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2014 Annual Summary of the Lower Gunnison River Basin Selenium Management Program Water-Quality Monitoring, Colorado

By Mark F. Henneberg

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
pound avoirdupois (lb)	0.4536	kilogram (kg)

Concentrations of chemical constituents in water are given in micrograms per liter (µg/L).
Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Abbreviations

LOWESS	LOcally WEighted Scatterplot Smoothing
SMP	Selenium Management Program
USGS	U.S. Geological Survey
WY	water year

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Abstract

Dissolved-selenium loading analyses of data collected at 18 water-quality sites in the lower Gunnison River Basin in Colorado were completed through water year (WY) 2014. A WY is defined as October 1–September 30. Selenium is a trace element that bioaccumulates in aquatic food chains and can cause reproductive failure, deformities, and other harmful effects. This report presents information on the dissolved-selenium loads at 18 sites in the lower Gunnison River Basin for WYs 2011–2014. Annual dissolved-selenium loads were calculated at 5 sites with continuous U.S. Geological Survey (USGS) streamflow gages, whereas instantaneous dissolved-selenium loads were calculated for the remaining 13 sites using water-quality samples that had been collected periodically during WYs 2011–2014. Annual dissolved-selenium loads for WY 2014 ranged from 336 pounds (lb) at Uncompahgre River at Colona to 13,300 lb at Gunnison River near Grand Junction (Whitewater). Most sites in the basin had a median instantaneous dissolved-selenium load of less than 20.0 lb per day. In general, dissolved-selenium loads at Gunnison River main-stem sites showed an increase from upstream to downstream.

The State of Colorado water-quality standard for dissolved selenium of 4.6 micrograms per liter (µg/L) was compared to the 85th percentiles for dissolved selenium at selected water-quality sites. Annual 85th percentiles for dissolved selenium were calculated for the five core USGS sites having streamflow gages using estimated dissolved-selenium concentrations from linear regression models. These annual 85th percentiles in WY 2014 ranged from 0.97 µg/L at Uncompahgre River at Colona to 16.7 µg/L at Uncompahgre River at Delta. Uncompahgre River at Delta and Whitewater were the only core sites where water samples exceeded the State of Colorado water-quality standard for dissolved selenium of 4.6 µg/L.

Instantaneous 85th percentiles for dissolved selenium were calculated for sites with sufficient data using water-quality samples collected during WYs 2011–2014. The instantaneous 85th percentiles for samples for WY 2014 ranged from 1.1 µg/L at Uncompahgre River at Colona to 125 µg/L at Loutzenhizer Arroyo at North River Road.

A trend analysis was completed for Whitewater to determine if dissolved-selenium loads are increasing or decreasing. The trend analysis indicates a decrease of 8,000 lb from WY 1986 to WY 2014, a 34.8 percent reduction during the time period, and an additional 6.2 percent reduction from a reported 28.6 percent reduction during WYs 1986–2008. The trend analysis for WY 1992 to WY 2014 indicates a decrease of 5,800 lb per year, or 27.9 percent.

Introduction

The primary goal of the Selenium Management Program (SMP), as recommended in the U.S. Fish and Wildlife Service's "Gunnison River Basin Programmatic Biological Opinion," is to meet the State of Colorado water-quality standard for dissolved selenium of 4.6 micrograms per liter (µg/L) at the U.S. Geological Survey (USGS) streamflow gage number 09152500—Gunnison River near Grand Junction, herein referred to as "Whitewater" (U.S. Fish and Wildlife Service, 2009). A parallel goal is to continue implementation of management practices that will maintain or improve the existing downward trend in dissolved-selenium concentration. Mayo and Leib (2012) documented a downward trend in dissolved-selenium load from 1986 to 2008 at the Whitewater gage. The SMP's long-term goal is to improve water quality by reducing dissolved-selenium concentrations sufficiently to assist in the recovery of the Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) (Bureau of Reclamation, 2011). Selenium is a trace element that bioaccumulates in aquatic food chains and can cause reproductive failure, deformities, and other harmful effects (Hamilton, 1998; Lemly, 2002).

The SMP has implemented a water-quality monitoring network in the lower Gunnison River Basin that has been in operation since 2011 (Bureau of Reclamation, 2011). The USGS, in cooperation with the Bureau of Reclamation, has completed a review of dissolved-selenium data from 18 sites (fig.1) that included the following 4 types of analyses (table 1):

1. Annual dissolved-selenium loading analyses using linear regression models for the five core USGS sites which have continuous streamflow gages (task A).
2. Instantaneous dissolved-selenium loading analyses for the 13 ancillary USGS sites where instantaneous water-quality sampling takes place (task B). Instantaneous dissolved-selenium load can be calculated if the dissolved-selenium sample was accompanied by a streamflow measurement.
3. Annual and instantaneous 85th-percentile analyses for dissolved selenium at the 18 sites (tasks C and D).
4. Dissolved-selenium concentration trend analysis for Whitewater (task E).

This report presents information on the dissolved-selenium loads at 18 sites in the lower Gunnison River Basin for WYs 2011–2014. In addition, trend analyses based on 1986–2014 and 1992–2014 streamflow and water-quality data are presented. All streamflow and water-quality data are available in the USGS National Water Information System (http://dx.doi.org/10.5066/F7P55KJN).

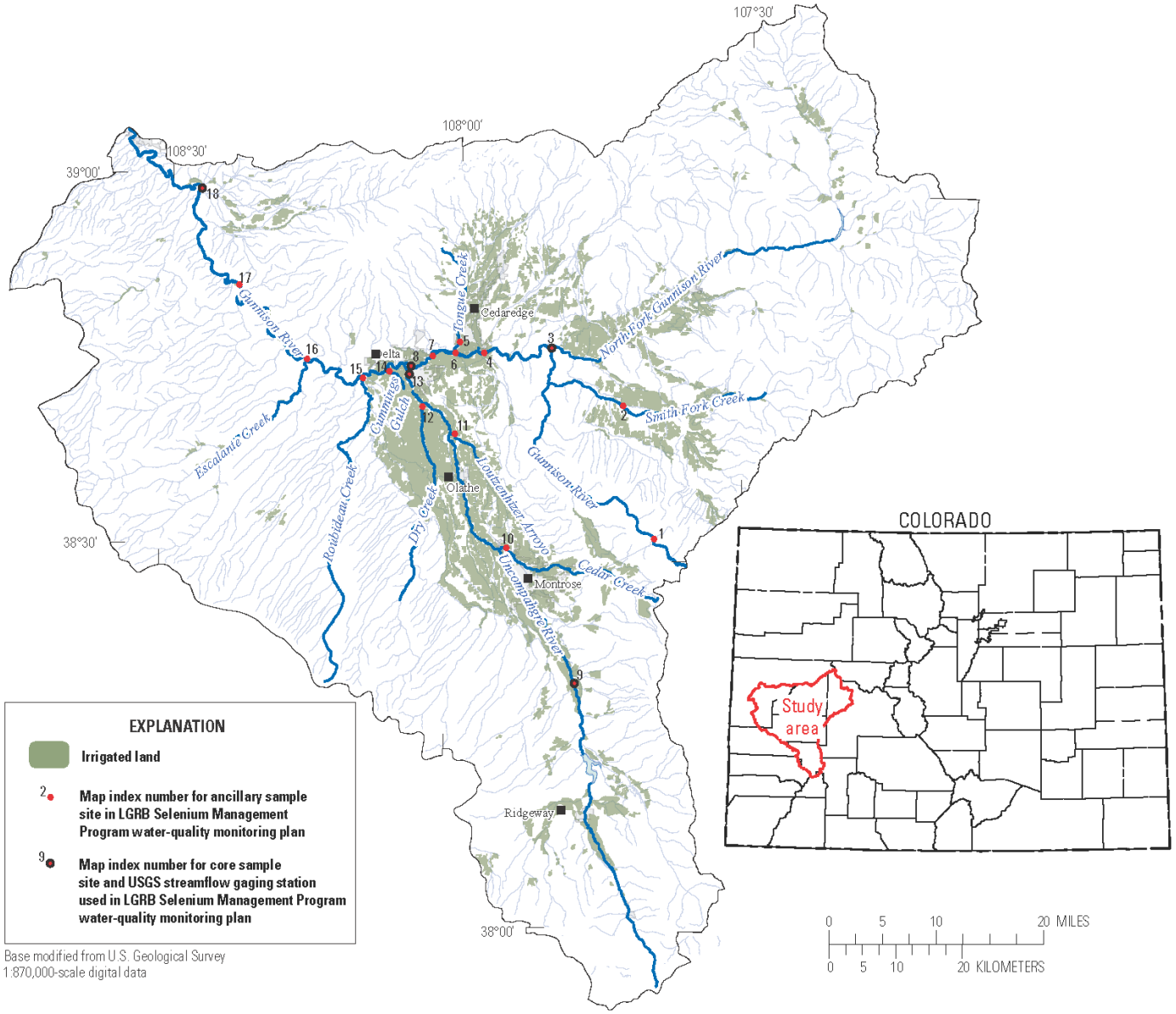

Figure 1. Map of the lower Gunnison River Basin showing the location of 18 U.S. Geological Survey water-quality monitoring sites. (LGRB, lower Gunnison River Basin; USGS, U.S. Geological Survey)

Table 1. Summary of tasks completed at 18 U.S. Geological Survey monitoring sites in the lower Gunnison River Basin.

[Analysis types are: A) annual dissolved-selenium loading analysis, B) instantaneous dissolved-selenium loading analysis, C) annual dissolved-selenium 85th-percentile estimate, D) instantaneous dissolved-selenium 85th-percentile estimate, and E) dissolved-selenium trend analysis. USGS, U.S. Geological Survey; R., River; blw, below; nr, near; abv, above; Ck., Creek]

Map index number	USGS station short name (USGS station number)	Site type	Analysis types (Tasks)
1	Gunnison R. blw Gunnison Tunnel (09128000) (Sampling terminated after water year 2012)	Ancillary	B, D
2	Smith Fork near Lazear (09129600)	Ancillary	B, D
3	North Fork Gunnison River near Lazear (09136100)	Core	A, B, C
4	Gunnison River at Austin (384624107570701)	Ancillary	B, D
5	Tongue Creek at Cory (09144200)	Ancillary	B, D
6	Gunnison River near Cory (09137500)	Ancillary	B, D
7	Gunnison River near Hartland Dam (384617108022901)	Ancillary	B, D
8	Gunnison River at Delta (09144250)	Core	A, B, C
9	Uncompahgre River at Colona (09147500)	Core	A, B, C
10	Cedar Creek near Mouth (383041107544201)	Ancillary	B, D
11	Loutzenhizer Arroyo at North River Road (383946107595301)	Ancillary	B, D
12	Dry Creek at Mouth nr Delta (384202108032001)	Ancillary	B, D
13	Uncompahgre River at Delta (09149500)	Core	A, B, C
14	Cummings Gulch at Mouth (384448108070301)	Ancillary	B, D
15	Roubideau Creek near Mouth (09150500)	Ancillary	B, D
16	Gunnison River abv Escalante Creek (384527108152701)	Ancillary	B, D
17	Gunnison R. blw Dominguez Ck. (385011108225401)	Ancillary	B, D
18	Whitewater (09152500)	Core	A, B, C, E

Dissolved-Selenium Concentrations and Loads

Concentration boxplots for instantaneous dissolved-selenium samples are plotted from left to right in an upstream to downstream order for water years (WYs) 2011–2014 in figure 2. A WY is defined as October 1–September 30. In general, the dissolved-selenium concentration increased from upstream to downstream at Gunnison River main-stem sites. Dissolved-selenium concentrations generally ranged from 1.0 µg/L to 10.0 µg/L at most sites. Gunnison R. blw Gunnison Tunnel and Loutzenhizer Arroyo at North River Road represent the lower and upper extremes, respectively. Gunnison R. blw Gunnison Tunnel had instantaneous dissolved-selenium concentrations that were less than 1.0 µg/L for all samples, and Loutzenhizer Arroyo at North River Road had dissolved-selenium concentrations exceeding 100 µg/L.

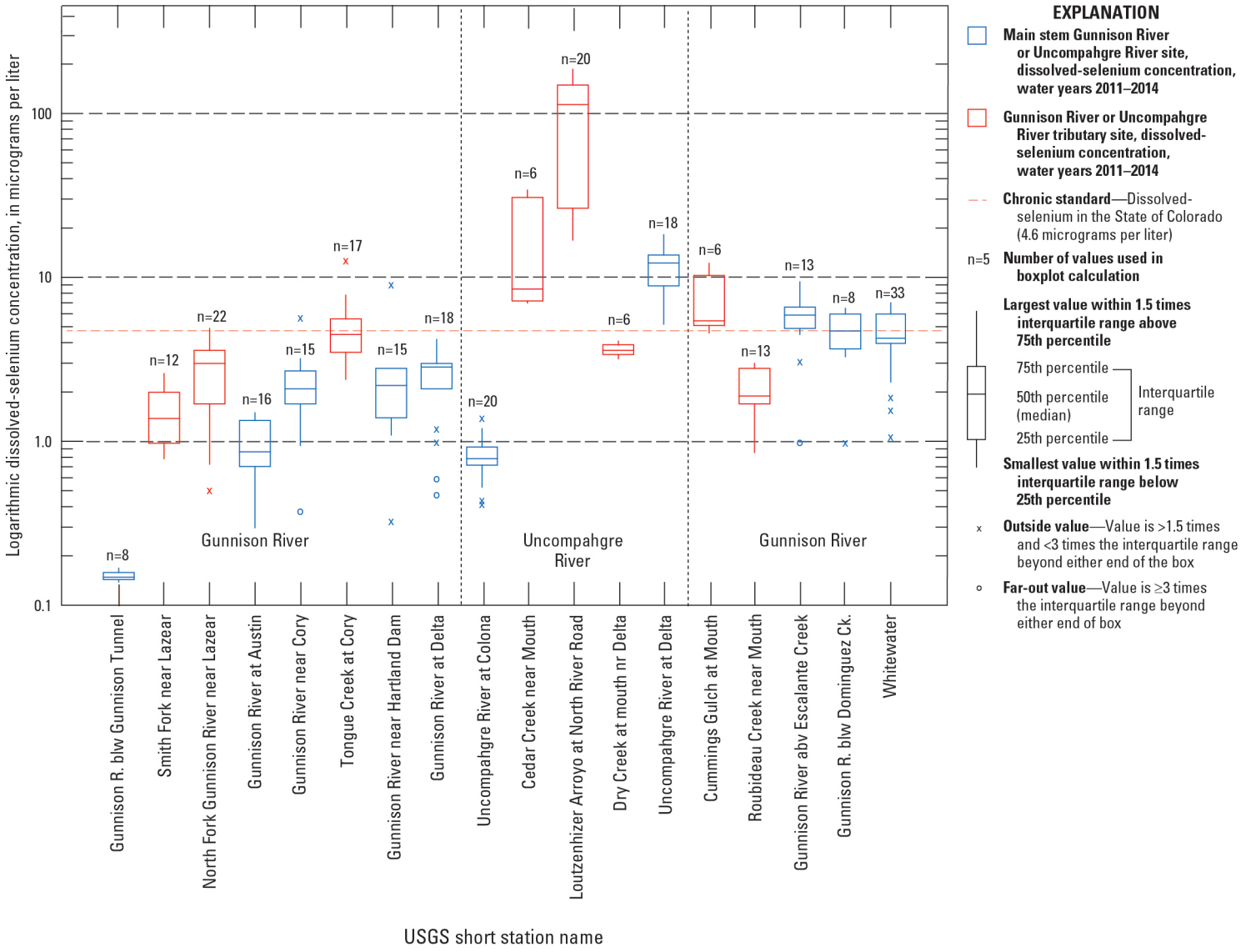

Figure 2. Concentration boxplots for dissolved-selenium concentration, in micrograms per liter, for instantaneous water-quality samples for water years 2011–2014. (R., River; blw, below; nr, near; abv, above; Ck., Creek; USGS, U.S. Geological Survey)

Annual dissolved-selenium loads were estimated for the five core sites using multiple linear regression techniques in S–LOADEST, a software program used for trend analysis and load estimation (Runkel and others, 2004). Mayo and Leib (2012) report on the methodology used to perform dissolved-selenium loading analysis. Equation forms, regression model coefficients, diagnostics, and calibration datasets are provided in appendixes 1 and 2. Instantaneous dissolved-selenium loads were calculated for the 13 ancillary sites that do not have a continuous streamgage. At these sites, instantaneous water-quality sampling events are accompanied by an instantaneous streamflow measurement. Annual loads were not estimated for sites for which instantaneous loading analyses were performed.

Results from the annual dissolved-selenium loading analyses for the five core sites, in pounds per year (lb/yr), are summarized in table 2. Annual dissolved-selenium load estimates for WY 2014 ranged from 336 lb/yr at Uncompahgre River at Colona to 13,300 lb/yr at Whitewater.

Table 2. Estimated annual dissolved-selenium loads, in pounds per year, calculated using multiple linear regression techniques in S-LOADEST (Runkel and others, 2004) at five core sites with a U.S. Geological Survey gaging station for water years 2011–2014.

[USGS, U.S. Geological Survey; WY, water year, defined as October 1–September 30]

Map index number	USGS station number	Annual dissolved-selenium load, in pounds per year				Total dissolved-selenium load for WYs 2011–2014, in pounds
		WY 2011	WY 2012	WY 2013	WY 2014	
3	09136100	1,580	1,050	967	1,220	4,820
8	09144250	5,880	4,920	4,130	4,540	19,500
9	09147500	391	194	179	336	1,100
13	09149500	7,920	4,860	4,850	7,190	24,800
18	09152500	17,300	12,800	11,100	13,300	54,500

Median and mean instantaneous dissolved-selenium loads, in pounds per day (lb/d), for all 18 sites were calculated using instantaneous water-quality samples (table 3). Median instantaneous dissolved-selenium loads ranged from 0.01 lb/d at Smith Fork near Lazear to 35.9 lb/d at Gunnison River abv Escalante Creek. Mean instantaneous dissolved-selenium loads ranged from 0.07 lb/d at Smith Fork near Lazear to 38.3 lb/d at Whitewater. Because there were no dissolved-selenium samples collected in 2013 or 2014 at Gunnison R. blw Gunnison Tunnel, the calculations for median and mean dissolved-selenium loads include WYs 2011 and 2012 only.

Table 3. Median and mean instantaneous dissolved-selenium daily load, in pounds per day, at 18 sites for water years 2011–2014.

[The median and mean dissolved-selenium loads for Gunnison R. blw Gunnison Tunnel include water years 2011 and 2012 only. USGS, U.S. Geological Survey; WY, water year, defined as October 1–September 30; R., River; blw, below; A, ancillary; C, core; nr, near; abv, above; Ck., Creek]

Map index number	USGS station number	USGS station short name	Site type	Number of samples WYs 2011–2013	Number of samples WY 2014	Median selenium load for sample years, in poundsper day	Mean selenium load for sample years, in pounds per day
1	09128000	Gunnison R. blw Gunnison Tunnel	A	8	0	0.57	1.2
2	09129600	Smith Fork near Lazear	A	8	4	0.01	0.07
3	09136100	North Fork Gunnison River near Lazear	C	18	4	2.7	3.5
4	384624107570701	Gunnison River at Austin	A	12	4	4.5	6.6
5	09144200	Tongue Creek at Cory	A	13	4	0.56	0.56
6	09137500	Gunnison River near Cory	A	11	4	8.3	10.1
7	384617108022901	Gunnison River near Hartland Dam	A	11	4	8.6	10.8
8	09144250	Gunnison River at Delta	C	14	4	12.2	14.9
9	09147500	Uncompahgre River at Colona	C	16	4	0.43	0.71
10	383041107544201	Cedar Creek near Mouth	A	2	4	3.4	3.5
11	383946107595301	Loutzenhizer Arroyo at North River Road	A	14	6	10.7	11.0
12	384202108032001	Dry Creek at mouth nr Delta	A	2	4	1.2	1.1
13	09149500	Uncompahgre River at Delta	C	14	4	17.2	17.5
14	384448108070301	Cummings Gulch at Mouth	A	2	4	1.3	1.0
15	09150500	Roubideau Creek near Mouth	A	9	4	0.51	0.5
16	384527108152701	Gunnison River abv Escalante Creek	A	9	4	35.9	36.9
17	385011108225401	Gunnison R. blw Dominguez Ck.	A	4	4	30.9	31.5
18	09152500	Whitewater	C	24	9	34.1	38.3

Most sites in the basin had a median instantaneous dissolved-selenium load of less than 20.0 lb/d. In general, dissolved-selenium loads at main-stem Gunnison River sites increased from upstream to downstream (fig. 3). Just downstream from the confluence of the Gunnison River and Uncompahgre River at site Gunnison River abv Escalante Creek, median dissolved-selenium loads increased to more than 35.0 lb/d. Median values for dissolved-selenium loads exceeding 30.0 lb/d are reasonable based on data from sites Gunnison River at Delta (12.2 lb/d) and Uncompahgre River at Delta (17.2 lb/d) (table 3).

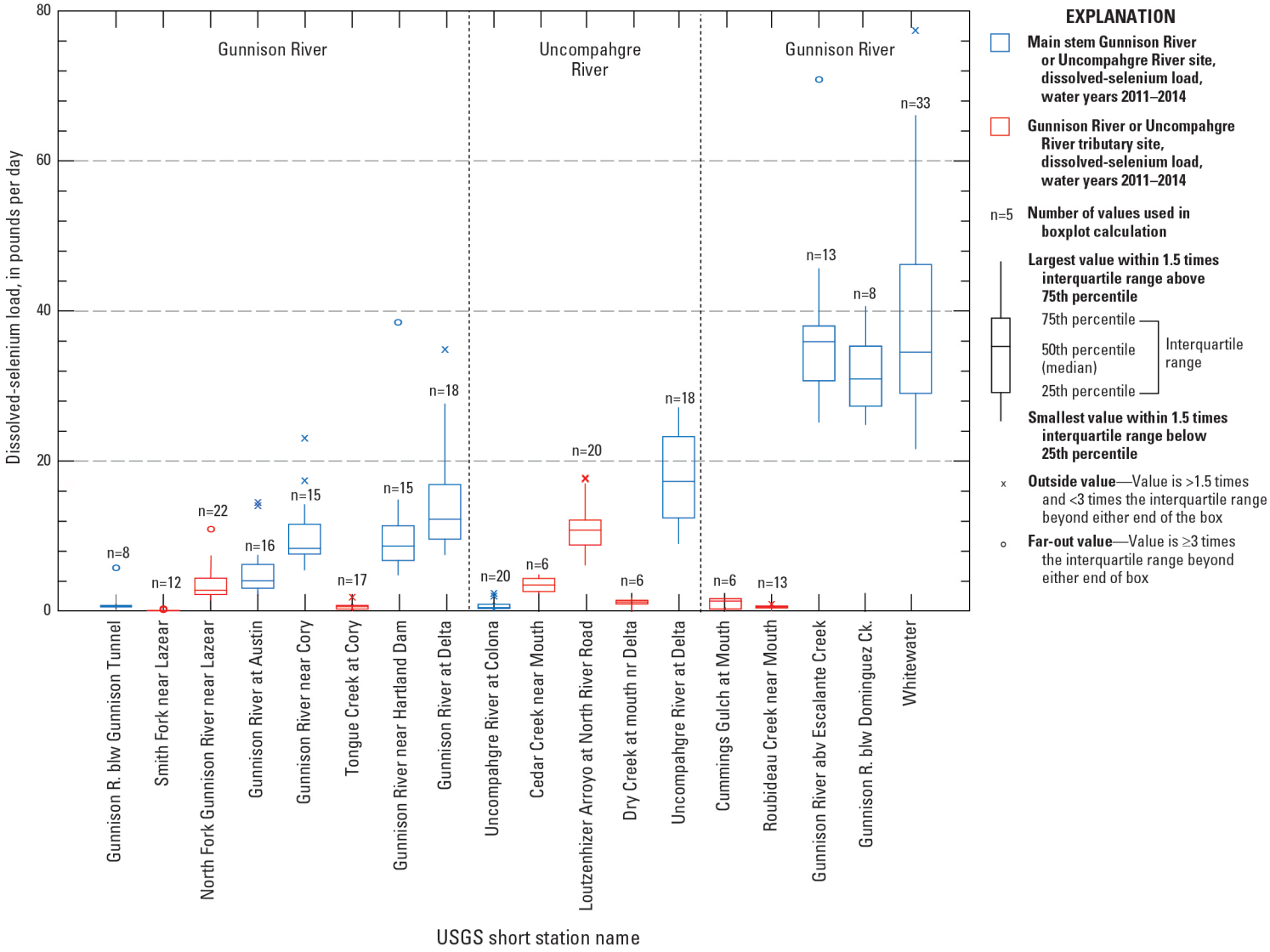

Figure 3. Concentration boxplots for dissolved-selenium load, in pounds per day, for instantaneous water-quality samples for water years 2011–2014. (R., River; blw, below; nr, near; abv, above; Ck., Creek; USGS, U.S. Geological Survey)

Changes in median dissolved-selenium load between selected sites along the main-stem Gunnison River are reported in table 4. The largest increase in dissolved-selenium load occurred between sites Gunnison River at Delta and Gunnison River abv Escalante Creek; the increase is due to the Uncompahgre River and unknown sources contributing approximately 23.7 lb/d of dissolved selenium. The dissolved-selenium load measured at Whitewater was 1.8 lb/d less than the load measured at Gunnison River abv Escalante Creek. This slight decrease may be because there is little irrigation in this reach of the river to contribute dissolved-selenium load (fig. 1).

Table 4. Changes in median dissolved-selenium loads along the main stem of the Gunnison River based on instantaneous water-quality samples for water years 2011–2014.

[USGS, U.S. Geological Survey; WY, water year, defined as October 1–September 30; abv, above]

Map index number	USGS station number	USGS station short name	Number of samples WYs 2011–2014	Median selenium load for 2011–2014, in pounds per day	Change in median dissolved-selenium load between stations for 2011–2014, in pounds per day
4	384624107570701	Gunnison River at Austin	16	4.5	
					3.8
6	09137500	Gunnison River near Cory	15	8.3	
					0.31
7	384617108022901	Gunnison River near Hartland Dam	15	8.6	
					3.6
8	09144250	Gunnison River at Delta	18	12.2	
					23.7
16	384527108152701	Gunnison River abv Escalante Creek	13	35.9	
					–1.8
18	09152500	Whitewater	33	34.1	

Dissolved-Selenium 85th-Percentile Analyses

Dissolved-selenium 85th-percentile concentrations were calculated for 17 sites for WY 2014. The 85th-percentile concentrations were not calculated for Gunnison R. blw Gunnison Tunnel (09128000) for WYs 2013 or 2014 because water samples were not collected during those years. The 85th percentiles for the five core sites presented in table 5 were calculated using the estimated dissolved-selenium concentration from the multiple linear-regression techniques as described by Mayo and Leib (2012). The dissolved-selenium 85th-percentile concentrations at these sites are referred to as the "annual dissolved-selenium 85th-percentile concentrations." At the 13 ancillary sites, multiple linear regression was not used due to a lack of continuous streamflow data; however, dissolved-selenium 85th-percentile concentrations were calculated using one WY of instantaneous water-quality samples. The instantaneous dissolved-selenium 85th-percentile concentrations for the 5 core and 13 ancillary sites are shown in table 6.

Table 5. Estimated annual dissolved-selenium 85th-percentile concentration for core sites, in micrograms per liter, calculated using multiple linear regression techniques in S-LOADEST (Runkel and others, 2004) at sites with a U.S. Geological Survey gaging station for water years 2011–2014.

[USGS, U.S. Geological Survey; WY, water year, defined as October 1–September 30]

Map index number	USGS station number	USGS station short name	Annual dissolved-selenium 85th-percentile concentration, in micrograms per liter				Change in dissolved-selenium concentration, in micrograms per liter, between WY 2011 and WY 2014
			WY 2011	WY 2012	WY 2013	WY 2014	
3	09136100	North Fork Gunnison River near Lazear	3.4	4.1	3.8	2.6	–0.80
8	09144250	Gunnison River at Delta	3.0	3.8	3.7	3.0	0.00
9	09147500	Uncompahgre River at Colona	0.91	0.87	1.1	0.97	0.06
13	09149500	Uncompahgre River at Delta	18.7	15.4	15.3	16.7	–2.0
18	09152500	Whitewater	6.6	6.4	7.1	6.2	–0.40

Table 6. Instantaneous dissolved-selenium 85th-percentile concentrations for 5 core sites and 13 ancillary sites, in micrograms per liter, for water-quality samples collected during water years 2011–2014.

[USGS, U.S. Geological Survey; WY, water year, defined as October 1–September 30; R., River; blw, below; ---, insufficient data to calculate a concentration; nr, near; abv, above; Ck., Creek]

Map index number	USGS station number	USGS station short name	WY 2011		WY 2012		WY 2013		WY2014	
			Number of samples	Instantaneous 85th percentile	Number of samples	Instantaneous 85th percentile	Number of samples	Instantaneous 85th percentile	Number of samples	Instantaneous 85th percentile
1	09128000	Gunnison R. blw Gunnison Tunnel	4	0.17	4	0.16	0	---	0	---
2	09129600	Smith Fork near Lazear	0	---	2	2.0	6	2.3	4	1.6
3	09136100	North Fork Gunnison River near Lazear	6	4.1	7	4.0	5	3.2	4	2.6
4	384624107570701	Gunnison River at Austin	2	0.99	4	1.2	6	1.5	4	1.4
5	09144200	Tongue Creek at Cory	4	3.5	4	10.0	5	9.3	4	6.0
6	09137500	Gunnison River near Cory	1	2.2	4	2.0	4	3.8	4	2.6
7	384617108022901	Gunnison River near Hartland Dam	1	2.4	4	2.2	6	4.4	4	2.5
8	09144250	Gunnison River at Delta	4	2.9	5	3.8	5	3.5	4	2.6
9	09147500	Uncompahgre River at Colona	6	0.98	6	0.85	4	1.2	4	1.1
10	383041107544201	Cedar Creek near Mouth	0	---	0	---	2	---	4	32.5
11	383946107595301	Loutzenhizer Arroyo at North River Road	5	170	3	153	6	126	6	125
12	384202108032001	Dry Creek at mouth nr Delta	0	---	0	---	2	---	4	3.8
13	09149500	Uncompahgre River at Delta	4	12.5	5	13.4	5	16.0	4	14.8
14	384448108070301	Cummings Gulch at Mouth	0	---	0	---	2	---	4	11.4
15	09150500	Roubideau Creek near mouth	0	---	3	2.5	6	2.8	4	2.6
16	384527108152701	Gunnison River abv Escalante Creek	0	---	3	5.8	6	8.1	4	6.3
17	385011108225401	Gunnison R. blw Dominguez Ck.	0	---	0	---	4	5.9	4	6.0
18	09152500	Whitewater	6	4.2	9	6.3	9	6.9	9	6.4

The annual dissolved-selenium 85th-percentile concentrations (table 5) for WY 2014 ranged from 0.97 µg/L at Uncompahgre River at Colona to 16.7 µg/L at Uncompahgre River at Delta. The only core sites that exceeded the State of Colorado water-quality standard of 4.6 µg/L were Uncompahgre River at Delta and Whitewater.

The instantaneous dissolved-selenium 85th-percentile concentrations shown in table 6 for samples in WY 2014 ranged from 1.1 µg/L at Uncompahgre River at Colona to 125 µg/L at Loutzenhizer Arroyo at North River Road. Water samples were not collected at Gunnison R. blw Gunnison Tunnel during 2014.

The largest instantaneous dissolved-selenium 85th-percentile concentrations for WY 2014 occurred at Loutzenhizer Arroyo at North River Road and Cedar Creek near Mouth and both of these ancillary sites exceeded the State of Colorado water-quality standard of 4.6 µg/L. Tongue Creek at Cory, Uncompahgre River at Delta, Cummings Gulch at Mouth, Gunnison River abv Escalante Creek, Gunnison R. blw Dominguez Ck., and Whitewater also exceeded the State of Colorado water-quality standard in WY 2014.

Dissolved-Selenium Trend Analysis

Using methods described in Mayo and Leib (2012), a trend analysis based on normalized mean-daily streamflow for 1986–2014 was completed using water-quality data collected at Whitewater. The calibration dataset contained all available instantaneous water-quality samples from WY 1986 to WY 2014. This process ensured that all data used for regression model development by Mayo and Leib (2012) were included in the dataset used for model development through WY 2014. Another period, WYs 1992–2014, was used for a trend analysis following the same methods as Mayo and Leib (2012), but with normalized mean daily streamflow and instantaneous water-quality samples for 1992–2014, and it is included here to provide more emphasis on the most recently collected data.

A continuing downward trend in annual dissolved-selenium load was observed at the Whitewater site, as indicated in tables 7 and 8. The dissolved-selenium loads decreased from 23,000 pounds (lb) in WY 1986 to 15,000 lb in WY 2014, a decrease of 8,000 lb (table 7). This decrease represents a 34.8 percent reduction during the time period, and an additional 6.2 percent reduction from the 28.6 percent reduction reported through WY 2008 in Mayo and Leib (2012). As shown in table 7, the dissolved-selenium load 95-percent confidence levels for WY 1986 were 21,300 lb (lower) and 24,800 lb (upper); for WY 2014, the dissolved-selenium 95-percent confidence levels were 13,900 lb (lower) and 16,200 lb (upper).

Table 7. Annual dissolved-selenium trend from water year 1986 to water year 2014 at U.S. Geological Survey site 09152500, Whitewater.

[A water year is defined as October 1–September 30. %, percent; ---, not applicable]

Water year	Average of the mean daily streamflow for 1986–2014, in cubic feet per second	Estimated dissolved-selenium annual load, in pounds	Lower 95%-confidence level for estimated annual dissolved-selenium load, in pounds	Upper 95%-confidence level for estimated annual dissolved-selenium load, in pounds	Estimated annual dissolved-selenium load reduction, in percent	Annual 50th percentile of estimated daily dissolved-selenium concentration, in micrograms per liter	Annual 85th percentile of estimated daily dissolved-selenium concentration, in micrograms per liter
1986	2,320	23,000	21,300	24,800	---	6.5	7.4
2014	2,320	15,000	13,900	16,200	34.8	4.3	4.9
Difference	---	–8,000	---	---	---	–2.3	–2.6

Table 8. Annual dissolved-selenium trend from water year 1992 to water year 2014 at U.S. Geological Survey site 09152500, Whitewater.

[A water year is defined as October 1–September 30. %, percent; ---, not applicable]

Water year	Average of the mean daily streamflow for 1992–2014, in cubic feet per second	Estimated dissolved-selenium annual load, in pounds	Lower 95%-confidence level for estimated annual dissolved-selenium load, in pounds	Upper 95%-confidence level for estimated annual dissolved-selenium load, in pounds	Estimated annual dissolved-selenium load reduction, in percent	Annual 50th percentile of estimated daily dissolved-selenium concentration, in micrograms per liter	Annual 85th percentile of estimated daily dissolved-selenium concentration, in micrograms per liter
1992	2,340	20,800	19,400	22,300	---	6.0	6.8
2014	2,340	15,000	13,800	16,300	27.9	4.3	4.9
Difference	---	–5,800	---	---	---	–1.7	–1.9

To graphically demonstrate the trend in dissolved-selenium concentration, the decimal time component was removed from the regression model to yield a load regression for partial residuals (Mayo and Leib, 2012). The calibration dataset was then used to predict dissolved-selenium concentrations on the same days that water samples were obtained. The predicted dissolved-selenium concentration for each sample date was then subtracted from the measured dissolved-selenium concentration from the sample, yielding a residual dissolved-selenium concentration. The residual dissolved-selenium concentrations are plotted by year with a LOcally WEighted Scatterplot Smoothing (LOWESS) fit line (Helsel and Hirsch, 2002) in figure 4 for WYs 1986–2014 and in figure 5 for WYs 1992–2014. Both figures 4 and 5 confirm a continuing decrease in dissolved selenium during the trend periods.

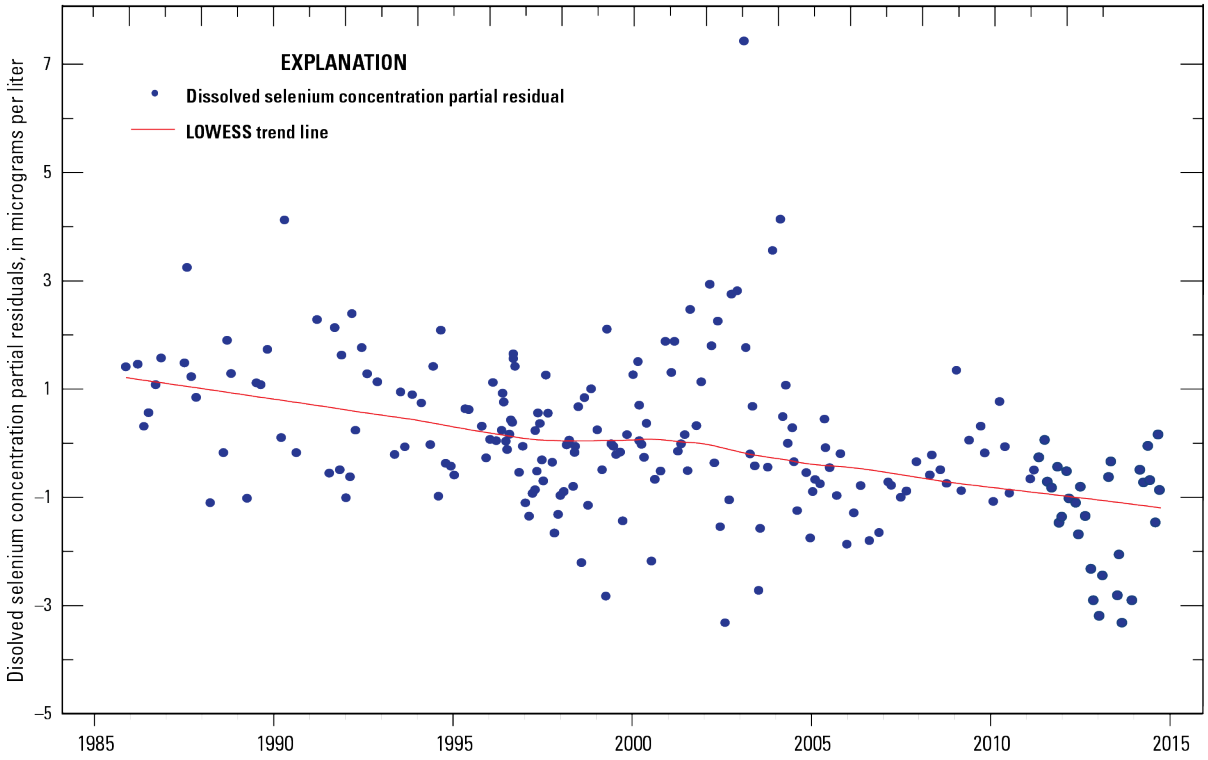

Figure 4. Plot of dissolved-selenium concentration partial residuals and LOcally WEighted Scatterplot Smoothing (LOWESS) fit line for Whitewater (09152500) for water years 1986–2014.

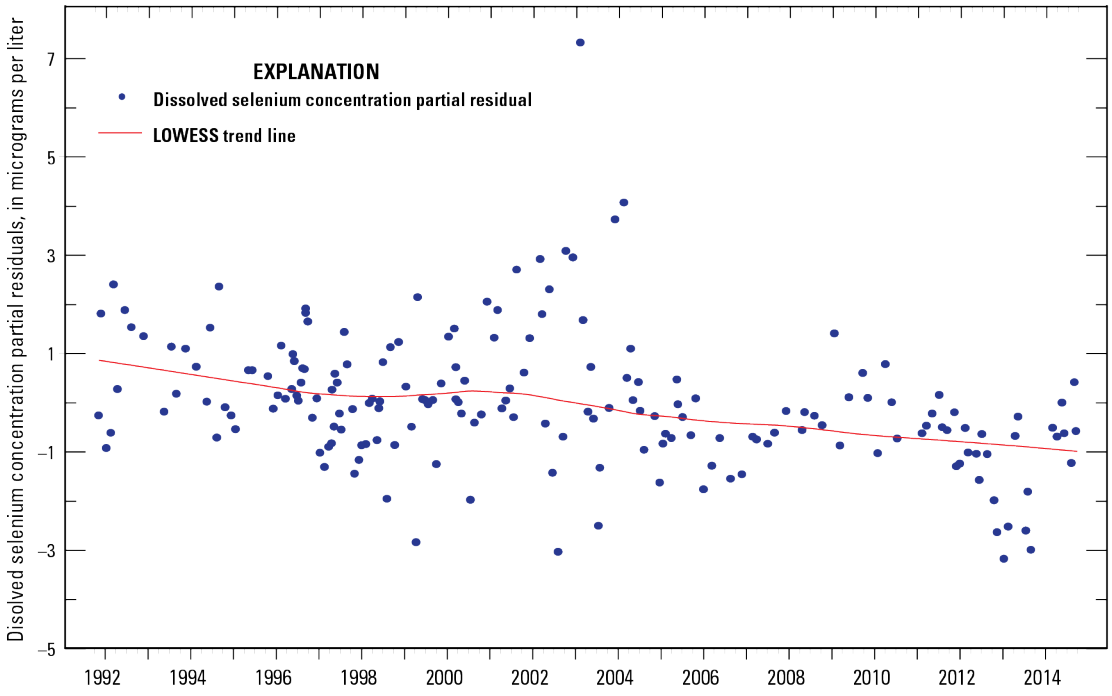

Figure 5. Plot of dissolved-selenium concentration partial residuals and LOcally WEighted Scatterplot Smoothing (LOWESS) fit line for Whitewater (09152500) for water years 1992–2014.

An annual dissolved-selenium trend was also completed for WY 1992 to WY 2014 (table 8). The annual dissolved-selenium load decreased from 20,800 lb in 1992 to 15,000 lb in 2014, a decrease of 5,800 lb, or 27.9 percent.

It is important to remember that the estimated loads and concentrations given in tables 7 and 8 were based on normalized streamflow and are only illustrative of the change in selenium loads and concentrations over the period of trend analysis. The loads and concentrations shown in tables 7 and 8 were not the actual loads and concentrations that occurred in those years (Mayo and Leib, 2012).

Summary

Dissolved-selenium loading analyses of water samples from 18 sites in the lower Gunnison River Basin were completed through water year (WY) 2014. A WY is defined as October 1–September 30. Selenium is a trace element that bioaccumulates in aquatic food chains and can cause reproductive failure, deformities, and other harmful effects. This report presents the dissolved-selenium loads at 18 sites in the lower Gunnison River Basin for WYs 2011–2014. Annual dissolved-selenium loads were calculated at 5 sites with continuous U.S. Geological Survey (USGS) streamflow gages, whereas the remaining 13 sites had instantaneous dissolved-selenium loads calculated using water-quality samples collected periodically during the period. Annual dissolved-selenium loads for WY 2014 ranged from 336 pounds (lb) at Uncompahgre River at Colona to 13,300 lb at Gunnison River near Grand Junction (Whitewater). Most sites in the basin had a median instantaneous dissolved-selenium load of less than 20.0 lb per day. In general, dissolved-selenium loads at Gunnison River main-stem sites showed an increase from upstream to downstream.

The State of Colorado water-quality standard for dissolved selenium of 4.6 micrograms per liter (µg/L) was compared to the 85th percentiles for dissolved selenium at selected water-quality sites. Annual 85th percentiles for dissolved selenium were calculated for the five core USGS sites having streamflow gages using estimated dissolved-selenium concentrations from linear regression models. These annual dissolved-selenium 85th percentiles for five core sites in WY 2014 ranged from 0.97 µg/L at Uncompahgre River at Colona to 16.7 µg/L at Uncompahgre River at Delta. The State of Colorado water-quality standard for dissolved selenium of 4.6 µg/L was exceeded at only two core sites: Uncompahgre River at Delta and Whitewater.

Instantaneous 85th percentiles for dissolved selenium were also calculated for sites with sufficient data using water-quality samples collected during WYs 2011–2014. The instantaneous dissolved-selenium 85th percentiles for samples for WY 2014 ranged from 1.1 µg/L at Uncompahgre River at Colona to 125 µg/L at Loutzenhizer Arroyo at North River Road.

A trend analysis was completed for Whitewater to determine if dissolved-selenium loads are increasing or decreasing. The trend analysis indicates a decrease of 8,000 lb from WY 1986 to WY 2014, a 34.8 percent reduction during the time period, and an additional 6.2 percent reduction from a reported 28.6 percent reduction from WY 1986 to WY 2008. The trend analysis for WY 1992 to WY 2014 indicates a decrease of 5,800 lb per year, or 27.9 percent.

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Appendix 1. S-LOADEST Equation Forms, Variable Coefficients, and Statistical Diagnostics

A summary of the equation forms used to estimate annual dissolved-selenium load at the five core sites in the lower Gunnison River Basin for water year 2014 is presented in table 1-1. Table 1-2 provides regression model coefficients and statistical diagnostics for the five core sites. All streamflow and water-quality data are available in the USGS National Water Information System (http://dx.doi.org/10.5066/F7P55KJN).

Table 1-1. Summary of equation forms used to estimate annual dissolved-selenium load for water year 2014 at five core sites in the lower Gunnison River Basin.

[USGS, U.S. Geological Survey; ln, natural logarithm; load, dissolved-selenium load in pounds per day; β_0, intercept of the regression on the y-axis; β_1–β_5, regression coefficients; Q, centered daily streamflow in cubic feet per second; sin(2πdectime), sine function of a Fourier Series; π, approximately 3.141593; dectime, centered decimal time in decimal years; cos(2πdectime), cosine function of a Fourier Series; ε, remaining unexplained variability in the data (error); SC, daily mean specific conductance in microsiemens per centimeter at 25 degrees Celsius]

USGS station number	Equation form[1]
09136100	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\sin(2\pi dectime) + \beta_3\cos(2\pi dectime) + \varepsilon$
09144250	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\sin(2\pi dectime) + \beta_3\cos(2\pi dectime) + \varepsilon$
09147500	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\sin(2\pi dectime) + \beta_3\cos(2\pi dectime) + \varepsilon$
09149500	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\ln(Q)2 + \beta3\sin(2\pi\cdot dectime) + \beta4\cos(2\pi\cdot dectime) + \varepsilon$
09152500[2]	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2 SC + \varepsilon$
09152500[3]	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\sin(2\pi dectime) + \beta_3\cos(2\pi dectime) + \varepsilon$
09152500[4]	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\ln(Q)2 + \beta_3 dectime + \beta_4\sin(2\pi dectime) + \beta_5\cos(2\pi dectime) + \varepsilon$
09152500[5]	$\ln(load) = \beta_0 + \beta_1\ln(Q) + \beta_2\ln(Q)2 + \beta_3 dectime + \beta_4\sin(2\pi dectime) + \beta_5\cos(2\pi dectime) + \varepsilon$

[1]Any bias that is introduced by the log transformation needs to be corrected if the results are transformed out of log space (Cohn and others, 1989), but this correction is automatically applied by the statistical software used for the regression analysis (Mayo and Leib, 2012).

[2]Equation form used when specific conductance data were available.

[3]Equation form used when specific conductance data were absent.

[4]Equation form used for 1986–2014 trend analysis.

[5]Equation form used for 1992–2014 trend analysis.

Table 1-2. Regression model coefficients and statistical diagnostics at five core sites in the lower Gunnison River Basin.

[USGS, U.S. Geological Survey; ln, natural logarithm; Q, centered daily streamflow in cubic feet per second; dectime, centered decimal time in decimal years; sin(2πdectime), sine function of a Fourier Series; π, approximately 3.141593; cos(2πdectime), cosine function of a Fourier Series; SC, daily mean specific conductance in microsiemens per centimeter at 25 degrees Celsius; ERV, estimated residual variance; R^2, coefficient of determination; SCR, serial correlation of the residuals; ---, no statistical diagnostic available]

USGS station number	Y-axis Intercept	ln(Q)	ln(Q)2	1/Q	dectime	sin(2πdectime)	cos(2πdectime)	SC	ERV	R^2	SCR
09136100	1.209	0.504	---	---	---	–0.180	–0.019	---	0.012	97.09	–0.339
09144250	2.693	0.411	---	---	---	–0.085	–0.036	---	0.005	98.16	0.262
09147500	–0.508	0.751	---	---	---	0.322	–0.130	---	0.056	95.58	–0.897
09149500	2.991	---	---	0.511	–0.158	0.144	0.139	---	0.004	96.21	–0.642
09152500[1]	2.668	0.749	---	---	---	---	---	0.001	0.015	87.25	0.019
09152500[2]	3.692	0.431	---	---	---	–0.181	0.099	---	0.027	78.52	–0.080
09152500[3]	3.931	0.352	0.061	---	0.015	–0.227	0.054	---	0.055	61.85	0.393
09152500[4]	3.896	0.342	0.072	---	–0.015	–0.218	0.048	---	0.054	59.23	0.379

[1]Coefficients and diagnostics when specific conductance data were available.

[2]Coefficients and diagnostics when specific conductance data were absent.

[3]Coefficients and diagnostics for 1986–2014 trend analysis.

[4]Coefficients and diagnostics for 1992–2014 trend analysis.

Appendix 2. Calibration Data for 2014 Annual Load and Trend Regressions

Table 2-1 provides calibration data for annual load regression models at selected sites. Calibration data for dissolved-selenium trend analysis at the U. S. Geological Survey gaging station Gunnison River near Grand Junction (Whitewater) are presented in table 2-2. All streamflow and water-quality data are available in the USGS National Water Information System (http://dx.doi.org/10.5066/F7P55KJN).

Table 2-1. Calibration data for annual load regression models at selected sites.

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
North Fork Gunnison River near Lazear (09136100)				
10/23/2012	09:45:00	153	1,110	3.2
11/16/2012	12:15:00	121	1,170	3.3
02/14/2013	11:15:00	85	1,140	3.1
05/24/2013	14:00:00	1,200	285	0.73
07/16/2013	12:15:00	115	1,340	3.2
12/09/2013	13:00:00	189	951	2.2
03/05/2014	10:30:00	323	685	1.5
06/11/2014	07:30:00	1,520	344	0.89
08/11/2014	11:00:00	131	1,350	2.9
Gunnison River at Delta (09144250)				
10/22/2012	13:15:00	532	831	3.5
11/13/2012	11:45:00	502	829	3.5
02/11/2013	11:30:00	519	752	2.9
05/17/2013	11:45:00	2,600	317	1.2
07/15/2013	14:15:00	847	648	2.5
12/12/2013	10:30:00	463	840	3.0
03/05/2014	13:15:00	799	675	2.2
06/13/2014	09:00:00	8,510	269	0.60
08/13/2014	10:30:00	1,030	628	2.1
Uncompahgre River at Colona (09147500)				
11/19/2012	10:15:00	54	654	0.79
02/19/2013	10:00:00	38	765	0.99
05/23/2013	11:00:00	112	507	1.4
07/15/2013	15:00:00	200	670	0.63
12/11/2013	13:00:00	65	626	0.79
03/03/2014	16:30:00	62	618	1.0
06/09/2014	12:45:00	647	471	0.72
08/11/2014	16:00:00	334	407	0.44
Uncompahgre River at Delta (09149500)				
10/22/2012	09:30:00	371	1,530	12.3
11/13/2012	09:15:00	258	1,580	13.3
02/11/2013	09:15:00	127	1,780	18.2
05/15/2013	14:30:00	230	1,260	14.5
07/16/2013	15:15:00	172	1,520	12.2
12/12/2013	12:45:00	238	1,660	13.7
03/04/2014	13:30:00	191	1,650	16.4
06/10/2014	13:45:00	753	866	5.2
08/13/2014	10:45:00	368	1,210	7.8

Table 2-1. Calibration data for annual load regression models at selected sites.—Continued

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
Gunnison River near Grand Junction (Whitewater) (09152500)				
10/24/2012	09:45:00	991	1,210	7.0
11/20/2012	12:15:00	859	1,140	7.0
01/16/2013	10:00:00	673	1,100	6.4
02/20/2013	10:00:00	649	1,060	6.1
04/23/2013	14:00:00	718	991	6.5
05/17/2013	15:00:00	3,360	460	2.3
07/23/2013	10:15:00	1,080	979	4.2
08/09/2013	14:30:00	1,320	1,000	4.5
09/05/2013	12:00:00	1,130	1,030	4.7
12/17/2013	13:30:00	885	1,060	6.0
03/07/2014	13:15:00	968	929	5.6
04/15/2014	12:00:00	2,540	497	2.3
05/28/2014	11:15:00	6,020	447	1.9
06/17/2014	12:15:00	8,110	345	1.1
07/18/2014	09:00:00	1,470	855	4.3
08/14/2014	12:30:00	1,790	857	4.0
09/10/2014	12:45:00	2,330	1,030	5.2
09/23/2014	10:30:00	1,820	1,020	5.2

Table 2-2. Calibration data for dissolved-selenium trend analysis at U.S. Geological Survey gaging station 09152500—Gunnison River near Grand Junction (Whitewater) for water years 1986–2014.

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
11/26/1985	13:00:00	2,660	880	6
03/26/1986	13:00:00	3,480	518	4
05/30/1986	11:00:00	7,970	340	2
07/16/1986	12:00:00	5,630	600	3
09/24/1986	12:30:00	3,710	790	5
11/20/1986	13:05:00	4,480	780	5
07/16/1987	14:30:00	1,990	838	6
08/11/1987	13:30:00	2,180	908	8
09/22/1987	13:30:00	1,960	1,090	7
11/10/1987	08:00:00	2,340	905	6
04/05/1988	14:20:00	2,460	598	2
08/16/1988	11:30:00	737	1,410	10
09/22/1988	14:50:00	1,800	1,220	8
11/02/1988	13:20:00	924	1,400	11
04/12/1989	11:10:00	2,550	510	2
07/18/1989	12:00:00	650	1,400	11
08/29/1989	12:05:00	941	1,370	10
11/07/1989	10:00:00	1,390	1,220	9
03/27/1990	13:15:00	766	977	7
05/02/1990	10:00:00	1,740	1,110	8

Table 2-2. Calibration data for dissolved-selenium trend analysis at U.S. Geological Survey gaging station 09152500—Gunnison River near Grand Junction (Whitewater) for water years 1986–2014.—Continued

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
08/28/1990	12:45:00	780	1,440	10
03/26/1991	12:30:00	997	942	8
07/31/1991	12:30:00	1,600	970	5
09/24/1991	09:50:00	1,510	1,200	9
11/13/1991	12:00:00	2,100	837	5
12/03/1991	11:20:00	2,000	797	7
01/16/1992	11:00:00	1,300	855	5
02/26/1992	12:45:00	1,130	881	5
03/18/1992	09:45:00	1,390	894	7
04/21/1992	12:20:00	2,950	538	3
06/24/1992	12:30:00	1,910	826	6
08/19/1992	13:00:00	1,720	1,030	7
12/01/1992	13:00:00	1,140	1,150	9
05/26/1993	10:20:00	15,500	274	1
07/27/1993	09:55:00	1,800	888	6
09/08/1993	12:35:00	2,290	967	5
11/23/1993	10:25:00	2,270	812	6
02/24/1994	11:05:00	977	1,030	7
05/25/1994	11:30:00	5,510	423	2
06/23/1994	11:20:00	2,460	865	5
08/17/1994	09:25:00	1,260	1,120	6
09/07/1994	12:30:00	1,790	1,110	8
10/27/1994	12:10:00	1,730	1,060	6
12/19/1994	13:00:00	1,400	920	6
01/24/1995	10:15:00	1,080	860	6
05/17/1995	10:33:00	11,400	350	2
06/19/1995	14:00:00	13,900	348	2
10/30/1995	11:20:00	2,800	794	5
12/12/1995	12:00:00	2,750	651	4
01/23/1996	10:15:00	1,670	806	5
02/21/1996	11:15:00	2,020	755	5
03/26/1996	12:00:00	2,710	553	3
05/20/1996	10:30:00	6,990	336	2
05/29/1996	10:45:00	2,740	686	4
06/11/1996	14:30:00	2,700	627	4
07/03/1996	13:15:00	3,620	530	3
07/16/1996	11:30:00	2,310	675	4
080/7/1996	12:30:00	1,230	992	7
08/21/1996	11:50:00	1,410	1,040	7
09/5/1996	11:40:00	1,500	1,030	7
09/16/1996	15:35:00	2,170	1,010	7
09/17/1996	07:30:00	2,120	1,020	7
10/04/1996	13:00:00	2,910	1,120	6
11/13/1996	13:00:00	2,070	794	5
12/20/1996	10:30:00	2,000	692	5
01/17/1997	13:00:00	2,310	572	3
02/24/1997	13:30:00	2,510	540	2
03/31/1997	12:45:00	5,610	386	1

Table 2-2. Calibration data for dissolved-selenium trend analysis at U.S. Geological Survey gaging station 09152500—Gunnison River near Grand Junction (Whitewater) for water years 1986–2014.—Continued

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
04/25/1997	10:30:00	5,890	384	1
04/28/1997	12:45:00	6,490	382	2
05/16/1997	08:30:00	9,170	302	1
05/24/1997	15:40:00	10,600	358	2
06/12/1997	12:30:00	9,240	412	2
070/3/1997	12:40:00	5,610	376	2
07/18/1997	11:30:00	2,780	616	3
08/12/1997	11:40:00	3,240	880	5
09/05/1997	12:15:00	2,790	888	5
10/20/1997	11:15:00	3,200	652	4
11/07/1997	12:20:00	2,780	649	3
12/15/1997	13:45:00	2,660	585	3
01/08/1998	10:30:00	2,600	519	3
02/11/1998	10:00:00	2,130	612	3
03/12/1998	09:30:00	1,740	645	4
04/08/1998	13:50:00	2,660	613	3
05/18/1998	13:00:00	6,670	367	1
06/03/1998	10:00:00	5,120	397	2
06/11/1998	09:40:00	2,960	590	3
07/09/1998	10:10:00	2,030	841	5
08/11/1998	11:30:00	1,450	1,040	4
09/11/1998	13:10:00	1,710	1,040	7
10/16/1998	10:00:00	1,840	948	5
11/18/1998	12:15:00	1,800	1,010	7
01/20/1999	11:10:00	1,350	896	6
03/10/1999	10:30:00	1,110	852	5
04/16/1999	13:15:00	948	740	3
04/30/1999	10:00:00	2,750	743	5
06/10/1999	10:00:00	3,020	605	3
06/30/1999	14:20:00	3,360	593	3
07/29/1999	10:00:00	2,430	914	4
09/09/1999	12:40:00	3,170	722	4
10/06/1999	13:00:00	4,790	484	2
11/17/1999	15:00:00	1,880	831	6
01/19/2000	09:30:00	1,520	888	6.6
03/09/2000	12:30:00	1,170	904	6.8
03/21/2000	12:50:00	1,670	632	4.1
03/22/2000	09:15:00	1,700	706	4.7
04/13/2000	10:30:00	3,430	439	2.5
05/10/2000	10:00:00	4,280	477	2.0
06/06/2000	10:50:00	2,390	627	3.8
07/24/2000	10:35:00	1,410	872	3.7
08/29/2000	13:45:00	1,890	866	4.9
10/25/2000	12:40:00	1,800	995	5.7
12/14/2000	13:30:00	1,440	920	8.3
02/13/2001	11:35:00	1,050	825	7.5
03/15/2001	12:00:00	1,240	958	6.9
04/20/2001	11:45:00	2,060	540	3.3

Table 2-2. Calibration data for dissolved-selenium trend analysis at U.S. Geological Survey gaging station 09152500—Gunnison River near Grand Junction (Whitewater) for water years 1986–2014.—Continued

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
05/22/2001	13:45:00	3,480	479	2.6
06/28/2001	13:40:00	1,300	949	5.7
07/27/2001	11:30:00	1,260	1,040	5.9
08/23/2001	10:30:00	2,140	1,400	7.5
10/26/2001	10:45:00	1,650	1,020	6.9
12/14/2001	13:15:00	1,200	965	8.4
03/11/2002	13:55:00	1,030	828	8.7
03/29/2002	11:00:00	1,200	792	6.8
04/25/2002	11:05:00	687	925	7.0
05/31/2002	09:00:00	946	1,090	8.5
06/26/2002	13:00:00	828	915	6.0
08/13/2002	13:00:00	818	1,130	6.0
09/24/2002	10:00:00	1,010	1,250	8.0
10/18/2002	11:15:00	1,070	1,200	11.6
12/17/2002	14:00:00	715	1,260	13.2
02/20/2003	12:45:00	607	1,180	16.4
03/13/2003	12:00:00	669	1,050	9.6
04/25/2003	13:45:00	1,150	642	4.9
05/20/2003	08:45:00	4,570	488	2.9
06/11/2003	10:35:00	1,840	724	3.7
07/22/2003	09:15:00	1,010	883	4.6
08/04/2003	11:05:00	1,040	981	6.0
10/22/2003	09:40:00	1,070	1,200	8.4
12/11/2003	11:20:00	771	1,300	13.6
02/26/2004	08:55:00	706	1,170	12.0
03/24/2004	09:15:00	1,460	688	4.9
04/23/2004	10:20:00	1,510	734	5.3
05/13/2004	11:30:00	2,830	526	2.9
06/28/2004	11:55:00	1,010	1,090	6.9
07/14/2004	11:00:00	997	974	6.8
08/17/2004	10:50:00	1,010	1,070	6.9
11/16/2004	12:00:00	1,090	1,180	7.9
12/28/2004	11:00:00	926	1,060	6.5
01/24/2005	13:35:00	1,210	860	5.2
02/15/2005	12:15:00	1,570	685	4.0
04/08/2005	11:30:00	2,980	484	2.0
05/23/2005	11:15:00	11,900	287	1.8
06/02/2005	13:18:00	5,990	454	1.9
07/12/2005	09:20:00	1,630	876	4.6
09/22/2005	09:50:00	1,570	1,110	5.7
10/31/2005	13:30:00	1,560	1,120	6.6
01/05/2006	14:30:00	998	1,050	5.7
03/17/2006	14:15:00	1,210	834	3.8
05/26/2006	14:00:00	3,390	512	1.9
08/24/2006	11:45:00	1,930	794	3.6
11/30/2006	15:15:00	2,170	671	3.5
03/01/2007	11:20:00	1,440	743	4.0
04/04/2007	10:45:00	2,630	480	2.2

Table 2-2. Calibration data for dissolved-selenium trend analysis at U.S. Geological Survey gaging station 09152500—Gunnison River near Grand Junction (Whitewater) for water years 1986–2014.—Continued

Sample date	Sample time	Streamflow, in cubic feet per second	Specific conductance, in microsiemens per centimeter	Dissolved-selenium concentration, in micrograms per liter
07/09/2007	14:15:00	1,270	981	4.9
09/05/2007	18:40:00	1,790	923	5.0
12/13/2007	11:42:00	1,810	752	5.2
04/28/2008	13:39:00	7,130	321	1.1
05/20/2008	12:15:00	12,500	307	1.1
08/13/2008	11:35:00	2,050	816	4.5
10/15/2008	14:00:00	1,840	962	5.4
01/27/2009	11:30:00	1,520	907	6.5
03/17/2009	11:45:00	1,410	653	3.7
06/02/2009	13:25:00	5,660	466	2.1
09/28/2009	14:15:00	1,880	904	6.3
11/10/2009	15:10:00	1,350	991	7.2
02/03/2010	14:20:00	1,330	732	4.4
04/08/2010	12:15:00	1,460	800	5.1
06/03/2010	15:15:00	3,160	537	2.8
07/20/2010	12:30:00	1,230	985	5.4
02/15/2011	15:15:00	1,480	707	4.2
03/25/2011	09:30:00	2,520	544	2.6
05/13/2011	13:20:00	6,150	390	1.6
07/13/2011	12:45:00	5,930	695	2.4
08/08/2011	12:00:00	1,970	830	4.3
09/20/2011	11:30:00	2,430	828	4.2
11/21/2011	09:20:00	1,460	936	6.4
12/06/2011	10:15:00	2,160	629	3.6
01/05/2012	10:45:00	1,610	682	4.1
02/21/2012	13:45:00	1,050	846	5.5
03/16/2012	12:20:00	1,270	709	3.9
05/25/2012	11:15:00	1,140	842	4.3
06/19/2012	09:30:00	1,010	899	4.7
07/11/2012	09:30:00	896	1,010	6.8
08/27/2012	09:45:00	1,210	1,070	6.1
10/24/2012	09:45:00	991	1,210	7.0
11/20/2012	12:15:00	859	1,140	7.0
01/16/2013	10:00:00	673	1,100	6.4
02/20/2013	10:00:00	649	1,060	6.1
04/23/2013	14:00:00	718	991	6.5
05/17/2013	15:00:00	3,360	460	2.3
07/23/2013	10:15:00	1,080	979	4.2
08/09/2013	14:30:00	1,320	1,000	4.5
09/05/2013	12:00:00	1,130	1,030	4.7
12/17/2013	13:30:00	885	1,060	6.0
03/07/2014	13:15:00	968	929	5.6
04/15/2014	12:00:00	2,540	497	2.3
05/28/2014	11:15:00	6,020	447	1.9
06/17/2014	12:15:00	8,110	345	1.1
08/14/2014	12:30:00	1,790	857	4.0
09/10/2014	12:45:00	2,330	1,030	5.2
09/23/2014	10:30:00	1,820	1,020	5.2

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