among those results dissolved copper, lead, and manganese, accounted for the largest RPDs (90th-percentile RPDs ranged from 34 to 45 percent). Excluding these dissolved metals, the range of 90th-percentile values in table 6 was 0.4 to 20 percent (table 6). The RPD results indicate generally satisfactory reproducibility for the majority water-quality analysis types. For the dissolved metals—copper, lead, and manganese—reproducibility was only fair.

Table 6. Relative percentage difference statistics for duplicate samples collected during 2006–2010.

[ft³/s, cubic foot per second; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; °C, Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; n, number of samples]

Property or constituent	n	Minimum	Maximum	10th percentile	25th percentile	Median	75th percentile	90th percentile
Specific conductance, field, µS/cm at 25°C	8	0	0.5	0	0	0	0.2	0.4
Hardness, total as CaCO ₃ , in mg/L	8	0	5.4	0	0.5	0.8	3.2	4.5
Calcium, dissolved, mg/L	8	0.2	4.4	0.2	0.4	0.9	3.0	3.6
Magnesium, dissolved, mg/L	8	0	2.7	0	0.2	1.0	1.5	2.3
Residue on evaporation at 105°C, mg/L	8	1.3	24	2.3	3.8	6.6	13	18
Nitrogen, ammonia plus organic, total as N, mg/L	7	0	10	0	0.6	6.9	8.9	9.7
Nitrogen, ammonia, dissolved as N, mg/L	8	0	22	0	0.0	0.9	3.2	12
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	8	0	1.9	0	1.0	1.5	1.7	1.9
Orthophosphate, dissolved as P, mg/L	8	0	20	0	0	1.2	7.6	20
Phosphorus, total as P, mg/L	8	0	10	0	1.4	3.5	5.8	9.4
Carbon, organic, dissolved as C, mg/L	8	0	5.7	0.9	1.3	2.4	3.8	4.6
Copper, dissolved, µg/L	8	0	115	2.9	6.4	12	15	45
Copper, total recoverable, µg/L	8	1.0	17	1.4	2.1	2.7	3.1	7.7
Lead, dissolved, µg/L	8	0	55	0	0	26	37	43
Lead, total recoverable, µg/L	8	0.2	7.3	0.2	1.9	3.1	4.2	6.9
Manganese, dissolved, µg/L	8	0	108	0.1	0.6	0.9	1.7	34
Manganese, total recoverable, µg/L	8	0.2	5.1	0.3	0.3	1.3	2.3	4.7
Zinc, dissolved, µg/L	8	0.4	19	0.4	5.4	8.1	9.4	13
Zinc, total recoverable, µg/L	8	0	16	0.6	1.6	2.0	5.9	9.1

Summary of Stormwater Quality

The results of laboratory analyses of stormwater samples for water-quality properties and constituents and biological indicators are summarized in this section. Summary statistics of laboratory results are presented for each of the five stations. In addition, analytical results are compared to numeric standards established by the CDPHE (Colorado Department of Public Health and Environment, 2011a, 2011b). Hydrographs of daily mean streamflow for each streamflow-gaging station and the dates of sampling events are presented in figure 3. The streamflow plots, in addition to the streamflow characteristics of the stations listed in table 3, provide a context for the hydrologic setting of stormwater collection. Precipitation data on the hydrographs were collected at the same station (Union, Toll Gate, Sand Creek, and Henderson) or at a nearby location (Denver), and the exact locations of the precipitation gages are listed in table 1.

Figure 3. Graphs showing daily values for streamflow and precipitation and dates of sample collection (2006-2010) at (A) South Platte River below Union Avenue at Englewood, (B) South Platte River at Denver, (C) Toll Gate Creek above 6th Avenue at Aurora, (D) Sand Creek at mouth near Commerce City, and (E) South Platte River at Henderson.

Figure 3. Graphs showing daily values for streamflow and precipitation and dates of sample collection (2006-2010) at (A) South Platte River below Union Avenue at Englewood, (B) South Platte River at Denver, (C) Toll Gate Creek above 6th Avenue at Aurora, (D) Sand Creek at mouth near Commerce City, and (E) South Platte River at Henderson.—Continued

Figure 3. Graphs showing daily values for streamflow and precipitation and dates of sample collection (2006-2010) at (A) South Platte River below Union Avenue at Englewood, (B) South Platte River at Denver, (C) Toll Gate Creek above 6th Avenue at Aurora, (D) Sand Creek at mouth near Commerce City, and (E) South Platte River at Henderson.—Continued

Water Quality of Stormwater Samples

A total of 197 composite samples were collected from 2006 through 2010; about 30 to 50 samples were collected at each station. Samples were collected during periods of rising, peak, or falling surface-water levels. Sampling events (2006–2010) are shown on hydrographs for each of the five stations (fig. 3).

Summary statistics of streamflow, water-quality properties and constituents, including bacteriological results, are presented in table 7 and illustrated with boxplots in figure 4 for each of the five stations. Table 7 also reports the number of samples that had censored values—unquantifiable concentrations that were less than the reporting level. Some reporting levels varied during 2006–2010 (table 7). Water-quality constituents having censored values included residue on evaporation, dissolved ammonia, dissolved orthophosphate, and dissolved copper and lead.

Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06710247 South Platte River below Union Avenue at Englewood, Colorado										
Streamflow, mean, ft³/s	410	312	131	346	632.	38	0	33	1,490	--
Streamflow, volume, acre-feet	378	282	136	322	574	38	0	30	1,360	--
pH, standard units	7.7	0.2	7.6	7.7	7.8	38	0	6.9	8.4	--
Specific conductance, µS/cm	490	210	345	409	585	38	0	226	993	--
Hardness, total, mg/L as CaCO₃	145	47.4	113	133	164	38	0	81.5	290	--
Calcium, mg/L	43	13	33	39	47	38	0	24	84	--
Magnesium, mg/L	9.3	3.6	6.8	7.9	11	38	0	5.1	20	--
Suspended solids, residue on evaporation at 105 °C, mg/L	226	183	77	196	326	37	1	16	670	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.4	0.72	0.83	1.4	1.7	8	0	0.46	4.00	--
Nitrogen, dissolved, ammonia as N, mg/L	0.06	0.06	0.02	0.05	0.08	38	6	0.01	6.00	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.82	0.56	0.42	0.59	1.03	38	0	0.17	2.71	--
Orthophosphate, dissolved as P, mg/L	0.059	0.051	0.024	0.043	0.068	38	0	0.004	0.237	--
Phosphorus, total as P, mg/L	0.38	0.24	0.22	0.35	0.49	38	0	0.07	0.98	--
Carbon, dissolved, organic as C, mg/L	6.7	3.0	4.8	6.1	7.5	38	0	2.9	18.6	--
<i>Escherichia coli</i> , MPN/100 mL	5,380	5,620	--	5,380	--	4	0	20	11,000	--
Fecal coliform, MPN/100 mL	6,180	6,200	--	6,180	--	4	0	20	12,000	--
Copper, dissolved, µg/L	2.1	0.8	1.6	1.9	2.6	38	0	1.1	4.6	--
Copper, total recoverable, µg/L	11	7.9	5.4	11	14	36	0	2.9	34	--
Lead, dissolved, µg/L	0.08	0.06	0.04	0.06	0.07	38	6	0.03	0.27	0.04, 0.06
Lead, total recoverable, µg/L	8.3	7.2	2.6	7.4	10.3	36	0	0.62	26.9	--
Manganese, dissolved, µg/L	19.5	26.0	6.4	11.6	20.6	38	0	0.2	119	--
Manganese, total recoverable, µg/L	304	242	143	263	379	36	0	42.2	884	--
Zinc, dissolved, µg/L	5.3	3.0	2.8	4.8	6.9	38	0	1.8	13.6	--
Zinc, total recoverable, µg/L	40	29	19	34	53	36	0	7	134	--

Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06714000 South Platte River at Denver, Colorado										
Streamflow, mean, ft³/s	1,480	1,370	656	1,090	1,790	49	0	184	8,083	--
Streamflow, volume, acre-feet	1,410	1,280	667	1,010	1,630	49	0	168	7,350	--
pH, standard units	7.5	0.3	7.5	7.5	7.7	48	0	6.6	8.0	--
Specific conductance, µS/cm	522	225	384	491	597	46	0	260	1,390	--
Hardness, total, mg/L as CaCO₃	141	43	108	138	160	48	0	74.4	251	--
Calcium, mg/L	42	12	32	42	49	48	0	22	76	--
Magnesium, mg/L	8.6	3.1	6.2	8	9.8	48	0	4.3	18	--
Suspended solids, residue on evaporation at 105 °C, mg/L	202	125	122	180	258	47	0	20.0	660	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.8	0.82	1.2	1.5	2.2	7	0	0.51	4.2	--
Nitrogen, dissolved, ammonia as N, mg/L	0.12	0.13	0.03	0.07	0.13	47	4	0.01	0.60	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.21	0.65	0.80	0.98	1.38	46	0	0.55	3.69	--
Orthophosphate, dissolved as P, mg/L	0.150	0.087	0.098	0.122	0.167	47	0	0.046	0.487	--
Phosphorus, total as P, mg/L	0.54	0.24	0.39	0.47	0.65	47	0	0.14	1.33	--
Carbon, dissolved, organic as C, mg/L	6.3	2.0	5.0	5.8	7.2	48	0	4.1	12.2	--
<i>Escherichia coli</i> , MPN/100 mL	8,900	9,926	--	6,250	--	4	0	110	23,000	--
Fecal coliform, MPN/100 mL	10,520	9,486	--	9,450	--	4	0	170	23,000	--
Copper, dissolved, µg/L	2.9	1.2	2.2	2.5	3.3	48	1	1.5	7.0	1
Copper, total recoverable, µg/L	17	11	9.1	15	21	45	0	3.8	67	--
Lead, dissolved, µg/L	0.118	0.062	0.075	0.1	0.155	48	0	0.04	0.31	--
Lead, total recoverable, µg/L	15.2	13.7	6.72	13.1	18	45	0	2.13	79.5	--
Manganese, dissolved, µg/L	11	25	1.1	3.3	9.7	48	0	0.1	156	--
Manganese, total recoverable, µg/L	333	182	215	288	412	45	0	77.9	873	--
Zinc, dissolved, µg/L	8.3	4.5	5.0	6.8	10.6	48	0	3.3	21.3	--
Zinc, total recoverable, µg/L	71	51	33	60	91	45	0	13	287	--

Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
394329104490101 Toll Gate Creek above 6th Avenue near Aurora, Colorado										
Streamflow, mean, ft³/s	261	289	73	182	345	30	0	4	1,400	--
Streamflow, volume, acre-feet	242	241	67	156	313	30	0	4	921	--
pH, standard units	7.7	0.2	7.5	7.6	7.8	33	0	7.4	8.0	--
Specific conductance, µS/cm	1,112	506	720	957	1,500	31	0	363	2,230	--
Hardness, total, mg/L as CaCO₃	316	167	193	251	418	33	0	84.6	746	--
Calcium, mg/L	95	50	60	77	129	33	0	26	226	--
Magnesium, mg/L	19	10	11	15	24	33	0	4.6	44	--
Suspended solids, residue on evaporation at 105 °C, mg/L	180	186	46	97	254	31	0	10	695	--
Nitrogen, total, ammonia plus organic as N, mg/L	1.6	0.78	1.1	1.4	2.0	32	0	0.63	3.5	--
Nitrogen, dissolved, ammonia as N, mg/L	0.14	0.15	0.04	0.09	0.20	32	3	0.01	0.66	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.64	0.21	0.49	0.59	0.77	32	0	0.36	1.28	--
Orthophosphate, dissolved as P, mg/L	0.022	0.020	0.007	0.013	0.035	32	1	0.003	0.077	0.003
Phosphorus, total as P, mg/L	0.33	0.32	0.12	0.22	0.44	32	0	0.04	1.38	--
Carbon, dissolved, organic as C, mg/L	10.4	3.7	8.5	10.4	11.7	33	0	5.3	20.9	--
<i>Escherichia coli</i> , MPN/100 mL	2,310	1,715	--	3,300	--	3	0	330	3,300	--
Fecal coliform, MPN/100 mL	2,310	1,715	--	3,300	--	3	0	330	3,300	--
Copper, dissolved, µg/L	2.5	1.1	1.8	2.2	2.8	33	0	1.0	4.9	--
Copper, total recoverable, µg/L	12	8.8	5.8	8.3	15	33	0	2.9	33	--
Lead, dissolved, µg/L	0.097	0.07	0.053	0.08	0.12	33	4	0.04	0.34	0.04, 0.06
Lead, total recoverable, µg/L	7.18	7.67	2.35	3.45	9.18	33	0	0.71	28.3	--
Manganese, dissolved, µg/L	75.29	78.83	20.3	50.9	105	33	0	2.8	330	--
Manganese, total recoverable, µg/L	381	269	192	244	480	33	0	103	1,120	--
Zinc, dissolved, µg/L	8.8	5.4	4.7	8.0	11	33	0	1.5	26.1	--
Zinc, total recoverable, µg/L	47	35	24	33	59	33	0	9	132	--

Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
394839104570300 Sand Creek at mouth near Commerce City, Colorado										
Streamflow, mean, ft³/s	285	275	100	229	374	47	0	21	1,620	--
Streamflow, volume, acre-feet	255	249	95	205	348	47	0	19	1,473	--
pH, standard units	7.6	0.2	7.4	7.6	7.8	47	0	7.3	8.0	--
Specific conductance, µS/cm	811	392	575	684	908	45	0	330	2,020	--
Hardness, total, mg/L as CaCO₃	195	79	153	171	210	47	0	74.8	455	--
Calcium, mg/L	59	22	47	52	64	47	0	23	131	--
Magnesium, mg/L	12	5.6	8.4	10	13	47	0	4.1	31	--
Suspended solids, residue on evaporation at 105 °C, mg/L	351	306	128	236	470	47	0	56.0	1,360	--
Nitrogen, total, ammonia plus organic as N, mg/L	2.6	1.6	1.6	2.0	3.2	45	0	1.1	9.5	--
Nitrogen, dissolved, ammonia as N, mg/L	0.11	0.11	0.02	0.09	0.18	45	8	0.01	0.47	0.005, 0.01, 0.02
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.88	0.43	0.59	0.78	0.95	45	0	0.41	2.55	--
Orthophosphate, dissolved as P, mg/L	0.121	0.113	0.059	0.089	0.141	45	0	0.017	0.627	--
Phosphorus, total as P, mg/L	0.79	0.47	0.49	0.63	0.90	45	0	0.27	2.36	--
Carbon, dissolved, organic as C, mg/L	10.8	4.2	7.8	9.3	13.2	46	0	5.8	23.6	--
<i>Escherichia coli</i> , MPN/100 mL	3,530	2,370	--	2,950	--	3	0	790	4,900	--
Fecal coliform, MPN/100 mL	2,630	2,090	--	2,140	--	3	0	790	4,900	--
Copper, dissolved, µg/L	3.0	2.0	1.6	2.4	3.6	47	0	1.2	12.5	--
Copper, total recoverable, µg/L	22	14	11	17	28	47	0	6.5	55	--
Lead, dissolved, µg/L	0.19	0.14	0.10	0.14	0.25	47	0	0.04	0.74	--
Lead, total recoverable, µg/L	21.0	17.3	6.16	14.5	31.6	47	0	3.67	60.5	--
Manganese, dissolved, µg/L	45	78	2.5	11	59	47	0	0.5	391	--
Manganese, total recoverable, µg/L	678	661	283	466	640	47	0	144	3,210	--
Zinc, dissolved, µg/L	67.2	191	7.8	10.9	21.0	47	0	2.8	1,170	--
Zinc, total recoverable, µg/L	524	1205.4	44	75	241	47	0	22	5,230	--

Table 7. Statistics for concentrations and measurement values at stormwater sampling sites, 2006–2010.—Continued

[ft³/s, cubic foot per second; mL, milliliter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; --, not calculated; %, percentile; MPN, most probable number]

Property or constituent	Summary statistics					n	nlt	Range of uncensored values		Censoring level
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum	
06720500 South Platte River at Henderson, Colorado										
Streamflow, mean, ft ³ /s	2,260	3,290	754	1,470	2,390	33	0	218	19,000	--
Streamflow, volume, acre-feet	1,720	1,570	663	1,340	2,040	33	0	198	6,920	--
pH, standard units	7.3	0.2	7.2	7.4	7.5	34	0	6.6	7.7	--
Specific conductance, µS/cm	557	196	454	528	601	34	0	205	1,260	--
Hardness, total, mg/L as CaCO ₃	141	31	119	133	154	34	0	95	226	--
Calcium, mg/L	42	9	36	41	47	34	0	28	64	--
Magnesium, mg/L	8.9	2.5	7.3	8.3	10	34	0	6.0	17	--
Suspended solids, residue on evaporation at 105 °C, mg/L	174	112	94	133	242	32	0	44	545	--
Nitrogen, total, ammonia plus organic as N, mg/L	2.9	1.7	2.0	2.6	3.4	3	0	0.96	9.4	--
Nitrogen, dissolved, ammonia as N, mg/L	0.80	0.88	0.24	0.58	0.73	33	1	0.11	3.38	0.01
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	2.08	0.81	1.53	1.87	2.24	33	0	0.96	4.64	--
Orthophosphate, dissolved as P, mg/L	0.461	0.279	0.262	0.367	0.621	33	0	0.152	1.15	--
Phosphorus, total as P, mg/L	1.02	0.46	0.72	0.96	1.18	33	0	0.37	2.85	--
Carbon, dissolved, organic as C, mg/L	9.1	5.3	6.2	7.5	10.6	34	0	4.8	34.4	--
<i>Escherichia coli</i> , MPN/100 mL	10,400	11,550	--	7,900	--	3	0	310	23,000	--
Fecal coliform, MPN/100 mL	12,100	11,370	--	13,000	--	3	0	310	23,000	--
Copper, dissolved, µg/L	3.04	0.92	2.4	2.75	3.4	34	0	1.7	5.5	--
Copper, total recoverable, µg/L	24	13	13	22	28	32	0	9.1	63	--
Lead, dissolved, µg/L	0.22	0.08	0.17	0.21	0.29	34	0	0.07	0.41	--
Lead, total recoverable, µg/L	22.6	15.9	10.2	17.3	32.4	32	0	5.09	70.9	--
Manganese, dissolved, µg/L	62	127	18	33	62	34	0	0.6	757	--
Manganese, total recoverable, µg/L	408	305	243	359	472	32	0	138	1,840	--
Zinc, dissolved, µg/L	18.3	7.5	13.1	17.3	22.1	34	0	6.7	45.8	--
Zinc, total recoverable, µg/L	114	68	68	91	148	32	0	32	308	--

Figure 4. Boxplots showing distribution of water-quality properties and constituents at South Platte River below Union Avenue at Englewood (SPRU), South Platte River at Denver (SPRD), Toll Gate Creek above 6th Avenue at Aurora (TGC6), Sand Creek at mouth near Commerce City (SCRM), and South Platte River at Henderson (SPRH), calendar years 1998–2001, 2002–2005, and 2006–2010. Plotted values and concentrations. Boxplot explanation provided in figure 2.

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The results from laboratory analyses indicate, in general, and particularly for nutrients, that some values and concentrations for water-quality constituents increase with contributing drainage area in the South Platte River, but no well-defined relation was identified between concentration and the amount of urban land cover identified using the U.S. Geological Survey National Land Cover data (table 2; fig. 4; table 7; appendix tables A1-A5). For example, the mean concentration for ammonia plus organic nitrogen is 1.4 milligrams per liter (mg/L) at Union, 1.8 mg/L at Denver, and 2.9 mg/L at Henderson. This pattern corresponds with the size of the local contributing drainage area, which also increases downstream (table 2). Sand Creek, a tributary that flows into the South Platte River between the Denver and Henderson sites, has Toll Gate Creek as tributary. Some values and concentrations of results also increase in a downstream direction from Toll Gate to Sand Creek (fig. 4; table 7; appendix tables A1-A5). For some water-quality constituents, concentrations measured in the tributary streams (Toll Gate Creek and Sand Creek) are higher than concentrations measured in the upstream reach of the South Platte River (Union) (table 7, fig. 4).

Comparison to Colorado Water-Quality Standards

Results from laboratory analyses of stormwater samples were compared to numeric water-quality standards for pH, *Escherichia coli*, dissolved nitrite plus nitrate, dissolved copper, lead, manganese, and zinc (Colorado Department of Public Health and Environment, 2011a, 2011b) (table 8). All numeric standards do not apply to all stations. The numeric standards are fixed values for pH, *Escherichia coli*, dissolved nitrite plus nitrate, and a water-supply-related standard for dissolved manganese. The numeric values for acute and chronic aquatic-life toxicity standards for dissolved copper, lead, manganese (in addition to the fixed standard just mentioned), and zinc are each calculated according to equations published by the CDPHE (Colorado Department of Public Health and Environment, 2011a, 2011b). The calculations for these values, often referred to as “table-value standards,” are based on hardness; in this study, the hardness value associated with the composite sample was used in the calculation.

Table 8. Summary of Colorado water-quality standards and properties and constituents that exceeded Colorado standards for this study, 2006–2010.

[--, no data or no standard; ml, milliliter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; TVS, table value standards equation; standards from Colorado Department of Public Health and Environment (2011a), 2011b); only data greater than or equal to the reporting level were compared to standards; nitrite plus nitrate concentration is used instead of nitrate for comparison to standard as nitrite concentrations are generally negligible; samples without hardness for trace element standards computation were not included in the exceedance evaluation; water temperature was not available for the computation of ammonia standards for composite samples]

Property or constituent	Total number of samples	Total number of uncensored samples	Type of standard	Range of concentration		Standards		Number of uncensored sample exceedances
				Minimum	Maximum	Chronic	Acute	
South Platte River below Union at Englewood								
pH, lab, standard units	38	38	Fixed	6.9	8.4	--	6.5 to 9.0	0
<i>Escherichia coli</i> , colonies/100ml	4	0	Fixed	20	11,000	--	120	3
Nitrate, dissolved, mg/L	38	38	Fixed	0.17	2.71	--	10	0
Copper, dissolved, µg/L	38	38	TVS acute	1.1	4.6	--	33 to 109	0
	38	38	TVS chronic	1.1	4.6	26 to 77	--	0
Lead, dissolved, µg/L	38	32	TVS acute	0.03	0.27	--	35 to 135	0
	38	32	TVS chronic	0.03	0.27	0.6 to 2.2	--	0
Manganese, dissolved, µg/L	38	38	TVS acute	0.2	119	--	37 to 57	3
	38	38	TVS chronic	0.2	119	31 to 47	--	4
	38	38	Fixed chronic	0.2	119	190	--	0
Zinc, dissolved, µg/L	38	38	TVS acute	1.8	1.8	--	103 to 304	0
	38	38	TVS chronic	13.6	13.6	91 to 269	--	0
South Platte River at Denver								
pH, lab, standard units	48	48	Fixed	6.6	8.0	--	6.5 to 9.0	0
<i>Escherichia coli</i> , colonies/100ml	4	0	Fixed	110	23,000	--	120	3
Nitrate, dissolved, mg/L	46	46	Fixed	0.60	3.7	--	10	0
Copper, dissolved, µg/L	48	47	TVS acute	1.5	7.0	--	11 to 35	0
	48	47	TVS chronic	1.5	7.0	30 to 96	--	0
Lead, dissolved, µg/L	48	48	TVS acute	0.04	0.31	--	31 to 116	0
	48	48	TVS chronic	0.04	0.31	0.5 to 1.9	--	0
Manganese, dissolved, µg/L	48	48	TVS acute	0.1	156	--	36 to 54	2
	48	48	TVS chronic	0.1	156	30 to 45	--	2
	48	48	Fixed chronic	0.1	156	190	--	0
Zinc, dissolved, µg/L	48	48	TVS acute	3.3	21.3	--	363 to 1,390	0
	48	48	TVS chronic	3.3	21.3	84 to 238	--	0

Table 8. Summary of Colorado water-quality standards and properties and constituents that exceeded Colorado standards for this study, 2006–2010.—Continued

[--, no data or no standard; ml, milliliter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; TVS, table value standards equation; standards from Colorado Department of Public Health and Environment (2011a), 2011b); only data greater than or equal to the reporting level were compared to standards; nitrite plus nitrate concentration is used instead of nitrate for comparison to standard as nitrite concentrations are generally negligible; samples without hardness for trace element standards computation were not included in the exceedance evaluation; water temperature was not available for the computation of ammonia standards for composite samples]

Toll Gate Creek above 6th Avenue at Aurora								
pH, lab, standard units	33	33	Fixed	7.4	8.0	--	6.5 to 9.0	0
<i>Escherichia coli</i> , colonies/100ml	3	0	Fixed	330	3,300	--	120	3
Nitrate, dissolved, mg/L	32	32	Fixed	0.009	0.66	--	10	0
Copper, dissolved, µg/L	33	33	TVS acute	0.97	4.9	--	13 to 99	0
	33	33	TVS chronic	0.97	4.9	10 to 64	--	0
Lead, dissolved, µg/L	33	29	TVS acute	0.04	0.34	--	58 to 352	0
	33	29	TVS chronic	0.04	0.34	0.93 to 5.7	--	0
Manganese, dissolved, µg/L	33	33	TVS acute	3	330	--	38 to 78	15
	33	33	TVS chronic	3	330	31 to 64	--	17
Zinc, dissolved, µg/L	33	33	TVS acute	1.5	26.1	--	419 to 4,620	0
	33	33	TVS chronic	1.5	26.1	94 to 603	--	0
Sand Creek at mouth near Commerce City								
pH, lab, standard units	47	47	Fixed	7.3	8.0	--	6.5 to 9.0	0
<i>Escherichia coli</i> , colonies/100ml	3	0	Fixed	790	4,900	--	120	3
Nitrate, dissolved, mg/L	45	45	Fixed	0.41	2.6	--	10	0
Copper, dissolved, µg/L	47	47	TVS acute	1.2	12.5	--	29 to 161	0
	47	47	TVS chronic	1.2	12.5	23 to 110	--	0
Lead, dissolved, µg/L	47	47	TVS acute	0.04	0.74	--	32 to 215	0
	47	47	TVS chronic	0.04	0.74	0.51 to 3.46	--	0
Manganese, dissolved, µg/L	47	47	TVS acute	0.5	391	--	36 to 66	13
	47	47	TVS chronic	0.5	391	30 to 54	--	15
Zinc, dissolved, µg/L	47	47	TVS acute	2.8	1,170	--	366 to 2,680	1
	47	47	TVS chronic	2.8	1,170	85 to 395	--	4
South Platte River at Henderson								
pH, lab, standard units	34	34	Fixed	6.6	7.7	--	6.5 to 9.0	0
<i>Escherichia coli</i> , colonies/100ml	3	0	Fixed	310	23,000	--	120	3
Nitrate, dissolved, mg/L	33	33	Fixed	0.96	4.6	--	10	0
Copper, dissolved, µg/L	34	34	TVS acute	1.7	5.5	--	33 to 74	0
	34	34	TVS chronic	1.7	5.5	25 to 53	--	0
Lead, dissolved, µg/L	34	34	TVS acute	0.07	0.41	--	41 to 104	0
	34	34	TVS chronic	0.07	0.41	0.66 to 1.67	--	0
Manganese, dissolved, µg/L	34	34	TVS acute	0.6	757	--	39 to 52	13
	34	34	TVS chronic	0.6	757	32 to 43	--	16
	34	34	Fixed chronic	0.6	757	400	--	1
Zinc, dissolved, µg/L	34	34	TVS acute	6.7	46	--	476 to 1,240	0
	34	34	TVS chronic	6.7	46	104 to 218	--	0

A summary of results from 2006–2010 stormwater samples that did not meet (exceeded) CDPHE water-quality standards (Colorado Department of Public Health and Environment, 2011a, 2011b) is presented in table 8 for individual stations. The results indicate few exceptions to standards except for dissolved manganese, dissolved zinc, and *Escherichia coli*. Stormwater collected at Union had about 10 percent acute or chronic dissolved manganese exceedances in samples; samples collected at Denver had less than 5 percent acute or chronic dissolved manganese exceedances (table 8). In contrast, samples collected at Toll Gate, Sand Creek, and Henderson, each had about 30 to 50 percent exceedances of both acute and chronic dissolved manganese standards. Of the samples collected at Sand Creek, 1 sample exceeded the acute standard and 4 samples exceeded the chronic standard for dissolved zinc (table 8), but no samples collected from the other sites exceeded either standard for zinc. Almost all samples of stormwater analyzed for *Escherichia coli* exceeded the Colorado numeric standards (table 8). A numerical standard for fecal coliform is no longer applicable as of 2004 (Colorado Department of Health and Environment, 2006).

Evaluation of Stormwater Quality between 2006–2010 and 2002–2005

The water quality of stormwater samples collected in this study is evaluated in this section by using the Mann-Whitney rank-sum test, which is a nonparametric statistical test (Helsel and Hirsch, 1992). The evaluation compares 2006–2010 results to 2002–2005 results. Previous reports (Bossong and others, 2005; Bossong and Fleming, 2008) grouped data by water years, but this report groups and analyzes data by calendar year.

Statistics

The distribution of data from stormwater samples collected during 2006–2010 was compared to the corresponding distribution of 2002–2005 data to determine if water quality changed between periods. In this report, an upward trend indicates increasing values or concentrations, and a downward trend indicates decreasing values or concentrations (table 9). Trends in stormwater quality also are illustrated in boxplots for each of the five sites (fig. 4) and presented in the statistics of table 7 and appendix tables A1-A5. Although boxplots also are presented for 1998–2001 data (Bossong and others, 2005), the statistical comparisons and trend analysis with the 2002–2006 data were made in Bossong and Fleming (2008) and are not repeated herein.

Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.

[n, number of samples, each time period separated by a comma; shaded values indicate statistical significance for this report with a p-value less than or equal to 0.1000; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO₃, calcium carbonate; cm, centimeter; N, nitrogen; P, phosphorus; C, carbon; MPN, most probable number]

Property or constituent	South Platte River below Union Avenue				
	n	Median value or concentration 2002-2005	Median value or concentration 2006-2010	p-value	Trend
Streamflow, mean, in ft ³ /s	37,38	154	346	0.0059	Upward
pH, lab	37,38	7.5	7.7	0.0018	Upward
Specific conductance, field, µS/cm at 25°C	31,38	478	410	0.4509	None
Hardness, as CaCO ₃ , in mg/L	37,38	155	133	0.0388	Downward
Calcium, dissolved, mg/L	28,38	42.6	39.6	0.3811	None
Magnesium, dissolved, mg/L	28,38	8.6	7.9	0.7753	None
Residue on evaporation at 105°C	37,38	199	196	0.6601	None
Nitrogen, ammonia plus organic, total as N, mg/L	37,38	1.40	1.35	0.2068	None
Nitrogen, ammonia, dissolved as N, mg/L	28,38	0.080	0.046	0.0422	Downward
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	28,38	0.775	0.585	0.1650	None
Orthophosphate, dissolved as P, mg/L	37,38	0.082	0.0435	0.0044	Downward
Phosphorus, total as P, mg/L	37,38	0.36	0.35	0.4908	None
Carbon, organic, dissolved as C, mg/L	25,38	6.7	6.1	0.3357	None
Copper, dissolved, µg/L	37,38	2.1	1.8	0.0431	Downward
Copper, total recoverable, µg/L	28,35	12.9	10.6	0.3125	None
Lead, dissolved, µg/L	28,38	0.05	0.06	0.9426	None
Lead, total recoverable, µg/L	28,36	9.6	7.4	0.2585	None
Manganese, dissolved, µg/L	28,38	12.8	11.6	0.4556	None
Manganese, total recoverable, µg/L	28,36	285	263	0.4690	None
Zinc, dissolved, µg/L	28,38	4.6	4.8	0.8609	None
Zinc, total recoverable, µg/L	28,36	45	34	0.2819	None

Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.—Continued

[n, number of samples, each time period separated by a comma; shaded values indicate statistical significance for this report with a p-value less than or equal to 0.1000; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO₃, calcium carbonate; cm, centimeter; N, nitrogen; P, phosphorus; C, carbon; MPN, most probable number]

Property or constituent	South Platte River at Denver				
	n	Median value or concentration 2002-2005	Median value or concentration 2006-2010	Mann-Whitney rank sum p-value	Trend
Streamflow, mean, in ft ³ /s	46,49	636	1,080	0.0010	Upward
pH, lab	46,48	7.5	7.5	0.0284	Upward
Specific conductance, field, µS/cm at 25°C	41,46	509	491	0.2956	None
Hardness, as CaCO ₃ , in mg/L	45,48	154	138	0.1222	None
Calcium, dissolved, mg/L	35,48	42.9	41.6	0.8537	None
Magnesium, dissolved, mg/L	35,48	8.22	8.03	0.7329	None
Residue on evaporation at 105°C	45,47	186	186	0.7281	None
Nitrogen, ammonia plus organic, total as N, mg/L	45,47	2.1	1.5	0.0059	Downward
Nitrogen, ammonia, dissolved as N, mg/L	35,47	0.220	0.074	<0.0001	Downward
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	35,46	2.00	0.98	<0.0001	Downward
Orthophosphate, dissolved as P, mg/L	45,47	0.238	0.122	<0.0001	Downward
Phosphorus, total as P, mg/L	45,47	0.67	0.47	0.0068	Downward
Carbon, organic, dissolved as C, mg/L	31,48	7.8	5.8	0.0006	Downward
Copper, dissolved, µg/L	45,48	3.0	2.5	0.3597	None
Copper, total recoverable, µg/L	35,45	18.0	15.4	0.1063	None
Lead, dissolved, µg/L	35,48	0.14	0.10	0.0036	Downward
Lead, total recoverable, µg/L	35,45	15.4	13.1	0.1888	None
Manganese, dissolved, µg/L	35,48	16.4	3.25	<0.0001	Downward
Manganese, total recoverable, µg/L	35,45	285	288	0.9961	None
Zinc, dissolved, µg/L	35,48	10.1	6.75	0.0147	Downward
Zinc, total recoverable, µg/L	35,45	84	60	0.0896	Downward

Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.—Continued

[n, number of samples, each time period separated by a comma; shaded values indicate statistical significance for this report with a p-value less than or equal to 0.1000; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO₃, calcium carbonate; cm, centimeter; N, nitrogen; P, phosphorus; C, carbon; MPN, most probable number]

Property or constituent	Toll Gate Creek above 6 th Avenue				
	n	Median value or concentration 2002-2005	Median value or concentration 2006-2010	Mann-Whitney rank sum p-value	Trend
Streamflow, mean, in ft ³ /s	20,30	47	182	0.0020	Upward
pH, lab	24,33	7.3	7.6	<0.0001	Upward
Specific conductance, field, µS/cm at 25°C	21,31	690	957	0.0188	Upward
Hardness, as CaCO ₃ , in mg/L	24,33	250	251	0.2934	None
Calcium, dissolved, mg/L	21,33	67.4	76.7	0.2142	None
Magnesium, dissolved, mg/L	21,33	12.4	14.6	0.1315	None
Residue on evaporation at 105°C	22,31	246	97	0.0109	Downward
Nitrogen, ammonia plus organic, total as N, mg/L	24,32	2.25	1.40	0.0142	Downward
Nitrogen, ammonia, dissolved as N, mg/L	21,32	0.190	0.088	0.0194	Downward
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	21,32	0.46	0.58	0.0373	Upward
Orthophosphate, dissolved as P, mg/L	32,32	0.032	0.013	0.0405	Downward
Phosphorus, total as P, mg/L	24,32	0.54	0.22	0.0016	Downward
Carbon, organic, dissolved as C, mg/L	21,33	8.4	10.4	0.4887	None
Copper, dissolved, µg/L	24,33	2.8	2.2	0.1038	None
Copper, total recoverable, µg/L	21,33	16.6	8.3	0.0051	Downward
Lead, dissolved, µg/L	21,33	0.08	0.08	0.5930	None
Lead, total recoverable, µg/L	21,33	9.17	3.45	0.0101	Downward
Manganese, dissolved, µg/L	21,33	41.8	50.9	0.6573	None
Manganese, total recoverable, µg/L	21,33	683	244	0.0042	Downward
Zinc, dissolved, µg/L	21,33	7.4	8.0	0.7494	None
Zinc, total recoverable, µg/L	21,33	94	32	0.0010	Downward

Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.—Continued

[n, number of samples, each time period separated by a comma; shaded values indicate statistical significance for this report with a p-value less than or equal to 0.1000; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO₃, calcium carbonate; cm, centimeter; N, nitrogen; P, phosphorus; C, carbon; MPN, most probable number]

Property or constituent	Sand Creek at Mouth near Commerce City				
	n	Median value or concentration 2002-2005	Median value or concentration 2006-2010	Mann-Whitney rank sum p-value	Trend
Streamflow, mean, in ft ³ /s	34,47	102	229	0.0145	Upward
pH, lab	34,47	7.4	7.6	0.0018	Upward
Specific conductance, field, µS/cm at 25°C	30,45	765	684	0.1781	None
Hardness, as CaCO ₃ , in mg/L	33,47	234	171	0.0106	Downward
Calcium, dissolved, mg/L	25,47	68.6	52.5	0.0790	Downward
Magnesium, dissolved, mg/L	25,47	14.0	10.1	0.1051	None
Residue on evaporation at 105°C	34,47	347	236	0.4999	None
Nitrogen, ammonia plus organic, total as N, mg/L	33,45	2.90	2.00	0.0579	Downward
Nitrogen, ammonia, dissolved as N, mg/L	25,45	0.28	0.09	0.0003	Downward
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	25,45	0.87	0.78	0.1096	None
Orthophosphate, dissolved as P, mg/L	33,45	0.152	0.089	0.0023	Downward
Phosphorus, total as P, mg/L	33,45	0.83	0.63	0.5141	None
Carbon, organic, dissolved as C, mg/L	24,46	12.9	9.3	0.1132	None
Copper, dissolved, µg/L	33,47	3.0	2.4	0.1222	None
Copper, total recoverable, µg/L	25,47	19.2	17.0	0.4246	None
Lead, dissolved, µg/L	25,47	0.13	0.14	0.3970	None
Lead, total recoverable, µg/L	25,47	19.1	14.5	0.5385	None
Manganese, dissolved, µg/L	25,47	35.1	10.6	0.0482	Downward
Manganese, total recoverable, µg/L	25,47	602	466	0.5191	None
Zinc, dissolved, µg/L	32,47	34.4	10.9	0.0322	Downward
Zinc, total recoverable, µg/L	24,47	148	75	0.2288	None

Table 9. Mann-Whitney test of differences between distributions of water-quality values and concentrations in stormwater samples collected in 2002–2005 and 2006–2010 at all sites.—Continued

[n, number of samples, each time period separated by a comma; shaded values indicate statistical significance for this report with a p-value less than or equal to 0.1000; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO₃, calcium carbonate; cm, centimeter; N, nitrogen; P, phosphorus; C, carbon; MPN, most probable number]

Property or constituent	South Platte River at Henderson				
	n	Median value or concentration 2002-2005	Median value or concentration 2006-2010	Mann-Whitney rank sum p-value	Trend
Streamflow, mean, in ft ³ /s	35,33	1,060	1,470	0.2538	None
pH, lab	35,34	7.4	7.4	0.6197	None
Specific conductance, field, µS/cm at 25°C	30,34	655	528	0.0102	Downward
Hardness, as CaCO ₃ , in mg/L	34,34	172	134	0.0009	Downward
Calcium, dissolved, mg/L	23,34	44	41	0.1796	None
Magnesium, dissolved, mg/L	23,34	10.1	8.28	0.0735	Downward
Residue on evaporation at 105°C	34,32	264	142	0.0033	Downward
Nitrogen, ammonia plus organic, total as N, mg/L	34,33	4.95	2.60	<0.0001	Downward
Nitrogen, ammonia, dissolved as N, mg/L	23,33	1.48	0.578	0.0003	Downward
Nitrogen, nitrite plus nitrate, dissolved as N, mg/L	23,33	2.57	1.87	0.0066	Downward
Orthophosphate, dissolved as P, mg/L	34,33	0.598	0.367	0.0094	Downward
Phosphorus, total as P, mg/L	34,33	1.585	0.96	<0.0001	Downward
Carbon, organic, dissolved as C, mg/L	19,34	10.6	7.5	0.1669	None
Copper, dissolved, µg/L	34,34	3.0	2.8	0.6673	None
Copper, total recoverable, µg/L	23,32	31.9	22.4	0.0238	Downward
Lead, dissolved, µg/L	23,34	0.26	0.21	0.0478	Downward
Lead, total recoverable, µg/L	23,32	33.2	17.3	0.0212	Downward
Manganese, dissolved, µg/L	23,34	85.8	33.1	0.0060	Downward
Manganese, total recoverable, µg/L	23,32	542	360	0.0217	Downward
Zinc, dissolved, µg/L	23,34	17.0	17.3	0.7634	None
Zinc, total recoverable, µg/L	23,32	146	91	0.0732	Downward

Comparison to Previous Results

For this report, the Mann-Whitney nonparametric rank sum statistical test was used to determine if the distribution of values and concentrations for 2002–2005 samples was different from the distributions of values and concentrations in stormwater determined for 2006–2010 (table 9). Additional corroboration of many of the statistical tests trends are illustrated in the boxplots of figure 4. A probability value (p-value) less than or equal to 0.10 was used as the criteria to determine if an apparent trend was statistically significant. These results are presented for each of the five stations in table 9.

In an earlier study, Bosson and others (2008) indicated that the general quality of stormwater had improved during 2002–2005 compared to 1998–2001, having fewer exceedances of Colorado standards, and showing downward trends for many water-quality values and concentrations. These trends coincided with general downward or relatively similar mean streamflows for the 2002–2005 compared to 1998–2001, which indicates that dilution may be a smaller influence on values and concentrations than other factors. For this report, downward trends were indicated for many constituents at each station during 2006–2010 compared to 2002–2005 (fig. 4; table 9). The trends for mean streamflow for 2006–2010 compared to 2002–2005 are upward at all sites except for the South Platte River at Henderson, indicating that dilution by larger streamflows could be a factor in the downward concentration trends (fig. 4). At Union, downward trends were indicated for hardness, dissolved ammonia, dissolved orthophosphate, and dissolved copper. Upward trends in properties and constituents at Union were indicated for pH. At Denver, downward trends were indicated for total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved organic carbon, and dissolved lead, manganese, and zinc, and total recoverable zinc. An upward trend in properties and constituents at Denver was indicated for pH. At Toll Gate, downward trends were indicated for residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved orthophosphate, total phosphorus, and total recoverable copper, lead, manganese, and zinc. Upward trends in properties and constituents at Toll Gate were indicated for pH, specific conductance, and dissolved nitrite plus nitrate. At Sand Creek, downward trends were indicated for hardness, dissolved calcium, total ammonia plus organic nitrogen, dissolved ammonia, orthophosphate, manganese, and zinc. An upward trend in properties and constituents at Sand Creek was indicated for pH. Downward trends at Henderson were indicated for specific conductance, hardness, dissolved magnesium, dissolved residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved lead and manganese, and total recoverable copper, lead, manganese, and zinc.

In general, the quality of stormwater (2006–2010) has improved for many water-quality constituents, which had lower values and concentrations than those in stormwater collected in 2002–2005. However, the physical basis, processes, and the role of dilution that account for these changes are complex and are beyond the scope of this report.

Summary

The quality of stormwater runoff is of interest to many management and regulatory agencies as well as scientists, recreational stream users, and the general public. In response to this interest, the U.S. Geological Survey, in cooperation with the Urban Drainage and Flood Control District, systematically collected stormwater samples from a network of five monitoring stations in

and around metropolitan Denver, Colorado. This report describes the quality of stormwater sampled from October 1, 2006, to December 31, 2010. The network includes three stations: South Platte River below Union Avenue at Englewood, South Platte River at Denver, and South Platte River at Henderson, known as Union, Denver, and Henderson. The stations on the South Platte River receive streamflow from several tributaries, and the South Platte River is sometimes referred to as a “receiving stream.” The network also includes stations on two tributary streams: Sand Creek, which is tributary to the South Platte River, and Toll Gate Creek, which is tributary to Sand Creek. Sampling was accomplished by using refrigerated automatic pumping samplers that were used to collect composite stormwater samples. About 200 time-weighted composite stormwater samples were collected by compositing individual aliquots of stormwater that were obtained at fixed-time increments typically during 12-hour intervals; bacteriological samples were collected manually from streams during some storms.

Stormwater samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory during 2006–2010 for water-quality properties pH, specific conductance, hardness, and residue on evaporation at 105 degrees Celsius; for major ions (calcium, magnesium) and organic carbon; for nutrients such as ammonia plus organic nitrogen, ammonia, dissolved nitrite plus nitrate, orthophosphate, and total phosphorus; and for metals, including total recoverable and dissolved phases of copper, lead, manganese, and zinc. Samples analyzed for bacteriological indicators including *Escherichia coli* and fecal coliform were collected during selected storms and were analyzed at the Metro Wastewater Reclamation Laboratory.

Quality-control samples were collected and the analyses of blank sample results indicated no substantial contribution to concentrations from ambient field conditions or sampling equipment. For the 151 duplicate analyses, the median RPD was 1.9 percent, and RPDs ranged from 0 to 115 percent. For the 151 duplicate analyses, the 90th-percentile RPDs ranged from 0.4 to 45 percent. Among those results dissolved copper, lead, and manganese, accounted for the largest RPDs (90th percentile RPDs ranged from 34 to 45 percent). Excluding these dissolved metals, the range of 90th percentile values in table was 0.4 to 20 percent. The RPD results indicate generally satisfactory reproducibility for the majority water-quality analysis types. For the dissolved phase of the metals copper, lead, and manganese, reproducibility was only fair.

The results from laboratory analyses indicate, in general, and particularly for nutrients, that some values and concentrations for water-quality constituents increase with contributing drainage area in the South Platte River. No well-defined relation was identified between concentration and the amount of urban land cover identified using the U.S. Geological Survey National Land Cover data. For example, the mean concentration for ammonia plus organic nitrogen is 1.4 mg/L at the South Platte River below Union Avenue station, 1.8 mg/L at South Platte River at Denver station, and 2.9 mg/L at South Platte River at Henderson station. This pattern correlates with the size of the local contributing drainage area, which also increases downstream. Sand Creek, a tributary that flows into the South Platte River between the South Platte River at Denver and South Platte River at Henderson stations, has Toll Gate Creek above 6th Avenue at Aurora station as tributary. Some values and concentrations of results also increase in a downstream direction from the Toll Gate above 6th Avenue at Aurora station to the Sand Creek at mouth near Commerce City station. For some water-quality constituents, concentrations measured in the tributary streams (Toll Gate above 6th Avenue at Aurora and Sand Creek at mouth near Commerce City) are higher than concentrations measured in the upstream reach of the South Platte River (South Platte River below Union Avenue).

A summary of results from 2006–2010 stormwater samples that did not meet (exceeded) CDPHE water-quality standards is presented in this report for individual stations. The results indicate few exceptions to standards except for dissolved manganese and zinc and *Escherichia coli*. Stormwater collected at South Platte River below Union Avenue had about 10 percent acute or chronic dissolved manganese exceedances in samples; samples collected at South Platte River at Denver had less than 5 percent acute or chronic dissolved manganese exceedances. In contrast, samples collected at Toll Gate above 6th Avenue at Aurora, Sand Creek at mouth near Commerce City, and South Platte River at Henderson, each had about 30 to 50 percent exceedances of both acute and chronic dissolved manganese standards. Of the samples collected at Sand Creek at mouth near Commerce City, 1 sample exceeded the acute standard and 4 samples exceeded the chronic standard for dissolved zinc, but no samples collected from the other sites exceeded either standard for zinc. Almost all samples of stormwater analyzed for *Escherichia coli* exceeded the Colorado numeric standards. A numerical standard for fecal coliform is no longer applicable as of 2004.

The Mann-Whitney nonparametric rank sum statistical test was used to determine if the distribution of concentrations and values from 2006–2010 was different from the distributions determined for 2002–2005. A probability value (p-value) less than or equal to 0.10 was the criteria used to determine if an apparent trend was statistically significant.

Results from the 2002–2005 study indicated that the general quality of stormwater had improved during 2002–2005 compared to 1998–2001, having fewer exceedances of Colorado standards, and showing downward trends for many water-quality values and concentrations. These trends coincided with general downward or relatively similar mean streamflows for the 2002–2005 compared to 1998–2001, which indicates that dilution may be a smaller influence on values and concentrations than other factors. For this report, downward trends were indicated for many constituents at each station during 2006–2010 compared to 2002–2005. The trends for mean streamflow for 2006–2010 compared to 2002–2005 are upward at all stations except for South Platte River at Henderson, indicating that dilution by larger flows could be a factor in the downward concentration trends. At South Platte River below Union Avenue, downward trends were indicated for hardness, dissolved ammonia, dissolved orthophosphate, and dissolved copper. Upward trends in properties and constituents at South Platte River below Union Avenue were indicated for pH. At South Platte River at Denver, downward trends were indicated for total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved organic carbon, and dissolved lead, manganese, and zinc, and total recoverable zinc. An upward trend in properties and constituents at South Platte River at Denver was indicated for pH. At Toll Gate above 6th Avenue at Aurora, downward trends were indicated for residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved orthophosphate, total phosphorus, and total recoverable copper, lead, manganese, and zinc. Upward trends properties and constituents at Toll Gate above 6th Avenue at Aurora were indicated for pH, specific conductance, and dissolved nitrite plus nitrate. At Sand Creek at mouth near Commerce City, downward trends were indicated for hardness, dissolved calcium, total ammonia plus organic nitrogen, and dissolved ammonia, orthophosphate, manganese, and zinc. Upward trends for properties and constituents at Sand Creek at mouth near Commerce City was indicated for pH. Downward trends at South Platte River at Henderson were indicated for specific conductance, hardness, dissolved magnesium, residue on evaporation, total ammonia plus organic nitrogen, dissolved ammonia, dissolved nitrite plus nitrate, dissolved orthophosphate, total phosphorus, dissolved lead and manganese, and total recoverable copper, lead, manganese, and zinc.

In general, the quality of stormwater (2006–2010) has improved for many water-quality constituents, which had lower values and concentrations than those in stormwater collected in 2002–2005. However, the physical basis, processes, and the role of dilution that account for these changes are complex beyond the scope of this report.

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Appendix

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood, 2006–2010.

[$\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25 degrees Celsius; mL, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed; multiple censoring level statistics uses log-probability regression on values greater than the censoring level to predict statistics that are affected by the censoring level (mean, standard deviation, and 25th percentile; conventional univariate statistics are used when no censored values are used; multiple detection limit techniques are used when censored values are part of the data for a particular value or concentration]

06710247 South Platte River below Union Avenue near Englewood, Colorado, 2006										
Property or constituent	Multiple censoring level statistics						n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%	Minimum			Maximum	
pH, standard units	7.8	0.2	7.6	7.8	7.8	10	0	7.6	8.4	
Specific conductance, μS/cm at 25°C	531	214	373	429	645	10	0	356	993	
Hardness, total, mg/L as CaCO ₃	159	42	124	141	186	10	0	121	247	
Calcium, mg/L	47.4	11.3	38.1	43.2	55.9	10	0	37.1	72.2	
Magnesium, mg/L	9.71	3.32	7.11	7.94	11.6	10	0	6.84	16.1	
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	199	190	60	178	296	10	0	16	645	
Nitrogen, total, ammonia plus organic as N, mg/L	1.38	1.02	0.73	1.10	1.40	10	0	0.50	4.00	
Nitrogen, dissolved, ammonia as N, mg/L	0.073	0.042	0.042	0.056	0.12	10	0	0.013	0.138	
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.758	0.507	0.39	0.6	0.94	10	0	0.17	1.71	
Orthophosphate, dissolved as P, mg/L	0.054	0.029	0.031	0.053	0.065	10	0	0.024	0.123	
Phosphorus, total as P, mg/L	0.326	0.246	0.140	0.300	0.400	10	0	0.080	0.930	
Carbon, dissolved, organic as C, mg/L	6.8	3.0	4.3	7.0	8.7	10	0	2.9	13.2	
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	9,400	--	
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	12,000	--	
Copper, dissolved, μg/L	2.06	0.57	1.70	2.30	2.50	0	0	1.10	2.80	
Copper, total recoverable, μg/L	10.8	8.9	4.6	9.7	12.9	10	0	3.3	33.5	
Lead, dissolved, μg/L	0.06	0.02	0.04	0.06	0.07	10	2	0.04	0.10	
Lead, total recoverable, μg/L	7.0	7.2	2.2	6.2	8.1	10	0	1.0	25.7	
Manganese, dissolved, μg/L	21.7	25.0	6.4	11.0	29.8	10	0	2.6	81.2	
Manganese, total recoverable, μg/L	286	204	183	257	307	10	0	42.2	806	
Zinc, dissolved, μg/L	5.6	2.0	4.3	5.9	7.3	10	0	1.9	8.2	
Zinc, total recoverable, μg/L	37	37	11	30	42	10	0	7	134	

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25 degrees Celsius; mL, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed; multiple censoring level statistics uses log-probability regression on values greater than the censoring level to predict statistics that are affected by the censoring level (mean, standard deviation, and 25th percentile; conventional univariate statistics are used when no censored values are used; multiple detection limit techniques are used when censored values are part of the data for a particular value or concentration]

Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.8	0.1	7.8	7.8	7.9	6	0	7.6	7.9
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	335	103	288	301	311	6	0	268	545
Hardness, total, mg/L as CaCO_3	103	27	89	93	106	6	0	82	156
Calcium, mg/L	30.2	7.3	25.7	27.6	32.2	6	0	24.3	44.3
Magnesium, mg/L	6.65	2.21	5.60	6.00	6.18	6	0	5.06	11.1
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	196	190	58	118	330	6	0	34	520
Nitrogen, total, ammonia plus organic as N, mg/L	1.3	0.7	0.67	1.25	2	6	0	0.46	2.20
Nitrogen, dissolved, ammonia as N, mg/L	0.065	0.027	0.039	0.067	0.076	6	1	0.039	0.108
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.521	0.215	0.38	0.46	0.58	6	0	0.33	0.92
Orthophosphate, dissolved as P, mg/L	0.059	0.045	0.017	0.050	0.113	6	0	0.010	0.114
Phosphorus, total as P, mg/L	0.428	0.318	0.130	0.395	0.740	6	0	0.070	0.840
Carbon, dissolved, organic as C, mg/L	9.0	5.3	5.7	6.5	11.7	6	0	4.9	18.6
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	1,100	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	1,700	--
Copper, dissolved, $\mu\text{g}/\text{L}$	2.15	1.21	1.60	1.75	1.80	6	0	1.40	4.60
Copper, total recoverable, $\mu\text{g}/\text{L}$	13.1	9.7	5.1	10.5	23.7	6	0	2.9	25.8
Lead, dissolved, $\mu\text{g}/\text{L}$	0.072	0.095	0.014	0.043	0.07	6	3	0.06	0.26
Lead, total recoverable, $\mu\text{g}/\text{L}$	11.2	9.3	4.0	8.3	22.4	6	0	1.6	22.7
Manganese, dissolved, $\mu\text{g}/\text{L}$	25.9	35.6	11.0	11.7	18.1	6	0	4.8	98.0
Manganese, total recoverable, $\mu\text{g}/\text{L}$	301	199	89	298	522	6	0	72	529
Zinc, dissolved, $\mu\text{g}/\text{L}$	4.0	1.9	2.8	3.5	3.8	6	0	2.8	7.8
Zinc, total recoverable, $\mu\text{g}/\text{L}$	44	31	21	34	79	6	0	13	87

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25 degrees Celsius; mL, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed; multiple censoring level statistics uses log-probability regression on values greater than the censoring level to predict statistics that are affected by the censoring level (mean, standard deviation, and 25th percentile; conventional univariate statistics are used when no censored values are used; multiple detection limit techniques are used when censored values are part of the data for a particular value or concentration]

06710247 South Platte River below Union Avenue near Englewood, Colorado, 2008									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.8	0.1	7.8	7.8	7.9	3	0	7.8	7.9
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	424	77	360	403	510	3	0	360	510
Hardness, total, mg/L as CaCO_3	129	26	107	121	158	3	0	107	158
Calcium, mg/L	38.0	6.8	31.9	36.8	45.4	3	0	31.9	45.4
Magnesium, mg/L	8.13	2.31	6.56	7.05	10.8	3	0	6.56	10.8
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	201	108	77	248	277	3	0	77	277
Nitrogen, total, ammonia plus organic as N, mg/L	1.41	0.54	0.83	1.5	1.9	3	0	0.83	1.90
Nitrogen, dissolved, ammonia as N, mg/L	0.095	0.096	0.024	0.057	0.205	3	0	0.024	0.205
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.9	0.213	0.66	0.97	1.07	3	0	0.66	1.07
Orthophosphate, dissolved as P, mg/L	0.049	0.016	0.037	0.044	0.068	3	0	0.037	0.068
Phosphorus, total as P, mg/L	0.326	0.153	0.150	0.410	0.420	3	0	0.150	0.420
Carbon, dissolved, organic as C, mg/L	7.4	2.7	4.6	7.8	9.9	3	0	4.6	9.9
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	11,000	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	11,000	--
Copper, dissolved, $\mu\text{g}/\text{L}$	1.83	0.40	1.40	1.90	2.20	3	0	1.40	2.20
Copper, total recoverable, $\mu\text{g}/\text{L}$	10.6	5.1	4.8	13.0	14.1	3	0	4.8	14.1
Lead, dissolved, $\mu\text{g}/\text{L}$	Fewer than 3 uncensored values					3	1	0.05	0.07
Lead, total recoverable, $\mu\text{g}/\text{L}$	6.9	3.9	2.4	8.6	9.7	3	0	2.4	9.7
Manganese, dissolved, $\mu\text{g}/\text{L}$	4.6	3.7	1.5	3.7	8.7	3	0	1.5	8.7
Manganese, total recoverable, $\mu\text{g}/\text{L}$	312	141	156	351	429	3	0	156	429
Zinc, dissolved, $\mu\text{g}/\text{L}$	3.4	1.3	2.6	2.7	4.9	3	0	2.6	4.9
Zinc, total recoverable, $\mu\text{g}/\text{L}$	36.3	21.2	12.7	42.5	53.8	3	0	12.7	53.8

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25 degrees Celsius; mL, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed; multiple censoring level statistics uses log-probability regression on values greater than the censoring level to predict statistics that are affected by the censoring level (mean, standard deviation, and 25th percentile; conventional univariate statistics are used when no censored values are used; multiple detection limit techniques are used when censored values are part of the data for a particular value or concentration]

06710247 South Platte River below Union Avenue near Englewood, Colorado, 2009									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.2	7.5	7.7	7.8	8	0	7.4	7.9
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	484	142	350	462	620	8	0	331	680
Hardness, total, mg/L as CaCO_3	139	24	113	141	164	8	0	111	167
Calcium, mg/L	40.3	6.3	33.8	40.4	46.2	8	0	33.3	48.6
Magnesium, mg/L	9.23	2.32	7.14	9.66	10.45	8	0	6.22	13.2
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	260	168	101	299	408	8	0	27	440
Nitrogen, total, ammonia plus organic as N, mg/L	1.35	0.65	0.72	1.5	1.75	8	0	0.5	2.40
Nitrogen, dissolved, ammonia as N, mg/L	0.086	0.088	0.023	0.048	0.144	8	1	0.018	0.252
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.742	0.367	0.44	0.595	1.105	8	0	0.38	1.28
Orthophosphate, dissolved as P, mg/L	0.068	0.044	0.029	0.054	0.116	8	0	0.022	0.127
Phosphorus, total as P, mg/L	0.371	0.182	0.195	0.440	0.509	8	0	0.100	0.580
Carbon, dissolved, organic as C, mg/L	5.8	1.9	4.2	5.3	7.4	8	0	3.7	8.8
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, $\mu\text{g}/\text{L}$	1.90	0.50	1.60	1.75	2.35	8	0	1.20	2.60
Copper, total recoverable, $\mu\text{g}/\text{L}$	8.97	4.7	5.75	7.45	13.15	8	0	3.2	16
Lead, dissolved, $\mu\text{g}/\text{L}$	0.06	0.06	0.04	0.05	0.06	8	0	0.03	0.20
Lead, total recoverable, $\mu\text{g}/\text{L}$	6.3	4.7	3.1	4.1	10.7	8	0	1.1	13.2
Manganese, dissolved, $\mu\text{g}/\text{L}$	29.9	37.0	12.5	21.3	26.3	8	0	0.2	119
Manganese, total recoverable, $\mu\text{g}/\text{L}$	238	180	101	142	379	8	0	90	567
Zinc, dissolved, $\mu\text{g}/\text{L}$	4.7	2.0	2.8	5.0	6.6	8	0	2.2	6.9
Zinc, total recoverable, $\mu\text{g}/\text{L}$	32	17	22	28	45	8	0	7	56

Table A1. Statistics for concentrations and measurement values at South Platte River below Union Avenue at Englewood, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$ at 25°C , microsiemens per centimeter at 25 degrees Celsius; mL, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed; multiple censoring level statistics uses log-probability regression on values greater than the censoring level to predict statistics that are affected by the censoring level (mean, standard deviation, and 25th percentile; conventional univariate statistics are used when no censored values are used; multiple detection limit techniques are used when censored values are part of the data for a particular value or concentration]

06710247 South Platte River below Union Avenue near Englewood, Colorado, 2010									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.2	7.6	7.6	7.7	11	0	6.9	7.8
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	558	282	330	419	923	11	0	226	955
Hardness, total, mg/L as CaCO_3	166	63	120	135	223	11	0	97	290
Calcium, mg/L	48.6	17.4	36.2	41.0	63.2	11	0	29.5	83.8
Magnesium, mg/L	10.81	4.72	7.15	8.68	15.8	11	0	5.71	19.6
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	250	219	110	220	284	11	1	46	670
Nitrogen, total, ammonia plus organic as N, mg/L	1.52	0.6	1.1	1.4	1.7	11	0	0.83	2.80
Nitrogen, dissolved, ammonia as N, mg/L	0.02	0.018	0.006	0.012	0.031	11	4	0.012	0.058
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.063	0.829	0.5	0.59	1.37	11	0	0.41	2.71
Orthophosphate, dissolved as P, mg/L	0.058	0.080	0.010	0.022	0.053	11	0	0.004	0.237
Phosphorus, total as P, mg/L	0.426	0.262	0.240	0.350	0.430	11	0	0.210	0.980
Carbon, dissolved, organic as C, mg/L	5.8	1.0	4.8	5.5	6.5	11	0	4.4	7.7
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	20	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	20	--
Copper, dissolved, $\mu\text{g}/\text{L}$	2.44	0.85	1.70	2.60	2.90	11	0	1.40	4.00
Copper, total recoverable, $\mu\text{g}/\text{L}$	13.7	9.3	7.4	12.2	14.4	9	0	3.1	30.4
Lead, dissolved, $\mu\text{g}/\text{L}$	0.10	0.07	0.06	0.06	0.14	11	0	0.03	0.27
Lead, total recoverable, $\mu\text{g}/\text{L}$	9.9	8.5	4.6	8.2	10.8	9	0	0.6	26.9
Manganese, dissolved, $\mu\text{g}/\text{L}$	10.5	8.7	2.5	7.6	16.9	11	0	0.5	28.4
Manganese, total recoverable, $\mu\text{g}/\text{L}$	364	273	176	267	430	9	0	91	884
Zinc, dissolved, $\mu\text{g}/\text{L}$	6.86	4.37	2.6	5.3	9.7	11	0	1.8	13.6
Zinc, total recoverable, $\mu\text{g}/\text{L}$	49.1	32.0	29.3	39.1	59.8	9	0	10.6	108

Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06714000 South Platte River at Denver, Colorado, 2006									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.2	7.5	7.7	7.7	6	0	7.3	7.9
Specific conductance, µS/cm at 25°C	408	42	375	416	439	4	0	349	447
Hardness, total, mg/L as CaCO ₃	141	38	121	129	159	6	0	99.3	209
Calcium, mg/L	42.4	9.9	37.2	39.6	48.5	6	0	30.6	59
Magnesium, mg/L	8.51	3.34	6.89	7.25	9.24	6	0	5.57	14.9
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	189	50	166	186	220	6	0	115	260
Nitrogen, total, ammonia plus organic as N, mg/L	1.9	1.0	1.3	1.5	2.0	6	0	1.1	3.9
Nitrogen, dissolved, ammonia as N, mg/L	0.192	0.200	0.095	0.119	0.131	6	0	0.087	0.600
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.56	1.07	0.91	1.21	1.49	6	0	0.83	3.69
Orthophosphate, dissolved as P, mg/L	0.179	0.089	0.121	0.147	0.197	6	0	0.110	0.349
Phosphorus, total as P, mg/L	0.57	0.26	0.39	0.51	0.62	6	0	0.35	1.07
Carbon, dissolved, organic as C, mg/L	6.38	2.74	5	5.7	6	6	0	4.1	11.8
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	7,900	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	7,900	--
Copper, dissolved, µg/L	2.2	0.5	1.8	2.1	2.5	6	0	1.5	3.2
Copper, total recoverable, µg/L	16.6	6.3	12.0	16.4	18.2	6	0	9.0	27.3
Lead, dissolved, µg/L	0.10	0.07	0.06	0.08	0.13	6	0	0.04	0.24
Lead, total recoverable, µg/L	12.2	4.3	8.2	13.4	15.4	6	0	6.0	17.0
Manganese, dissolved, µg/L	27.7	62.9	1.4	2.1	3.5	6	0	1.1	156.0
Manganese, total recoverable, µg/L	337	93	272	297	412	6	0	254	487
Zinc, dissolved, µg/L	7.9	6.6	4.9	5.6	6.3	6	0	3.7	21.1
Zinc, total recoverable, µg/L	64	32	40	63	68	6	0	30	121

Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06714000 South Platte River at Denver, Colorado, 2007									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.7	0.2	7.5	7.7	7.8	6	0	7.5	8.0
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	410	99	367	384	429	5	0	303	568
Hardness, total, mg/L as CaCO_3	108.9	24.9	89.2	110	126	6	0	74.4	144
Calcium, mg/L	32.6	7.2	26.9	33.4	37.6	6	0	22.2	42.2
Magnesium, mg/L	6.71	1.76	5.35	6.54	7.81	6	0	4.59	9.49
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	231	140	156	205	355	6	0	39	428
Nitrogen, total, ammonia plus organic as N, mg/L	1.45	0.61	1.3	1.4	1.7	6	0	0.51	2.4
Nitrogen, dissolved, ammonia as N, mg/L	0.106	0.091	0.024	0.089	0.186	6	0	0.014	0.234
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.94	0.29	0.73	0.80	1.21	6	0	0.69	1.39
Orthophosphate, dissolved as P, mg/L	0.106	0.028	0.074	0.106	0.133	6	0	0.073	0.142
Phosphorus, total as P, mg/L	0.472	0.216	0.39	0.445	0.65	6	0	0.14	0.76
Carbon, dissolved, organic as C, mg/L	7.08	2.07	5.3	6.9	7.6	6	0	5.2	10.6
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	4,600	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	11,000	--
Copper, dissolved, $\mu\text{g}/\text{L}$	3.5	2.3	1.8	2.4	5.9	6	0	1.7	7.0
Copper, total recoverable, $\mu\text{g}/\text{L}$	17.2	9.5	12.3	16.3	22.6	6	0	3.8	32.0
Lead, dissolved, $\mu\text{g}/\text{L}$	0.13	0.06	0.08	0.10	0.20	6	0	0.07	0.20
Lead, total recoverable, $\mu\text{g}/\text{L}$	16.7	10.4	9.7	16.4	22.6	6	0	2.4	32.5
Manganese, dissolved, $\mu\text{g}/\text{L}$	8.8	3.6	7.0	8.1	10.9	6	0	4.3	14.7
Manganese, total recoverable, $\mu\text{g}/\text{L}$	257	112	215	253	335	6	0	78	406
Zinc, dissolved, $\mu\text{g}/\text{L}$	7.5	3.2	4.8	6.8	10.4	6	0	4.6	11.9
Zinc, total recoverable, $\mu\text{g}/\text{L}$	69.7	41.8	41.6	68.5	92.3	6	0	13	134

Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06714000 South Platte River at Denver, Colorado, 2008									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.3	7.4	7.6	7.8	4	0	7.2	7.8
Specific conductance, µS/cm at 25°C	377	112	291	363	462	4	0	260	520
Hardness, total, mg/L as CaCO ₃	104	29	83	96	125	4	0	78.4	146
Calcium, mg/L	31.4	8.1	25.6	29.2	37.2	4	0	24.4	42.8
Magnesium, mg/L	6.26	2.25	4.77	5.66	7.75	4	0	4.26	9.47
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	267	199	105	242	428	4	0	74	510
Nitrogen, total, ammonia plus organic as N, mg/L	2.5	1.6	1.2	2.4	3.8	4	0	1.0	4.2
Nitrogen, dissolved, ammonia as N, mg/L	0.266	0.190	0.104	0.261	0.429	4	0	0.082	0.463
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.37	0.43	1.00	1.36	1.74	4	0	0.97	1.78
Orthophosphate, dissolved as P, mg/L	0.183	0.046	0.143	0.184	0.223	4	0	0.140	0.223
Phosphorus, total as P, mg/L	0.74	0.46	0.38	0.64	1.11	4	0	0.36	1.33
Carbon, dissolved, organic as C, mg/L	7.1	1.8	5.7	6.9	8.6	4	0	5.6	9.1
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	23,000	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	23,000	--
Copper, dissolved, µg/L	2.0	0.6	1.5	1.9	2.4	4	1	1.7	2.7
Copper, total recoverable, µg/L	28.8	26.9	9.9	20.4	47.7	4	0	7.5	67.0
Lead, dissolved, µg/L	0.12	0.04	0.09	0.11	0.14	4	0	0.07	0.17
Lead, total recoverable, µg/L	30.2	34.2	7.4	18.7	53.0	4	0	4.0	79.5
Manganese, dissolved, µg/L	4.1	4.9	0.9	2.5	7.3	4	0	0.1	11.2
Manganese, total recoverable, µg/L	509	340	221	493	795	4	0	174	873
Zinc, dissolved, µg/L	6.6	2.0	5.4	7.4	7.9	4	0	3.7	8.1
Zinc, total recoverable, µg/L	128	118	40	99	216	4	0	25	287

Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

Property or constituent	06714000 South Platte River at Denver, Colorado, 2009								
	Multiple censoring level statistics						Range of uncensored values		
	Mean	SD	25%	Median 50%	75%	n	nlt	Minimum	Maximum
pH, standard units	7.5	0.3	7.5	7.5	7.8	6	0	6.6	8.0
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	509	140	394	524	620	16	0	295	721
Hardness, total, mg/L as CaCO_3	140	45	101	138	165	16	0	85.6	225
Calcium, mg/L	42.4	13.8	29.6	42	50.2	16	0	26.7	67.5
Magnesium, mg/L	8.43	2.77	6.08	8.2	10.0	16	0	4.61	13.7
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	150	83	83	158	204	16	1	20.0	300
Nitrogen, total, ammonia plus organic as N, mg/L	1.4	0.53	0.84	1.5	1.9	15	0	0.81	2.3
Nitrogen, dissolved, ammonia as N, mg/L	0.076	0.089	0.021	0.034	0.123	15	2	0.010	0.300
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.94	0.42	0.67	0.80	0.99	15	0	0.55	1.94
Orthophosphate, dissolved as P, mg/L	0.152	0.079	0.103	0.12	0.168	15	0	0.068	0.368
Phosphorus, total as P, mg/L	0.46	0.15	0.32	0.47	0.61	15	0	0.22	0.67
Carbon, dissolved, organic as C, mg/L	6.0	2.2	4.6	5.3	6.3	16	0	4.3	12.2
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, $\mu\text{g}/\text{L}$	2.7	0.9	2.2	2.4	2.9	16	0	1.5	4.8
Copper, total recoverable, $\mu\text{g}/\text{L}$	13.6	6.8	7.8	13.6	19.0	16	0	4.2	26.9
Lead, dissolved, $\mu\text{g}/\text{L}$	0.11	0.08	0.06	0.09	0.11	16	0	0.04	0.31
Lead, total recoverable, $\mu\text{g}/\text{L}$	12.2	8.4	6.0	9.7	17.8	16	0	2.1	31.0
Manganese, dissolved, $\mu\text{g}/\text{L}$	6.8	7.9	0.7	2.5	12.4	16	0	0.2	23.1
Manganese, total recoverable, $\mu\text{g}/\text{L}$	272	122	168	258	348	16	0	111	490
Zinc, dissolved, $\mu\text{g}/\text{L}$	7.9	3.8	4.9	6.8	10.6	16	0	3.3	15.8
Zinc, total recoverable, $\mu\text{g}/\text{L}$	57	32	28	55	88	16	0	15	112

Table A2. Statistics for concentrations and measurement values at South Platte River at Denver by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

Property or constituent	06714000 South Platte River at Denver, Colorado, 2010								
	Multiple censoring level statistics						Range of uncensored values		
	Mean	SD	25%	Median 50%	75%	n	nlt	Minimum	Maximum
pH, standard units	7.5	0.3	7.4	7.5	7.6	16	0	7.0	8.0
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	627	308	409	537	613	17	0	294	1,390
Hardness, total, mg/L as CaCO_3	163	40	138	156	176	16	0	110	251
Calcium, mg/L	48.2	10.7	42	47	53.1	16	0	34.2	75.9
Magnesium, mg/L	10.2	3.49	7.97	9.53	10.8	16	0	6.00	17.7
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	230	146	138	197	301	16	0	50	660
Nitrogen, total, ammonia plus organic as N, mg/L	2.0	0.71	1.4	1.9	2.4	16	0	0.82	3.2
Nitrogen, dissolved, ammonia as N, mg/L	0.095	0.111	0.029	0.044	0.117	16	2	0.024	0.395
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.415	0.712	0.93	1.27	1.5	15	0	0.71	3.44
Orthophosphate, dissolved as P, mg/L	0.149	0.113	0.084	0.109	0.166	16	0	0.046	0.487
Phosphorus, total as P, mg/L	0.56	0.22	0.40	0.53	0.71	16	0	0.19	1.04
Carbon, dissolved, organic as C, mg/L	6.2	1.6	5.0	6.1	7.2	16	0	4.1	9.8
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	110	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	170	--
Copper, dissolved, $\mu\text{g}/\text{L}$	3.3	1.1	2.4	3.1	3.7	16	0	2.0	6.2
Copper, total recoverable, $\mu\text{g}/\text{L}$	17.4	10.6	10.5	15.1	21.2	13	0	5.2	41.8
Lead, dissolved, $\mu\text{g}/\text{L}$	0.13	0.05	0.08	0.12	0.16	16	0	0.06	0.23
Lead, total recoverable, $\mu\text{g}/\text{L}$	15.0	12.9	6.7	11.3	16.5	13	0	2.1	50.2
Manganese, dissolved, $\mu\text{g}/\text{L}$	10.0	22.1	1.0	3.1	6.8	16	0	0.6	90.1
Manganese, total recoverable, $\mu\text{g}/\text{L}$	391	211	244	319	608	13	0	97	741
Zinc, dissolved, $\mu\text{g}/\text{L}$	9.5	5.2	5.4	8.6	13.3	16	0	3.4	21.3
Zinc, total recoverable, $\mu\text{g}/\text{L}$	76	49	35	70	89	13	0	22	183

Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010.

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394329104490101 Toll Gate Creek above 6th Avenue at Aurora, Colorado, 2006										
Property or constituent	Multiple censoring level statistics						n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%	Minimum			Maximum	
pH, standard units	7.6	0.1	7.5	7.6	7.8	7	0	7.5	7.8	
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	1,090	579	643	780	1,950	7	0	587	2,210	
Hardness, total, mg/L as CaCO_3	298	182	162	209	539	7	0	156	583	
Calcium, mg/L	90	52	51	64	159	7	0	49	172	
Magnesium, mg/L	17.8	12.5	8.67	12.1	34.4	7	0	8.24	37.4	
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	215	260	40	105	323	6	0	21	695	
Nitrogen, total, ammonia plus organic as N, mg/L	1.64	0.69	1.10	1.30	2.30	7	0	1.00	2.80	
Nitrogen, dissolved, ammonia as N, mg/L	0.087	0.088	0.011	0.059	0.166	7	0	0.009	0.230	
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.584	0.205	0.450	0.520	0.700	7	0	0.420	1.000	
Orthophosphate, dissolved as P, mg/L	0.018	0.018	0.005	0.007	0.034	7	0	0.004	0.052	
Phosphorus, total as P, mg/L	0.323	0.292	0.120	0.210	0.520	7	0	0.070	0.900	
Carbon, dissolved, organic as C, mg/L	12.9	3.8	11.1	11.9	14.3	7	0	8.6	20.7	
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	3,300	--	
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	3,300	--	
Copper, dissolved, $\mu\text{g}/\text{L}$	3.5	1.3	2.2	3.5	4.9	7	0	1.9	4.9	
Copper, total recoverable, $\mu\text{g}/\text{L}$	12.6	9.3	7.0	8.3	16.8	7	0	6.9	32.0	
Lead, dissolved, $\mu\text{g}/\text{L}$	0.127	0.105	0.04	0.12	0.18	7	1	0.04	0.31	
Lead, total recoverable, $\mu\text{g}/\text{L}$	5.60	5.93	1.83	2.98	9.18	7	0	1.52	17.7	
Manganese, dissolved, $\mu\text{g}/\text{L}$	93.7	147	5.0	11.7	286	7	0	4.7	330	
Manganese, total recoverable, $\mu\text{g}/\text{L}$	367	229	184	365	583	7	0	128	751	
Zinc, dissolved, $\mu\text{g}/\text{L}$	12.4	9.6	4.1	11.7	23.0	7	0	1.8	26.1	
Zinc, total recoverable, $\mu\text{g}/\text{L}$	48	26	28	40	63	7	0	26	96	

Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394329104490101 Toll Gate Creek above 6th Avenue at Aurora, Colorado, 2007									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.7	0.1	7.6	7.7	7.9	12	0	7.5	7.9
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	999	442	720	922	1,500	10	0	363	1,710
Hardness, total, mg/L as CaCO_3	301	134	221	280	406	12	0	85	525
Calcium, mg/L	91	39	68	85	123	12	0	26	158
Magnesium, mg/L	18.0	8.85	12.3	16.5	24.5	12	0	4.60	32.1
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	208	205	62	110	407	12	0	10	590
Nitrogen, total, ammonia plus organic as N, mg/L	1.73	0.91	1.04	1.40	2.60	12	0	0.74	3.20
Nitrogen, dissolved, ammonia as N, mg/L	0.126	0.093	0.054	0.103	0.184	12	1	0.037	0.299
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.616	0.136	0.490	0.625	0.725	12	0	0.410	0.820
Orthophosphate, dissolved as P, mg/L	0.03	0.026	0.009	0.02	0.05	12	1	0.003	0.077
Phosphorus, total as P, mg/L	0.460	0.421	0.120	0.290	0.700	12	0	0.070	1.38
Carbon, dissolved, organic as C, mg/L	9.5	1.7	8.6	9.1	10.8	12	0	6.1	12.7
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	2	0	330	3,300
Fecal coliform, MPN/100 mL	--	--	--	--	--	2	0	330	3,300
Copper, dissolved, $\mu\text{g}/\text{L}$	2.3	1.0	1.7	2.1	2.6	12	0	1.0	4.5
Copper, total recoverable, $\mu\text{g}/\text{L}$	14.9	11.0	6.7	10.2	25.4	12	0	3.0	32.8
Lead, dissolved, $\mu\text{g}/\text{L}$	0.11	0.08	0.07	0.09	0.12	12	1	0.06	0.34
Lead, total recoverable, $\mu\text{g}/\text{L}$	10.4	10.5	2.85	5.09	19.7	12	0	0.71	28.3
Manganese, dissolved, $\mu\text{g}/\text{L}$	69.0	55.3	29.9	49.9	112	12	0	2.8	165
Manganese, total recoverable, $\mu\text{g}/\text{L}$	432	302	202	276	715	12	0	111	940
Zinc, dissolved, $\mu\text{g}/\text{L}$	7.8	2.5	5.9	8.1	9.2	2	0	4.1	12.6
Zinc, total recoverable, $\mu\text{g}/\text{L}$	56.1	46.8	23.4	34.7	101	12	0	9.3	132

Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394329104490101 Toll Gate Creek above 6th Avenue at Aurora, Colorado, 2008									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.3	7.4	7.5	8.0	6	0	7.4	8.0
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	1,080	244	905	992	1,220	6	0	860	1,510
Hardness, total, mg/L as CaCO_3	265	98	186	228	381	6	0	172	396
Calcium, mg/L	79.6	29.2	55.6	69.5	115	6	0	51	117
Magnesium, mg/L	16.1	6.21	11.4	13.3	22.8	6	0	10.8	25.0
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	152	188	46	97	102	5	0	31	484
Nitrogen, total, ammonia plus organic as N, mg/L	1.62	1.03	0.78	1.50	1.80	6	0	0.63	3.50
Nitrogen, dissolved, ammonia as N, mg/L	0.331	0.204	0.159	0.300	0.462	6	0	0.110	0.655
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.723	0.161	0.580	0.695	0.830	6	0	0.570	0.970
Orthophosphate, dissolved as P, mg/L	0.021	0.014	0.010	0.021	0.028	6	0	0.003	0.044
Phosphorus, total as P, mg/L	0.242	0.192	0.110	0.215	0.230	6	0	0.070	0.610
Carbon, dissolved, organic as C, mg/L	11.1	6.1	6.1	9.3	15.6	6	0	5.3	20.9
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, $\mu\text{g}/\text{L}$	1.7	0.5	1.3	1.8	2.1	6	0	1.1	2.3
Copper, total recoverable, $\mu\text{g}/\text{L}$	9.2	7.2	5.0	7.3	9.7	6	0	2.9	23.1
Lead, dissolved, $\mu\text{g}/\text{L}$	0.08	0.04	0.05	0.08	0.11	6	2	0.05	0.12
Lead, total recoverable, $\mu\text{g}/\text{L}$	5.61	5.70	2.93	3.38	5.70	6	0	1.38	16.9
Manganese, dissolved, $\mu\text{g}/\text{L}$	114	45.2	91.5	113	130	6	0	50.9	187
Manganese, total recoverable, $\mu\text{g}/\text{L}$	377	371	159	242	351	6	0	149	1,120
Zinc, dissolved, $\mu\text{g}/\text{L}$	7.95	3.72	6.5	8.45	11.1	6	0	1.5	11.7
Zinc, total recoverable, $\mu\text{g}/\text{L}$	39.5	31.4	23.6	27.1	45.5	6	0	13.4	100

Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394329104490101 Toll Gate Creek above 6th Avenue at Aurora, Colorado, 2009										
Property or constituent	Multiple censoring level statistics						n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%	Minimum			Maximum	
pH, standard units	7.7	0.2	7.6	7.6	7.8	4	0	7.5	7.9	
Specific conductance, μS/cm at 25°C	798	131	695	765	900	4	0	692	970	
Hardness, total, mg/L as CaCO ₃	207	59	161	222	252	4	0	130	254	
Calcium, mg/L	63	19	49	67	78	4	0	38	79	
Magnesium, mg/L	12.1	2.87	9.86	12.6	14.4	4	0	8.52	14.9	
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	156	106	66	164	246	4	0	42	254	
Nitrogen, total, ammonia plus organic as N, mg/L	1.52	0.57	0.86	1.80	1.90	3	0	0.86	1.90	
Nitrogen, dissolved, ammonia as N, mg/L	0.085	0.085	0.010	0.067	0.177	3	0	0.010	0.177	
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.379	0.017	0.360	0.388	0.390	3	0	0.360	0.390	
Orthophosphate, dissolved as P, mg/L	0.022	0.013	0.011	0.018	0.036	3	0	0.011	0.036	
Phosphorus, total as P, mg/L	0.193	0.200	0.040	0.120	0.420	3	0	0.040	0.420	
Carbon, dissolved, organic as C, mg/L	7.2	1.5	6.0	7.0	8.4	4	0	5.6	9.0	
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--	
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--	
Copper, dissolved, μg/L	2.1	0.7	1.6	2.2	2.6	4	0	1.2	2.8	
Copper, total recoverable, μg/L	10.3	5.4	5.8	11.2	14.8	4	0	3.8	14.9	
Lead, dissolved, μg/L	0.08	0.04	0.06	0.08	0.11	4	0	0.05	0.13	
Lead, total recoverable, μg/L	6.64	4.20	3.16	7.34	10.1	4	0	1.72	10.2	
Manganese, dissolved, μg/L	49.5	22.0	32.8	53.7	66.2	4	0	20.3	70.1	
Manganese, total recoverable, μg/L	315	174	173	338	456	4	0	103	480	
Zinc, dissolved, μg/L	5.5	2.6	4.0	4.4	7.0	4	0	3.8	9.4	
Zinc, total recoverable, μg/L	41.5	26.5	19.7	43.7	63.3	4	0	10.6	68.0	

Table A3. Statistics for concentrations and measurement values at Toll Gate Creek above 6th Avenue at Aurora by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394329104490101 Toll Gate Creek above 6th Avenue at Aurora, Colorado, 2010									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.1	7.6	7.6	7.7	4	0	7.5	7.7
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	1,757	464	1,360	1,740	2,155	4	0	1,320	2,230
Hardness, total, mg/L as CaCO_3	579	178	425	576	733	4	0	418	746
Calcium, mg/L	177	53	131	177	223	4	0	129	226
Magnesium, mg/L	33.3	11.2	23.7	32.9	43.0	4	0	23.2	44.4
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	102	83	44	79	160	4	0	33	219
Nitrogen, total, ammonia plus organic as N, mg/L	1.35	0.45	1.05	1.20	1.65	4	0	0.99	2.00
Nitrogen, dissolved, ammonia as N, mg/L	Fewer than 3 uncensored values					4	2	0.040	0.047
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.868	0.343	0.585	0.805	1.150	4	0	0.580	1.280
Orthophosphate, dissolved as P, mg/L	0.009	0.002	0.008	0.009	0.010	4	0	0.007	0.010
Phosphorus, total as P, mg/L	0.208	0.131	0.125	0.160	0.290	4	0	0.110	0.400
Carbon, dissolved, organic as C, mg/L	11.5	1.9	10.5	10.6	12.5	4	0	10.4	14.4
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, $\mu\text{g}/\text{L}$	2.7	0.56	2.25	2.6	3.15	4	0	2.2	3.4
Copper, total recoverable, $\mu\text{g}/\text{L}$	7.0	3.8	4.9	5.5	9.2	4	0	4.3	12.7
Lead, dissolved, $\mu\text{g}/\text{L}$	0.06	0.01	0.06	0.06	0.07	4	0	0.05	0.08
Lead, total recoverable, $\mu\text{g}/\text{L}$	3.06	2.60	1.64	1.88	4.48	4	0	1.54	6.95
Manganese, dissolved, $\mu\text{g}/\text{L}$	29.5	17.7	19.3	22.3	39.6	4	0	17.5	55.8
Manganese, total recoverable, $\mu\text{g}/\text{L}$	326	238	201	217	450	4	0	185	682
Zinc, dissolved, $\mu\text{g}/\text{L}$	10.4	4.4	7.2	9.2	13.7	4	0	6.9	16.4
Zinc, total recoverable, $\mu\text{g}/\text{L}$	32.0	16.4	19.3	29.6	44.7	4	0	15.8	52.9

Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394839104570300 Sand Creek at mouth near Commerce City, Colorado, 2006									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.7	0.1	7.6	7.8	7.8	12	0	7.5	7.9
Specific conductance, µS/cm at 25°C	907	606	508	632	1,325	12	0	424	2,020
Hardness, total, mg/L as CaCO ₃	218	126	136	163	284	12	0	113	455
Calcium, mg/L	65.5	35.2	42.6	51.2	82.9	12	0	35.4	131
Magnesium, mg/L	13.2	9.24	7.30	8.65	18.8	12	0	6.06	30.9
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	252	199	86	190	347	12	0	56	685
Nitrogen, total, ammonia plus organic as N, mg/L	2.4	1.0	1.7	2.1	3.0	12	0	1.1	4.4
Nitrogen, dissolved, ammonia as N, mg/L	0.072	0.076	0.011	0.049	0.106	12	3	0.010	0.267
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.12	0.58	0.76	0.91	1.19	12	0	0.67	2.55
Orthophosphate, dissolved as P, mg/L	0.141	0.099	0.081	0.133	0.157	12	0	0.027	0.405
Phosphorus, total as P, mg/L	0.68	0.26	0.53	0.60	0.82	12	0	0.38	1.25
Carbon, dissolved, organic as C, mg/L	11.7	4.3	7.8	10.8	13.8	12	0	7.2	19.2
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	4,900	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	4,900	--
Copper, dissolved, µg/L	3.2	0.9	2.5	2.9	3.8	12	0	2.1	5.0
Copper, total recoverable, µg/L	17.2	9.7	9.7	13.8	22.9	12	0	8.0	39.3
Lead, dissolved, µg/L	0.19	0.09	0.13	0.16	0.26	12	0	0.07	0.34
Lead, total recoverable, µg/L	12.8	9.53	4.21	12.2	14.9	12	0	3.67	35.9
Manganese, dissolved, µg/L	53.0	100	0.8	1.3	55.7	12	0	0.5	304
Manganese, total recoverable, µg/L	478	284	287	405	602	12	0	144	1,240
Zinc, dissolved, µg/L	11.0	5.9	6.8	8.4	14.8	12	0	3.8	21.1
Zinc, total recoverable, µg/L	73.0	36.9	52.5	67.0	78.5	12	0	22.0	166

Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394839104570300 Sand Creek at mouth near Commerce City, Colorado, 2007									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.7	0.2	7.6	7.7	7.8	16	0	7.4	7.9
Specific conductance, µS/cm at 25°C	734	270	595	667	848	14	0	330	1,340
Hardness, total, mg/L as CaCO ₃	186	69.2	151	171	214	16	0	74.8	363
Calcium, mg/L	56.5	20.0	46.0	52.5	65.2	16	0	23.2	106
Magnesium, mg/L	11.0	4.69	8.69	9.75	12.8	16	0	4.09	23.7
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	304	266	123	236	374	16	0	72.0	966
Nitrogen, total, ammonia plus organic as N, mg/L	2.0	0.87	1.4	1.7	2.5	16	0	1.1	3.7
Nitrogen, dissolved, ammonia as N, mg/L	0.134	0.086	0.050	0.133	0.192	16	0	0.019	0.286
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.81	0.29	0.59	0.73	1.00	16	0	0.41	1.41
Orthophosphate, dissolved as P, mg/L	0.158	0.155	0.068	0.104	0.160	16	0	0.041	0.627
Phosphorus, total as P, mg/L	0.73	0.41	0.44	0.61	0.87	16	0	0.34	1.65
Carbon, dissolved, organic as C, mg/L	10.6	4.5	7.8	9.1	11.7	15	0	5.8	23.6
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	2	0	790	4,900
Fecal coliform, MPN/100 mL	--	--	--	--	--	2	0	790	2,200
Copper, dissolved, µg/L	2.9	1.6	1.8	2.3	3.7	6	0	1.2	6.0
Copper, total recoverable, µg/L	21.2	13.5	11.5	16.4	25.4	16	0	6.5	51.1
Lead, dissolved, µg/L	0.19	0.13	0.11	0.15	0.25	16	0	0.07	0.57
Lead, total recoverable, µg/L	18.0	14.7	6.21	11.3	22.7	16	0	4.99	50.3
Manganese, dissolved, µg/L	18.9	20.0	3.4	8.8	31.3	16	0	0.5	59.4
Manganese, total recoverable, µg/L	490	346	259	331	620	16	0	177	1,270
Zinc, dissolved, µg/L	12.5	7.2	7.9	11.3	15.4	16	0	2.8	31.1
Zinc, total recoverable, µg/L	92.6	74.0	40.7	60.3	113	16	0	30.1	252

Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394839104570300 Sand Creek at mouth near Commerce City, Colorado, 2008									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.6	0.3	7.4	7.5	7.8	10	0	7.3	8.0
Specific conductance, µS/cm at 25°C	826	206	630	800	945	10	0	575	1,140
Hardness, total, mg/L as CaCO ₃	194	37.8	167	189.5	205	10	0	143	262
Calcium, mg/L	58.3	11.1	49.7	57.8	61.2	10	0	43.6	77.6
Magnesium, mg/L	11.7	2.63	9.23	11.4	13.4	10	0	8.24	16.6
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	488	474	98	233	822	10	0	77	1,360
Nitrogen, total, ammonia plus organic as N, mg/L	3.7	3.1	1.6	1.9	6.0	8	0	1.2	9.5
Nitrogen, dissolved, ammonia as N, mg/L	0.232	0.155	0.130	0.214	0.340	8	0	0.021	0.472
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.07	0.31	0.91	0.94	1.33	8	0	0.63	1.54
Orthophosphate, dissolved as P, mg/L	0.094	0.048	0.058	0.094	0.106	8	0	0.039	0.193
Phosphorus, total as P, mg/L	1.00	0.85	0.36	0.52	1.82	8	0	0.27	2.36
Carbon, dissolved, organic as C, mg/L	11.6	4.5	9.0	11.0	12.4	10	0	6.1	21.1
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, µg/L	2.9	3.4	1.6	1.8	2.1	10	0	1.5	12.5
Copper, total recoverable, µg/L	25.0	21.1	7.9	11.5	47.2	10	0	7.2	54.8
Lead, dissolved, µg/L	0.15	0.11	0.10	0.11	0.14	10	0	0.09	0.45
Lead, total recoverable, µg/L	25.8	24.9	5.62	9.72	55.0	10	0	4.71	58.5
Manganese, dissolved, µg/L	48.0	43.8	2.8	47.8	66.1	10	0	0.9	132.0
Manganese, total recoverable, µg/L	1,200	1,190	280	416	1,970	10	0	226	3,210
Zinc, dissolved, µg/L	9.2	6.2	4.7	8.4	9.2	10	0	3.9	25.5
Zinc, total recoverable, µg/L	151	188	33.0	50.7	211	10	0	27.2	625

Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394839104570300 Sand Creek at mouth near Commerce City, Colorado, 2009									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.37	0.1	7.3	7.35	7.45	4	0	7.3	7.5
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	691	185	552	692	829	4	0	470	908
Hardness, total, mg/L as CaCO_3	188	52.2	148	192	228	4	0	123	245
Calcium, mg/L	57.0	15.6	45.2	58.3	69.0	4	0	37.7	73.9
Magnesium, mg/L	11.0	3.29	8.50	11.1	13.4	4	0	6.91	14.7
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	242	98	185	200	299	4	0	180	388
Nitrogen, total, ammonia plus organic as N, mg/L	2.3	0.48	2	2.45	2.6	4	0	1.6	2.7
Nitrogen, dissolved, ammonia as N, mg/L	Fewer than 3 uncensored values					4	2	0.090	0.123
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.52	0.16	0.44	0.46	0.61	4	0	0.42	0.76
Orthophosphate, dissolved as P, mg/L	0.059	0.043	0.024	0.054	0.094	4	0	0.017	0.112
Phosphorus, total as P, mg/L	0.61	0.15	0.50	0.66	0.72	4	0	0.39	0.74
Carbon, dissolved, organic as C, mg/L	9.7	3.7	7.3	8.5	12.2	4	0	6.7	15.1
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, $\mu\text{g}/\text{L}$	4.6	2.5	3.0	4.7	6.2	4	0	1.5	7.5
Copper, total recoverable, $\mu\text{g}/\text{L}$	18.3	4.8	14.6	19.0	22.1	4	0	12.2	23.1
Lead, dissolved, $\mu\text{g}/\text{L}$	0.46	0.23	0.31	0.46	0.61	4	0	0.18	0.74
Lead, total recoverable, $\mu\text{g}/\text{L}$	30.3	12.2	20.6	29.7	40.0	4	0	17.2	44.7
Manganese, dissolved, $\mu\text{g}/\text{L}$	134	174	35.2	67.0	233	4	0	10.6	391
Manganese, total recoverable, $\mu\text{g}/\text{L}$	466	128	368	472	565	4	0	311	609
Zinc, dissolved, $\mu\text{g}/\text{L}$	570	415	300	438	841	4	0	237	1,170
Zinc, total recoverable, $\mu\text{g}/\text{L}$	3,360	1,950	1,680	3,340	5,040	4	0	1,530	5,230

Table A4. Statistics for concentrations and measurement values at Sand Creek at mouth near Commerce City by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

394839104570300 Sand Creek at mouth near Commerce City, Colorado, 2010									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.42	0.13	7.3	7.4	7.5	5	0	7.3	7.6
Specific conductance, µS/cm at 25°C	862	507	552	686	950	5	0	423	1,700
Hardness, total, mg/L as CaCO ₃	175	47.8	155	170	190	5	0	115	245
Calcium, mg/L	53.4	13.8	48.0	52.0	57.9	5	0	35.9	73.4
Magnesium, mg/L	10.1	3.26	8.52	9.86	10.9	5	0	6.17	15.0
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	557	208	445	530	734	5	0	284	790
Nitrogen, total, ammonia plus organic as N, mg/L	3.3	0.98	2.5	3.3	4.2	5	0	2.2	4.4
Nitrogen, dissolved, ammonia as N, mg/L	Fewer than 3 uncensored values					5	3	0.011	0.018
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	0.5	0.03	0.49	0.49	0.52	5	0	0.46	0.53
Orthophosphate, dissolved as P, mg/L	0.056	0.026	0.035	0.069	0.072	5	0	0.022	0.082
Phosphorus, total as P, mg/L	1.07	0.36	0.77	1.09	1.38	5	0	0.63	1.46
Carbon, dissolved, organic as C, mg/L	8.9	3.9	6.4	8.2	8.7	5	0	5.8	15.5
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, µg/L	1.7	0.6	1.2	1.6	2.3	5	0	1.2	2.4
Copper, total recoverable, µg/L	29.3	12.4	19.2	25.4	38.9	5	0	17.3	45.6
Lead, dissolved, µg/L	0.12	0.09	0.07	0.10	0.12	5	0	0.04	0.28
Lead, total recoverable, µg/L	33.2	18.0	19.2	31.1	39.5	5	0	15.8	60.5
Manganese, dissolved, µg/L	31.86	45.22	2.7	7.8	39	5	0	1.8	108
Manganese, total recoverable, µg/L	905	332	623	988	1,080	5	0	514	1,320
Zinc, dissolved, µg/L	90.4	84.5	22.2	80.9	120	5	0	10.2	219
Zinc, total recoverable, µg/L	1,467	1,708	528	562	1,360	5	0	436	4,450

Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010.

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

Property or constituent	06720500 South Platte River at Henderson, Colorado, 2006								
	Multiple censoring level statistics						Range of uncensored values		
	Mean	SD	25%	Median 50%	75%	n	nlt	Minimum	Maximum
pH, standard units	7.5	0.2	7.3	7.5	7.6	7	0	7.1	7.7
Specific conductance, μS/cm at 25°C	524	46	495	526	540	7	0	459	608
Hardness, total, mg/L as CaCO ₃	132	9.8	126	129	140	7	0	119	149
Calcium, mg/L	39.7	3.0	37.8	38.3	42.2	7	0	36.0	44.6
Magnesium, mg/L	8.04	0.68	7.45	8.18	8.48	7	0	7.06	9.07
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	176	76	66	218	254	7	0	47	350
Nitrogen, total, ammonia plus organic as N, mg/L	2.9	0.9	2.2	2.9	3.6	7	0	1.4	4.2
Nitrogen, dissolved, ammonia as N, mg/L	0.840	0.550	0.650	0.690	1.12	7	0	0.141	1.92
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	2.58	0.70	1.85	2.38	3.24	7	0	1.75	3.49
Orthophosphate, dissolved as P, mg/L	0.510	0.232	0.346	0.407	0.767	7	0	0.326	0.909
Phosphorus, total as P, mg/L	1.03	0.26	0.9	1.04	1.22	7	0	0.57	1.43
Carbon, dissolved, organic as C, mg/L	9.0	2.6	6.2	9.2	11.9	7	0	6.2	12.5
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, μg/L	3.0	0.8	2.3	2.8	3.3	7	0	2.3	4.6
Copper, total recoverable, μg/L	21.3	10.0	13.1	22.8	28.4	7	0	9.5	37.6
Lead, dissolved, μg/L	0.26	0.06	0.20	0.28	0.33	7	0	0.18	0.34
Lead, total recoverable, μg/L	16.7	9.6	7.4	17.2	22.1	7	0	7.0	32.9
Manganese, dissolved, μg/L	51.3	26.1	20.8	56.6	76.9	7	0	17.5	79.6
Manganese, total recoverable, μg/L	350	150	220	397	412	7	0	155	600
Zinc, dissolved, μg/L	16.5	3.2	13.1	17.8	19.1	7	0	11.4	20.3
Zinc, total recoverable, μg/L	89	38	67	91	105	7	0	39	158

Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06720500 South Platte River at Henderson, Colorado, 2007									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.38	0.13	7.3	7.4	7.4	6	0	7.2	7.6
Specific conductance, µS/cm at 25°C	396	24	383	402	415	6	0	355	419
Hardness, total, mg/L as CaCO ₃	107	7.2	102	109	112	6	0	95	115
Calcium, mg/L	31.6	2.0	30.1	32.4	33.0	6	0	28.2	33.5
Magnesium, mg/L	6.82	0.55	6.55	6.79	7.27	6	0	5.99	7.53
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	154	88	98	132	156	6	0	80	324
Nitrogen, total, ammonia plus organic as N, mg/L	1.7	0.69	1.3	1.5	2.3	6	0	0.96	2.8
Nitrogen, dissolved, ammonia as N, mg/L	0.242	0.074	0.217	0.267	0.295	6	0	0.107	0.298
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.34	0.20	1.18	1.30	1.38	6	0	1.16	1.72
Orthophosphate, dissolved as P, mg/L	0.208	0.047	0.165	0.203	0.225	6	0	0.164	0.290
Phosphorus, total as P, mg/L	0.637	0.283	0.41	0.535	0.9	6	0	0.37	1.07
Carbon, dissolved, organic as C, mg/L	9.8	3.8	6.6	8.9	14.0	6	0	6.2	14.4
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	7,900	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	13,000	--
Copper, dissolved, µg/L	3.3	0.8	2.7	3.1	4.0	6	0	2.5	4.4
Copper, total recoverable, µg/L	25.1	10.7	15.8	25.6	27.4	6	0	13.0	43.2
Lead, dissolved, µg/L	0.20	0.04	0.19	0.22	0.22	6	0	0.13	0.23
Lead, total recoverable, µg/L	32.4	23.1	13.8	27.5	45.4	6	0	9.1	70.9
Manganese, dissolved, µg/L	48.8	23.8	31.0	44.1	57.9	6	0	25.9	89.9
Manganese, total recoverable, µg/L	308	142	172	291	451	6	0	149	493
Zinc, dissolved, µg/L	21.8	2.9	19.9	21.8	23.6	6	0	17.6	26.0
Zinc, total recoverable, µg/L	135	54	86	141	145	6	0	71	224

Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06720500 South Platte River at Henderson, Colorado, 2008									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.2	0.3	7.0	7.2	7.5	6	0	6.6	7.5
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	527	167	510	572	650	6	0	205	651
Hardness, total, mg/L as CaCO_3	140	13.7	128	139	151	6	0	124	159
Calcium, mg/L	41.5	3.8	39.0	41.1	43.8	6	0	36.8	47.2
Magnesium, mg/L	8.76	1.13	7.86	8.69	10.00	6	0	7.33	10.00
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	210	187	62	162	284	6	0	44	545
Nitrogen, total, ammonia plus organic as N, mg/L	4.05	2.69	2.5	3	4	6	0	2.4	9.4
Nitrogen, dissolved, ammonia as N, mg/L	1.26	1.00	0.614	0.785	1.63	6	0	0.578	3.14
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	1.99	0.54	1.68	1.83	2.18	6	0	1.46	2.98
Orthophosphate, dissolved as P, mg/L	0.671	0.246	0.445	0.652	0.911	6	0	0.374	0.993
Phosphorus, total as P, mg/L	1.39	0.75	0.92	1.10	1.53	6	0	0.86	2.85
Carbon, dissolved, organic as C, mg/L	13.9	10.4	8.1	9.4	14.6	6	0	7.6	34.4
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	23,000	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	23,000	--
Copper, dissolved, $\mu\text{g}/\text{L}$	2.4	0.4	2.3	2.6	2.7	6	0	1.7	2.7
Copper, total recoverable, $\mu\text{g}/\text{L}$	25.4	17.4	10.5	23.8	27.4	6	0	9.4	57.5
Lead, dissolved, $\mu\text{g}/\text{L}$	0.23	0.07	0.18	0.22	0.30	6	0	0.16	0.32
Lead, total recoverable, $\mu\text{g}/\text{L}$	23.5	17.9	7.5	21.3	30.7	6	0	6.3	54.0
Manganese, dissolved, $\mu\text{g}/\text{L}$	176	288	26.9	52.8	140	6	0	25.2	757
Manganese, total recoverable, $\mu\text{g}/\text{L}$	639	602	282	432	596	6	0	252	1,840
Zinc, dissolved, $\mu\text{g}/\text{L}$	15.1	4.6	11.7	15.4	17.0	6	0	9.0	21.9
Zinc, total recoverable, $\mu\text{g}/\text{L}$	105	77	45	90	113	6	0	42	252

Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010.—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO₃, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06720500 South Platte River at Henderson, Colorado, 2009									
Property or constituent	Multiple censoring level statistics						Range of uncensored values		
	Mean	SD	25%	Median 50%	75%	n	nlt	Minimum	Maximum
pH, standard units	7.4	0.2	7.2	7.4	7.5	10	0	7.0	7.6
Specific conductance, µS/cm at 25°C	578	110	505	580	702	10	0	365	710
Hardness, total, mg/L as CaCO ₃	151	27.6	133	149.5	165	10	0	100	193
Calcium, mg/L	45.1	8.0	40.2	45.3	49.2	10	0	30.2	57.5
Magnesium, mg/L	9.25	1.82	8.12	8.86	10.4	10	0	6.0	11.8
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	138	66	94	126	179	10	2	53	250
Nitrogen, total, ammonia plus organic as N, mg/L	2.3	0.61	2.0	2.3	2.9	9	0	1.2	3.1
Nitrogen, dissolved, ammonia as N, mg/L	0.479	0.319	0.230	0.416	0.717	9	1	0.167	1.10
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	2.26	1.06	1.86	2.06	2.13	9	0	0.96	4.64
Orthophosphate, dissolved as P, mg/L	0.384	0.162	0.297	0.367	0.451	9	0	0.152	0.725
Phosphorus, total as P, mg/L	0.83	0.19	0.70	0.73	0.96	9	0	0.63	1.18
Carbon, dissolved, organic as C, mg/L	7.2	2.5	5.4	5.9	8.7	10	0	5.0	12.0
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	--	--	--	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	--	--	--	--
Copper, dissolved, µg/L	3.1	0.7	2.7	3.0	3.5	0	0	2.2	4.6
Copper, total recoverable, µg/L	19.0	8.6	12.6	17.9	22.1	10	0	9.1	33.5
Lead, dissolved, µg/L	0.21	0.11	0.13	0.19	0.29	10	0	0.07	0.41
Lead, total recoverable, µg/L	16.5	10.0	11.4	14.1	17.4	10	0	5.1	36.0
Manganese, dissolved, µg/L	32.9	26.8	3.8	31.3	56.0	10	0	0.6	77.4
Manganese, total recoverable, µg/L	314	125	231	309	368	10	0	138	580
Zinc, dissolved, µg/L	20.4	10.2	14.4	16.5	23.6	10	0	11.4	45.8
Zinc, total recoverable, µg/L	108	84	57	74	150	10	0	32	308

Table A5. Statistics for concentrations and measurement values at South Platte River at Henderson by year, 2006–2010.—Continued

[$\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; ml, milliliter; CaCO_3 , calcium carbonate; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; mm, millimeter; N, nitrogen; P, phosphorus; C, carbon; SD, standard deviation; n, number of samples; nlt, number of “less thans” or censored data; %, percentile; MPN, most probable number; --, not computed]

06720500 South Platte River at Henderson, Colorado, 2010									
Property or constituent	Multiple censoring level statistics					n	nlt	Range of uncensored values	
	Mean	SD	25%	Median 50%	75%			Minimum	Maximum
pH, standard units	7.2	0.2	7.1	7.2	7.3	5	0	7.0	7.4
Specific conductance, $\mu\text{S}/\text{cm}$ at 25°C	789	375	540	563	1,130	5	0	454	1,260
Hardness, total, mg/L as CaCO_3	176	48.4	148	161	226	5	0	118	226
Calcium, mg/L	50.58	12.15	44.1	47.8	62.1	5	0	35.2	63.7
Magnesium, mg/L	12.0	4.46	9.16	10.1	16.3	5	0	7.27	17.2
Suspended solids, residue on evaporation at 105 degrees Celsius, mg/L	225	102	150	196	286	5	0	122	370
Nitrogen, total, ammonia plus organic as N, mg/L	4.1	2.1	2.8	3.8	6.0	5	0	1.6	6.4
Nitrogen, dissolved, ammonia as N, mg/L	1.475	1.627	0.193	0.495	3.12	5	0	0.19	3.38
Nitrogen, dissolved, nitrite plus nitrate as N, mg/L	2.09	0.77	1.56	1.97	1.98	5	0	1.52	3.42
Orthophosphate, dissolved as P, mg/L	0.584	0.461	0.262	0.306	1.02	5	0	0.184	1.15
Phosphorus, total as P, mg/L	1.31	0.31	1.20	1.39	1.48	5	0	0.84	1.68
Carbon, dissolved, organic as C, mg/L	6.5	1.2	5.8	7.0	7.4	5	0	4.8	7.6
<i>Escherichia Coli</i> , MPN/100 mL	--	--	--	--	--	1	0	310	--
Fecal coliform, MPN/100 mL	--	--	--	--	--	1	0	310	--
Copper, dissolved, $\mu\text{g}/\text{L}$	3.5	1.8	2.1	2.4	5.3	5	0	2.0	5.5
Copper, total recoverable, $\mu\text{g}/\text{L}$	40.9	23.7	16.1	43.5	63.2	3	0	16.1	63.2
Lead, dissolved, $\mu\text{g}/\text{L}$	0.20	0.11	0.11	0.16	0.27	5	0	0.10	0.35
Lead, total recoverable, $\mu\text{g}/\text{L}$	35.0	15.4	17.4	42.0	45.7	3	0	17.4	45.7
Manganese, dissolved, $\mu\text{g}/\text{L}$	11.6	6.5	8.1	12.1	17.2	5	0	2.6	18.2
Manganese, total recoverable, $\mu\text{g}/\text{L}$	599	215	366	642	789	3	0	366	789
Zinc, dissolved, $\mu\text{g}/\text{L}$	16.4	11.1	8.3	9.9	27.9	5	0	6.7	29.1
Zinc, total recoverable, $\mu\text{g}/\text{L}$	166	75	79	201	217	3	0	79	217