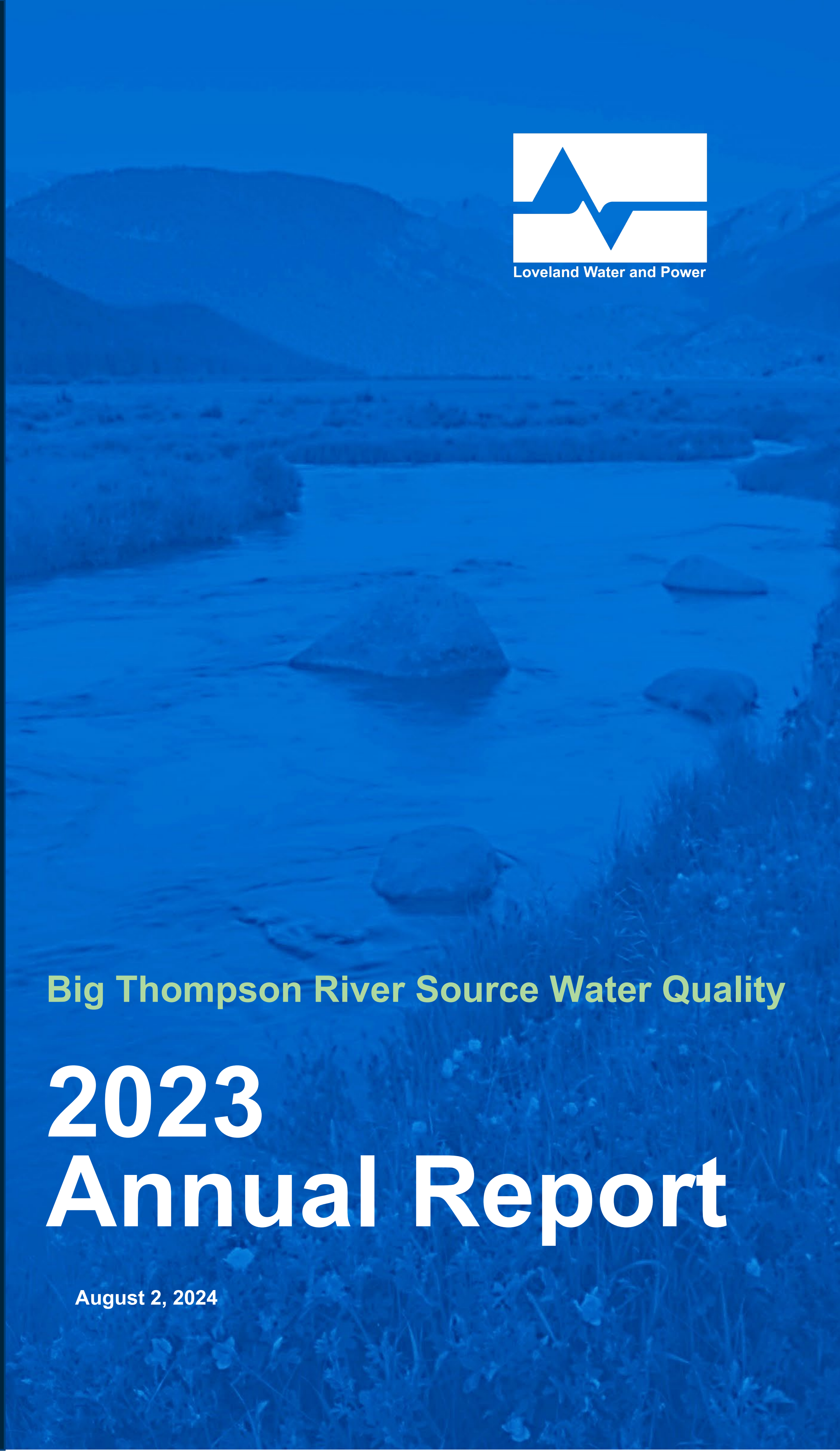

Loveland Water and Power

Big Thompson River Source Water Quality

2023 Annual Report

August 2, 2024

Loveland Water and Power

Contents

Common Acronyms

BTWF	Big Thompson Watershed Forum
CFS	Cubic Feet per Second
CPF	Cameron Peak Fire
CSWMP	Cooperative Source Water Monitoring Program
DO	Dissolved Oxygen
LWP	Loveland Water and Power
mg/L	Milligrams per liter (parts per million)
$CaCO_3$	Calcium carbonate
NTU	Nephelometric Turbidity Unit
North Fork	North Fork of the Big Thompson River
SU	Standard Units
SWMP	Source Water Monitoring Program
TOC	Total Organic Carbon
µg/L	Micrograms per liter (parts per billion)
µS/cm	Microsiemens per centimeter
USGS	United States Geological Survey

Executive Summary

The Big Thompson River continues to be a quality drinking water source for the City of Loveland, CO. Water quality in 2023 improved in some areas compared to recent years and some parameters also demonstrated long term improvement, as suggested by significant trends over the past decade. 2023 data also demonstrate some evidence of recovery from the Cameron Peak Fire (CPF) as some impacted water quality parameters improved. Other parameters reflected continued fire impacts. While there were some negative water quality impacts from the CPF, Loveland Water and Power (LWP) staff were able to utilize different drinking water sources and treatment as necessary to effectively manage these effects.

In 2023, the cooperative source water monitoring program between Loveland Water and Power (LWP) and the United States Geological Survey (USGS) collected samples that provided information on 51 different water quality parameters, representing a variety of different aspects of water quality, from nine locations within the Big Thompson River watershed. Sampling occurred from February through November and sampling has also occurred at these locations for more than 20 years. This long time series and relatively broad range of parameters provides a good understanding of the state of water quality as well as changes over time.

Water quality parameters that appear to demonstrate some recovery from the CPF include dissolved manganese and total organic carbon. The North Fork of the Big Thompson River (North Fork, T10) was the sampling location most affected by the CPF. In 2023, the median dissolved manganese concentration remained somewhat above the ten-year average value but was somewhat lower than it was in 2022 and substantially lower than it was in 2021. In addition, elevated manganese levels at sites downstream of the confluence of the North Fork with the main stem of the Big Thompson River (M70 and M90) caused by the elevated manganese in the North Fork seen in 2021 and 2022 were not apparent in 2023. Total organic carbon concentrations also appear to be returning to pre-fire levels. Unlike manganese concentrations, total organic carbon were generally depressed in the post-fire samples taken from the North Fork. Increasing TOC concentrations seen in 2023 are evidence of watershed recovery.

Although there is some evidence of watershed recovery from the CPF, other parameters including turbidity, inorganic nitrogen, and total nitrogen continue to be impacted. Turbidity, inorganic nitrogen, and total nitrogen concentrations increased in the North Fork after the CPF and appear to have remained elevated. These parameters are commonly elevated in a post-fire environment (Rust et al. 2018) and recovery can, depending on factors such as fire severity, climate, and geology, remain elevated for seven years or more (Rust et al. 2019).

There were water quality improvements apparent in 2023 that were unrelated to the CPF as well, including turbidity (except at site T10), copper, and orthophosphate. These parameters were relatively low across sites in 2023 when compared to values measured in the past decade. In addition, dissolved copper concentrations have declined significantly throughout the watershed during this time period. Similarly, although dissolved manganese levels have been somewhat elevated in response to the CPF, the overall trend at several sampling locations (T10, M30, and M50) was significantly negative. Dissolved manganese levels at these locations were very elevated immediately following the 2013 flood and have declined substantially in the past ten years. In addition, inorganic nitrogen and total nitrogen were very low at the site below the LWP WRF outfall (M140) thanks to continued successful operation of the biological nutrient reduction system.

There were also apparent changes in water quality in 2023 that may suggest future water quality issues. None of these changes were of immediate concern but are worth monitoring in case they require management actions in the future. Both sodium and chloride concentrations have increased significantly at several sites in the canyon portion of the Big Thompson River. These increases are likely due to the use of ice-melting materials on roadways during the winter months. However, sodium and chloride levels remain far below drinking water and aquatic life use standards. Total coliform concentrations have also increased significantly throughout the watershed without an obvious cause. However, recreational use standards are generally established for *E. coli* concentrations rather than total coliform, and although there were significant increases in *E. coli* concentrations over time in the last decade at two sites below WRF discharges (M50 and M140), *E. coli* concentrations were only infrequently above standard values. In addition, *E. coli* standard values are meant to be calculated as the two-month geometric mean (WQCC 2023a) so individual values above the standard are not of immediate concern.

Introduction

The purpose of the Loveland Water and Power (LWP) Source Water Monitoring Program (SWMP) is to collect, analyze, and interpret water quality data that are of interest with regard to drinking water, wastewater, recreation, and aquatic ecosystems. These data are used to identify and quantify current issues, document management successes, evaluate regulatory compliance and the appropriateness of current water quality standards, and identify issues that may present themselves in the future.

One central component of the SWMP is the cooperative source water monitoring that occurs in partnership with the USGS. The USGS is recognized as one of the world leaders in water quality data collection, analysis, and data storage. USGS has participated in data collection efforts in the Big Thompson River for over 20 years and its database includes a wide range of water quality parameters. Sites were previously sampled as a result of a cooperative agreement between the Big Thompson Watershed Forum (BTWF) and the USGS. LWP was a substantial contributor to the BTWF. The BTWF ceased data collection efforts in 2020. LWP, recognizing the importance of this dataset and its continuity, assumed the partnership role with the USGS in 2021. This partnership maintained the continuity of important water quality data collection and allowed the efforts to better reflect the needs of LWP. The USGS collects and analyzes a subset of water quality samples as requested by LWP Water Quality Staff. The resulting data are

statistically analyzed and summarized as appropriate to address water quality questions and issues of interest to LWP.

Historic USGS water quality data in the Big Thompson River are substantial in breadth and depth. For over 20 years, more than 40 parameters have been collected monthly from 9-15 core sites within the watershed. The fact that these data are standardized, easily available (https://www.waterqualitydata.us/), have a long time series, and include a large number of parameters, provides opportunities to quantitatively evaluate long-term trends (e.g., Stets et al. 2020, Stevens 2003), investigate potential causes of changes in water quality (e.g., Fayram et al. 2019, Voelz et al. 2005), be included in broad-scale investigations that may be of local utility (Kaushal et al. 2018, Spahr et al. 2010), and characterize changes to water quality in response to management actions or natural events (e.g., Mast et al. 2016). The diversity of parameters sampled increases the likelihood that long-term historical data will exist to examine the status of various river segments regarding new or changing regulations or circumstances. The ready access of current and historic data means that more people will be examining and utilizing Big Thompson River Watershed information. The greater the exposure, the higher the likelihood that analyses relevant to LWP and the watershed as a whole will take place.

Scope

Data, summary statistics, and results presented here are those collected and analyzed by USGS staff at the request of LWP (and previously BTWF) over the past ten years. These data represent conditions present in Big Thompson River source water for LWP and while these conditions help determine water treatment methodology at the WTP, they do not reflect drinking water quality. While the ten-year time period is an arbitrary length of time, it is long enough for significant trends to emerge, or begin to emerge, and also short enough to adequately reflect current ambient conditions. The annual sampling frequency of these data is ten months/year (February-November) as this follows the historical data collection schedule. This frequency is also sufficient to capture seasonal events and is representative of annual conditions in general (Giardullo 2006). The objective of this annual report is to summarize data collected in 2023, compare sample results to established water quality standards and comparable data collected over the past ten years, and quantify any significant temporal trends in water quality parameters that may exist. Results can aid in identifying emerging water quality issues, which can in turn be used to begin developing appropriate water treatment and watershed management activities.

Sampling Locations

The nine core sites included in this sampling effort are located from the headwaters of the Big Thompson River in Rocky Mountain National Park to the plains portion of the watershed past the City of Loveland (Figure 1, Table 1). Cumulatively, these sites provide an opportunity to understand the condition of the watershed as a whole. In addition, each sampling location has site-specific characteristics of interest. For example, downstream or upstream of the LWP wastewater discharge.

Table 1. USGS Cooperative Surface Water Monitoring Program location descriptions.

Site	USGS Site Name	Water Body	Description	Latitude	Longitude
M10	402114105350101	Big Thompson River	Downstream of Moraine Park USGS Benchmark Site	40 21’ 14’’	105 35’ 01’’
M30	402245105302300	Big Thompson River	Downstream of Estes Park Sanitation District Outlet	40 22' 45"	105 30' 23"
M50	402249105282000	Big Thompson River	Downstream of Upper Thompson Sanitation District Outlet	40 22' 49"	105 28' 20"
M60	402554105202100	Big Thompson River	Upstream of the confluence with the North Fork Big Thompson River	40 25' 54"	105 20' 21"
M70	6736700	Big Thompson River	Upstream of Dille Tunnel diversion	40 24' 54"	105 15' 00"
M90	40253310512430	Big Thompson River	Upstream of Loveland drinking water intake	40 25' 33"	105 12' 43"
M130	6741510	Big Thompson River	Upstream of Loveland Water Reclamation Facility outlet	40 22' 43"	105 03' 38"
M140	6741520	Big Thompson River	Downstream of Loveland Water Reclamation Facility outlet	40 23' 00"	105 01' 45"
T10	6736000	North Fork Big Thompson River	Upstream of the confluence with the Big Thompson River	40 26' 00"	105 20' 18"

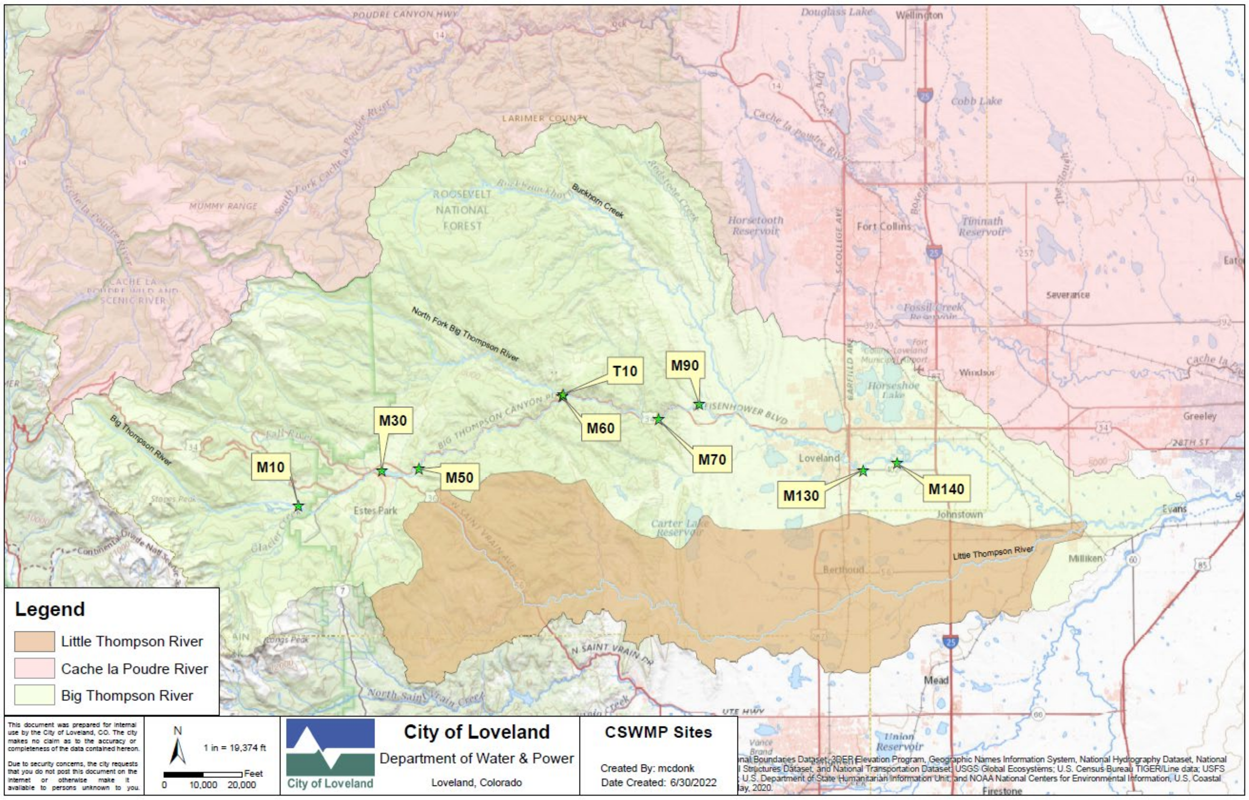

Figure 1. USGS Cooperative Surface Water Monitoring Program locations.

The sampling locations included in this report are those that have a long history of data collection as well as a specific rationale for inclusion. However, the USGS has historically collected water quality information at 37 sites within the Big Thompson Watershed and the eastern slope portion of the Colorado-Big Thompson Project. Data collected from some of the discontinued sites were collected for a specific short-term purpose and others were discontinued due to budgetary and/or logistical constraints.

Methods

Parameter Summaries

Each year, at least 51 different water quality parameters are quantified from water samples collected at nine sites in ten months of the year (Table 3). Data associated with additional parameters and/or months are collected due to regulatory requirements or site-specific conditions (e.g., dissolved selenium). The months of December and January have historically been excluded from sampling efforts due to difficult field conditions and the fact that water quality parameters are generally stable during the winter months.

Additional focus was placed on a subset of 18 parameters that are either commonly used to characterize water quality or are of potential concern regarding water quality standards. These parameters include flow, water temperature, specific conductance, dissolved oxygen, pH, alkalinity, total organic carbon, hardness, sulfate, turbidity, dissolved copper, dissolved manganese, dissolved selenium, nitrate + nitrite, orthophosphate, total nitrogen, total phosphorus, and *E. coli*. Specifically, the relative spread of data for each parameter at each site sampled between 2013 and 2023 was examined with box plots. The box plots also provide a reference point for the relative value of data collected in 2023.

A number of aquatic life use and drinking water standards apply to the principal parameters examined (Tables 4 and 5) and 2023 data were examined relative to these standards to provide an indication of the degree to which they are being met at the sampling locations. These standards are meant to be protective of aquatic ecosystems and human health. Water quality standards are used to provide context for the purpose of evaluating water quality status within and/or between sites. These comparisons are not meant to substitute for a formal surface water quality regulatory assessment under the federal Clean Water Act.

Table 3. Name, associated laboratory, analysis method, and detection limits of parameters included in 2022 sampling efforts.

Parameter	Detection Level	Laboratory	USGS Method
Barometric Pressure	n/a	USGS Field Staff	BAROM
Instantaneous Flow	n/a	USGS Field Staff	QSCMM
Oxygen, Dissolved	n/a	USGS Field Staff	LUMIN
pH	n/a	USGS Field Staff	PROBE
Specific Conductance	n/a	USGS Field Staff	SC001
Stream Width	n/a	USGS Field Staff	-
Temperature, Water	n/a	USGS Field Staff	THM01
Acidity (H+)	n/a	NWQL	ALGOR
Alkalinity	4 mg/L	NWQL	TT040
Aluminum, Total	3 ug/L	NWQL	PLM77
Ammonia and Ammonium, Dissolved	0.2 mg/L	NWQL	SHC02
Arsenic, Dissolved	0.1 ug/L	NWQL	PLM10
Calcium, Dissolved	0.02 mg/L	NWQL	PLA11
Carbon Dioxide	n/a	NWQL	ALGOR
Chloride, Dissolved	0.02 mg/L	NWQL	ICO02
Chlorophyll a	0.1 ug/L	NWQL	50
Chromium, Total	0.5 ug/L	NWQL	PLM77
Copper, Dissolved	0.4 ug/L	NWQL	PLM10
Copper, Total	0.4 ug/L	NWQL	PLM77
E. coli	1 CFU/100 mL	LWQL	Colilert© Quantitray
Fluoride, Dissolved#	0.01 mg/L	NWQL	IC003
Hardness, Ca, Mg	n/a	NWQL	ALGOR
Hardness, Non-carbonate	n/a	NWQL	ALGOR
Inorganic Nitrogen, Dissolved	0.01 mg/L	NWQL	RED02
Iron, Dissolved	5 ug/L	NWQL	PLA11
Kjeldahl Nitrogen, Total	0.07 mg/L	NWQL	KJ008
Lead, Dissolved	0.02 ug/l	NWQL	PLM43
Magnesium, Dissolved	0.01 mg/L	NWQL	PLA11
Manganese, Dissolved	0.4 ug/L	NWQL	PLM43
Manganese, Total	0.4 ug/l	NWQL	PLM78
Nickel, Dissolved	0.2 ug/l	NWQL	PLM10
Nitrate, Dissolved, (as N)	n/a	NWQL	ALGOR
Nitrite, Dissolved (as N)	0.001 mg/L	NWQL	DZ001
Nitrite, Dissolved (as NO2)	n/a	NWQL	ALGOR
Nitrogen, Mixed Forms (NH3, NH4, NO2, NO3), Total	n/a	NWQL	ALGOR
Organic Carbon, Total	0.7 mg/L	LWQL	COM89
Organic Nitrogen, Total	n/a	NWQL	ALGOR
Orthophosphate, Dissolved (as P)	0.004 mg?L	NWQL	PHM01
Pheophytin a	0.1 ug/L	NWQL	50
Phosphorus, Dissolved (as P)	0.003 mg/L	NWQL	CL020
Phosphorus, Total (as P)	0.003 mg/L	NWQL	CL021
Potassium, Dissolved	0.3 mg/L	NWQL	PLO03
Selenium, Dissolved*	0.05 ug/L	NWQL	PLM10
Silica, Dissolved	0.05 mg/L	NWQL	PLA11
Silver, Dissolved	1 ug/L	NWQL	PLM43
Sodium Adsorption Ratio	n/a	NWQL	ALGOR
Sodium, Dissolved	0.4 mg/L	NWQL	PLA11
Sodium, Percent Total Cations	n/a	NWQL	ALGOR
Sulfate, Dissolved	0.02 mg/L	NWQL	ICO02
Total Dissolved Solids	20 mg/L	NWQL	ROE10
Turbidity	2 NTU	NWQL	TS098

Temporal Trends

Forty-nine water quality parameters were analyzed for temporal trends over the past decade using a non-parametric seasonal Mann-Kendall trend test. Parameter values below detection limits were set to half of the detection limit or were omitted if detection limit values were not available. The non-parametric nature of this test does not require the data to be normally distributed and the effect of outliers is minimized, both of which are generally advantageous when analyzing water quality data. The primary disadvantages to this test are that the power to detect a trend is somewhat lower than for parametric tests (Mozejko 2012) and that a significant trend can include a somewhat misleading slope of zero. While a slope of zero intuitively implies lack of a trend, the Mann-Kendall test measures the direction of increases or decreases over time, not the magnitude. Therefore, it is possible that a large enough proportion of the samples are increasing (or decreasing) over time to provide a significant result, but the offsetting magnitudes of increases and decreases may result in a slope of zero. For example, if a parameter were to increase each year by a small amount (e.g., 1 unit) for ten years and then decrease by a large amount (e.g., 10 units) in the next year, the number of increases would be 10 and the number of decreases would be 1, providing evidence of a significant upward trend. However, the resulting slope based on the magnitude of the increases and decreases would be approximately flat or zero. An additional consideration in interpreting statistical results is the relationship between the large number of tests and the alpha level. The alpha level considered to be significant is $p = 0.05$, which suggests that one out of every twenty tests will appear to have a significant trend simply due to chance rather than an actual trend. Therefore, it is important to examine patterns or causative relationships that may be present in statistical test results. For example, if a decline in a particular parameter is significant across all sites or neighboring sites, it is more likely to be a valid trend than if it exists in isolation. To be included in the analysis for temporal trend, parameters needed to be sampled both in 2023 and in at least two other years in the previous ten-year period

Table 4. Metal standards according to Colorado Regulations 31 and 38 (WQCC 2023a, WQCC2024b). All standards listed are in dissolved form and in units of µg/L.

Segment	Site	Copper (acute)[1]	Copper (acute)[1]	Selenium (acute)	Selenium (chronic)	Manganese (acute)[1]	Manganese (chronic)[1]	Manganese (domestic water supply-chronic)
COSPBT01	M10	$e^{(0.9422*\ln(hardness)-1.7408)}$	$e^{(0.8545*\ln(hardness)-1.7428)}$	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	M30	$e^{(0.9422*\ln(hardness)-1.7408)}$	$e^{(0.8545*\ln(hardness)-1.7428)}$	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	M50	11	7.5	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	M60	11	7.5	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	M70	11	7.5	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	M90	11	7.5	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT03	M130	$e^{(0.9422*\ln(hardness)-1.7408)}$	$e^{(0.8545*\ln(hardness)-1.7428)}$	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT04	M140	$e^{(0.9422*\ln(hardness)-1.7408)}$	$e^{(0.8545*\ln(hardness)-1.7428)}$	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50
COSPBT02	T10	11	7.5	18.4	4.6	$e^{(0.3331*\ln(hardness)+6.4676)}$	$e^{(0.3331*\ln(hardness)+5.87743)}$	50

1. Maximum hardness value for acute and chronic standart calculations is 400

Table 5. Water quality standards according to 31, 38, and 93 (WQCC 2023a, WQCC2024b, WQCC2023c).

		Parameter									Clean Water Act (303(d)	
Segment	Site	Nitrate+Nitrite (domestic water supply-acute)	Sulfate (domestic water supply - chronic)	Dissolved Oxygen	pH (lower limit)	pH (upper limit)	Temperature (upper limit-acute)	Temperature (upper limit-chronic)	Temperature (upper limit-acute)	Temperature (upper limit-chronic)	Impairment	Priority
COSPBT01	M10	10	250	6	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	As, Cu, Hg, Zn	H,H,H,H
COSPBT02	M30	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	Macro, As, Cu, NO_3, Hg	H, L, M, H, H
COSPBT02	M50	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	As, Cu, Hg	L, H, H
COSPBT02	M60	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	As, Cu, Hg	L, H, H
COSPBT02	M70	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	As, Cu	L, M
COSPBT02	M90	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	As, Cu	L, M
COSPBT03	M130	10	250	5	6.5	9	29.0 [3]	24.2 [3]	24.6 [4]	12.1 [4]	As, Hg, Mn, Se	L, H, L, L
COSPBT04	M140	10	250	5	6.5	9	29.0 [3]	24.2 [3]	24.6 [4]	12.1 [4]	Hg	M
COSPBT02	T10	10	250	5	6.5	9	21.7 [1]	17 [1]	13 [2]	9 [2]	Cu, As, Hg	H, L, H

1. June-September
2. October-May
3. March-November
4. December-February

Parameter Descriptions and Results

General Parameters

Flow

Flow represents the volume of water passing by a given site over time measured in cubic feet per second (cfs). Flow was measured at all nine stations. Flow rate data presented are median values and as such do not address important components of flow such as seasonal dynamics. However, the data do capture site differences due to water diversions and tributary inputs (e.g., North Fork Big Thompson River confluence between M60 and M70 and LWP diversion below M90) as well as the relative flow compared to previous years.

Flows ranged from 1.8 cfs at site M10 in January to 435 cfs at site M30 in June. Flows were somewhat lower than average at all sites compared to the previous ten-year time period (Figure 4). Interestingly, the snowpack in the early spring 2023 was considerably above average (~160% of normal) but the runoff may have come fairly quickly given that median values were somewhat low.

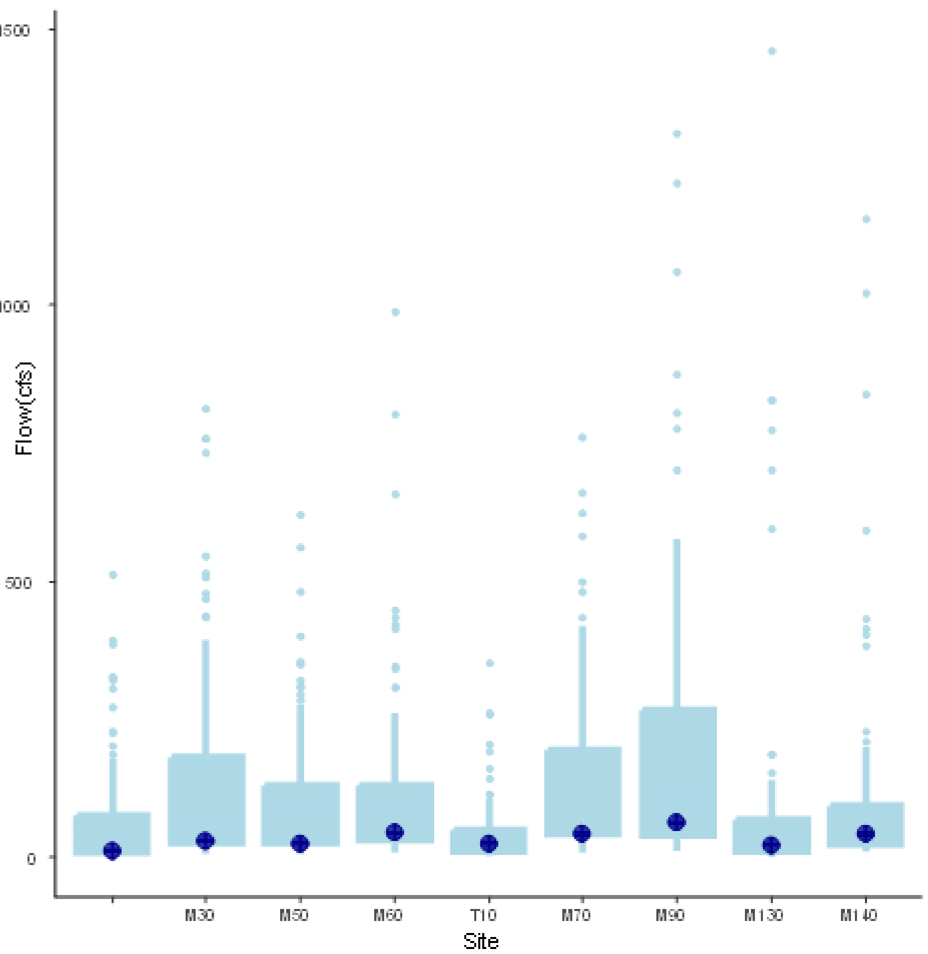

Figure 4. Box plot of flow data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Water temperature

Water temperature affects both aquatic organisms and drinking water treatment processes. Aquatic organisms have preferred and lethal temperatures. These temperatures vary widely and species with similar temperature tolerances are often associated with one another. Some organisms require relatively cold water to survive, particularly during spawning and other stressful time periods. Elevated water temperatures can cause reduced reproduction, growth, or mortality. Conversely, water temperatures can be too low for optimal growth and survival of some species, particularly those found in the lower reaches of the Big Thompson River. As such, temperature standards are based on species groups with similar thermal tolerances.

Segments of the Big Thompson River are classified as Coldwater I or Warmwater I. In addition, temperature is of interest to water treatment operators because the temperature of the water influences the speed at which chemical reactions used to treat drinking water take place. Chemical reactions generally take longer to complete in colder water.

Temperatures appeared to be slightly average or below average in 2023 compared to the previous ten-year time period. Temperatures ranged from an expected 0ºC at several sites in the winter months to a high of 18.7ºC at site M90 in September. While there were no recorded instances where the acute temperature standards were exceeded (Table 5), chronic standards were exceeded three times (3%) in 2023. In general, temperatures were lower than they were in 2022. However, temperatures in the reference time period included the first, third, fourth, sixth, seventh, and ninth warmest years on record in Colorado (1886-present) (Colorado Climate Center n.d.). There was a notable decrease in river water temperature between M130 and M140 during the summer and late fall months (May-October). This reduction took place because the water returned to the river via the outfall from the LWP Water Reclamation Facility is generally colder than ambient river temperatures during this time period.

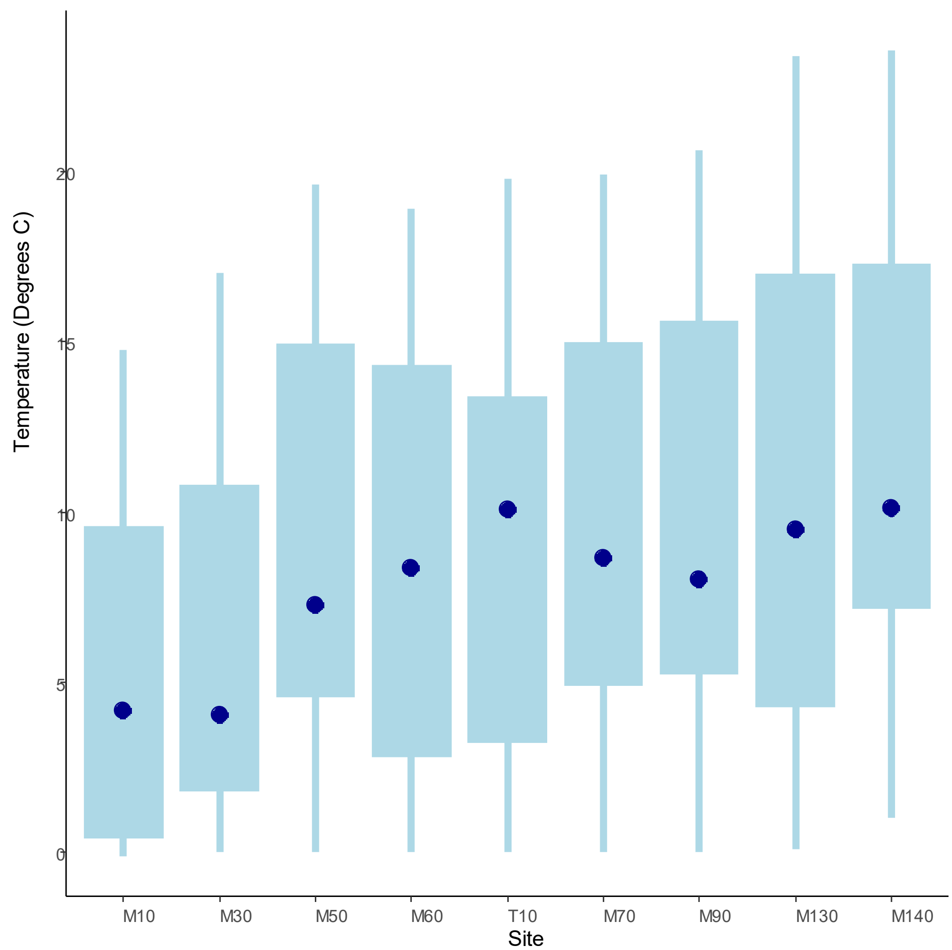

Figure 5. Box plot of temperature data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Specific conductance

Specific conductance is a measure of how well water conducts electricity. Specific conductance increases with increasing concentrations of ions that are dissolved in water such as chloride, sulfate, nitrate, phosphate, sodium, magnesium, calcium, potassium. and iron. Although specific conductance itself does not directly impact water quality, it is easily measured and indicates general seasonal and spatial differences in water quality. Specific conductance may also indicate whether an issue may exist that merits more detailed investigation. In 2023, specific conductance ranged from 16.5 µS/cm to 983 µS/cm at sites M10 in July and M130 in December respectively.

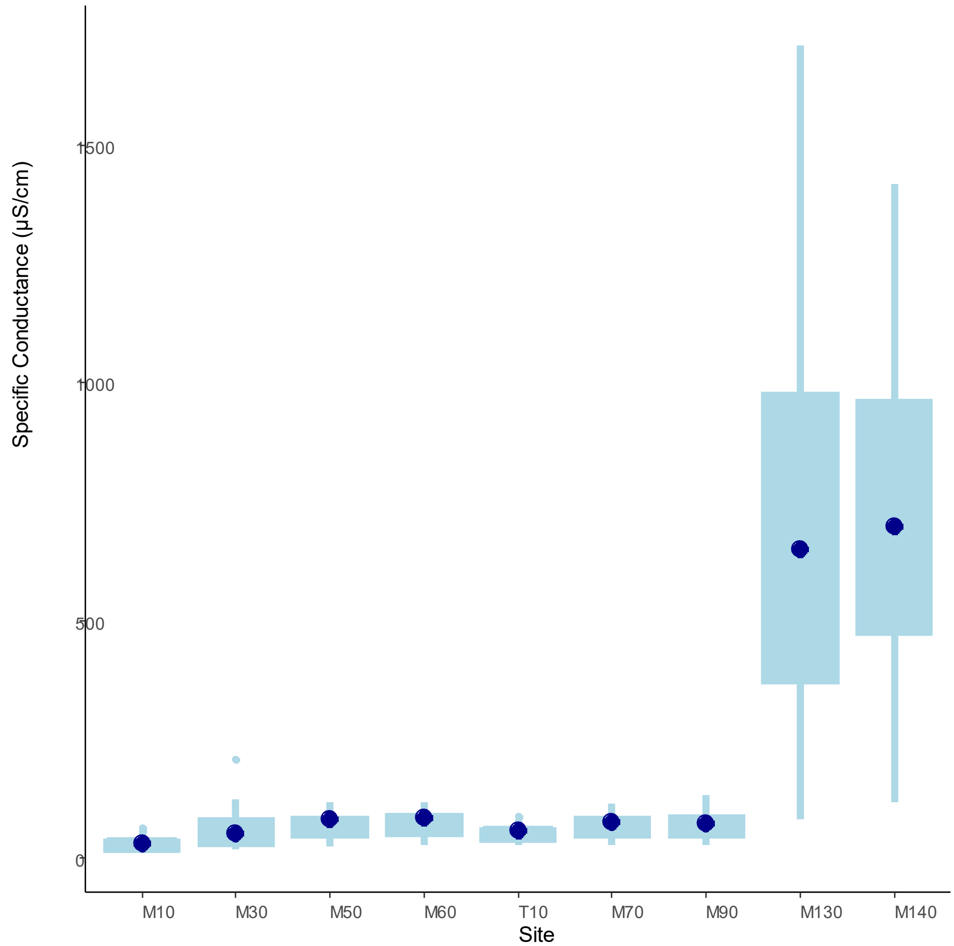

Figure 6. Box plot of specific conductance data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Dissolved Oxygen

Dissolved oxygen levels are important to aquatic life and drinking water facilities and are affected by a number of factors such as temperature, altitude, turbulence, and biological activity. Turbulent cold water at a low altitude can have higher levels of dissolved oxygen than stagnant warm water at a higher altitude. Biological activity (particularly photosynthesis) can increase dissolved oxygen during the day and can decrease dissolved oxygen levels at night when respiration dominates. Often biological activity has no net effect on dissolved oxygen levels, but it can increase the daily range of values with wider ranges being associated with greater biological activity. Virtually all aquatic organisms require dissolved oxygen to survive with the necessary concentration differing by species. For example, many fish species in the upper portion of the Big Thompson River have evolved to live in cold water streams and require higher concentrations of dissolved oxygen (e.g., cutthroat trout *Oncorhynchus clarkii*) than those that evolved to persist in the lower warm water portion of the river (e.g., plains killifish *Fundulus zebinus*). Aquatic organisms can experience mortality if the dissolved oxygen levels drop below their threshold level for even a short time. Although some life stages require higher levels of dissolved oxygen, a minimum threshold to support most aquatic life is 6 mg/L. In addition, dissolved oxygen levels regulate the degree to which some elements (like manganese) remain in solution. Relatively high dissolved oxygen levels allow these elements to precipitate out of the water column and make drinking water treatment easier.

Dissolved oxygen levels ranged from a high of 12.7 mg/L at site M140 in March to a low of 7.6 mg/L at site M50 in August. There were no recorded instances of dissolved oxygen levels declining below aquatic life use standards in 2023.

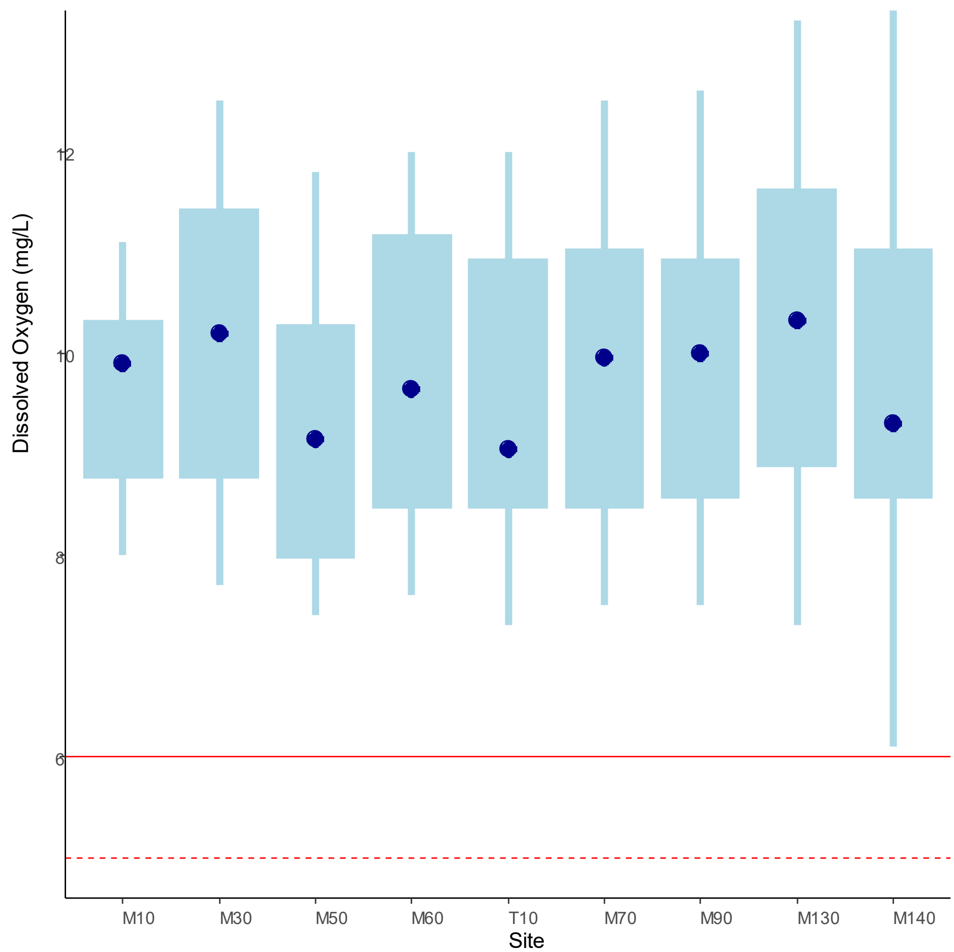

Figure 7. Box plot of dissolved oxygen data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the minimum CDPHE standard for site M10 and the dashed red line represents the minimum CDPHE standard for all other sites.

pH

The pH of water is a measurement of the degree to which it is acidic or basic. The number represents the concentration of hydrogen ions on a log scale and ranges from 0 to 14 SU with acidic conditions resulting in lower values and basic conditions resulting in higher values. The relative acidity of water can affect both water treatment and aquatic life. Relatively high (> 9 SU) and low (< 6.5 SU) can cause the aquatic environment to be inhospitable for many aquatic organisms. Water treatment processes, particularly flocculation, depend in part on the pH of the water. Flocculation is a process by which a coagulant is added to the water to cause bonding between water impurities which then are more prone to settling and are easier to separate. Low pH levels can impede the flocculation process while high pH can cause flocculated particles to re-disperse before settling.

Measured pH values ranged from a high of 8.2 SU at site M130 in November to a low of 6.6 SU at site M10 in June. There were no recorded instances when water samples were either above or below water quality standards at any site.

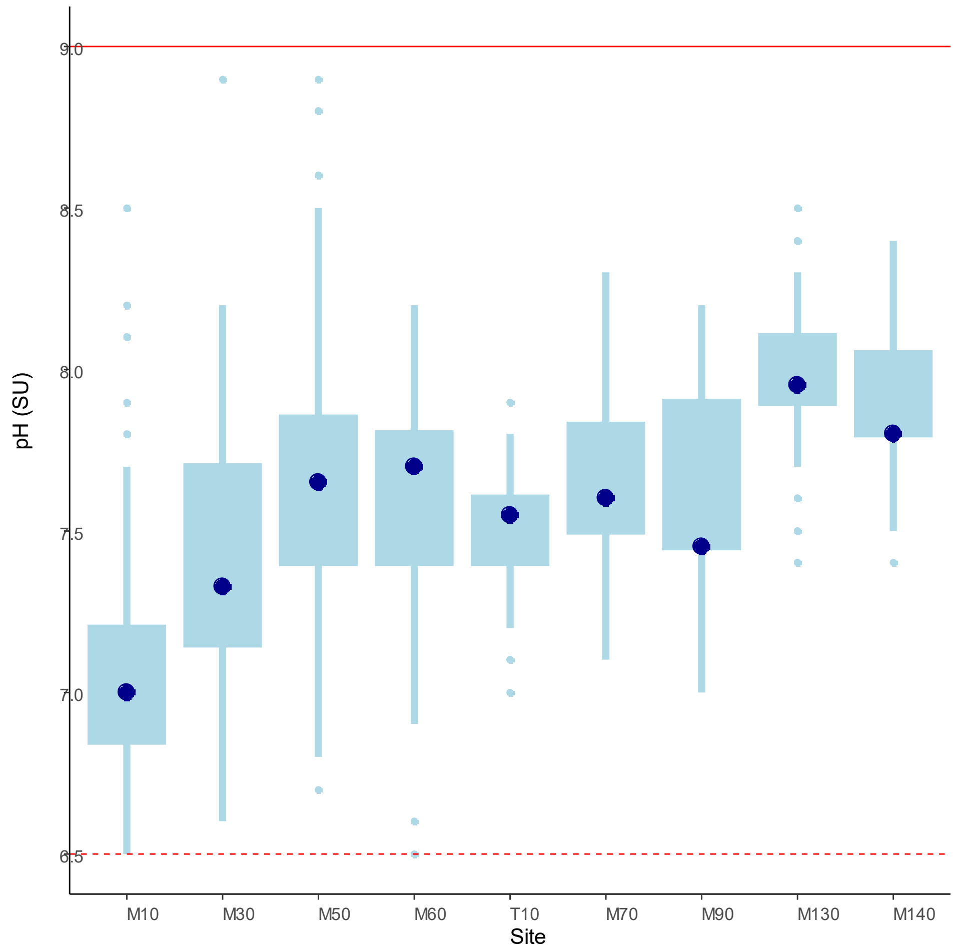

Figure 8. Box plot of pH data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the CDPHE standard upper limit and the dashed red line represents the CDPHE standard lower limit.

Alkalinity

Alkalinity is a measure of the degree to which water can resist acidic changes in pH (or buffer changes in pH). This buffering capacity is measured by the amount of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) anions in the water and is described in terms of mg/L $CaCO_3$. These anions buffer changes in pH by absorbing hydrogen ions when the water is acid and releasing them when it is basic. Higher alkalinity means higher amounts of acid will need to be added to the water before a change in pH occurs.

Alkalinity levels affect aquatic ecosystems and water treatment. Water treatment plants often use flocculation techniques to purify water and these techniques are generally optimized by altering the pH (Naceradska et al. 2019). High alkalinity makes this pH adjustment more difficult. Conversely, aquatic ecosystems can benefit from elevated alkalinity because water with a pH lower than approximately 6.5 can have negative effects on aquatic life.

Elevated alkalinity causes pH levels of 6.5 or lower to be less likely. In 2023, alkalinity ranged from 5.0 mg/L $CaCO_3$ at site M10 in July to 131 mg/L $CaCO_3$ at site M140 in February.

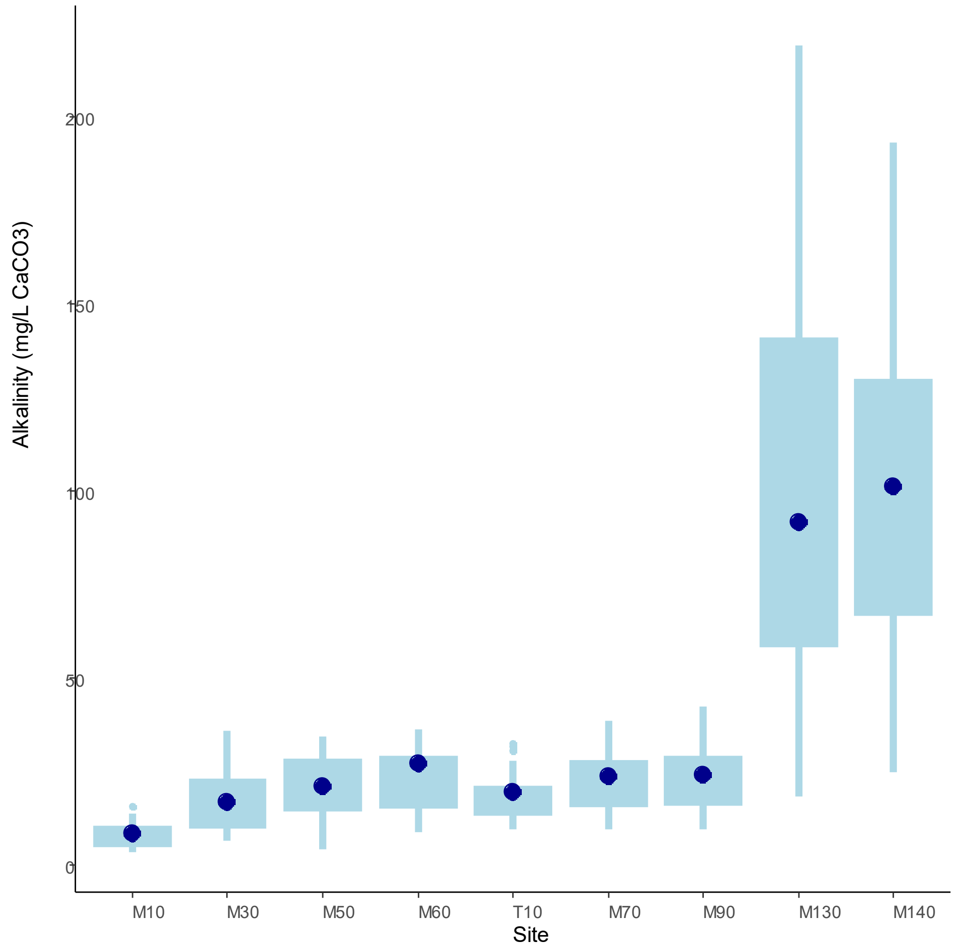

Figure 9. Box plot of alkalinity data representing the 2012-2021 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2022 median value.

Total organic carbon

Total organic carbon (TOC) is a measure of the amount of dissolved and particulate organic matter in a water sample. Organic carbon compounds are the result of the decomposition of organic matter such as algae, terrestrial plants, animal waste, detritus, and organic soils. The higher the carbon or organic content of a water body, the more oxygen is consumed as microorganisms break down the organic matter. Although TOC is not a direct human health hazard, the dissolved portion of the TOC can react with chemicals (chlorine and others) used for drinking water disinfection to form disinfection byproducts that are regulated as potential carcinogens. As such, TOC levels are of concern to drinking water treatment facilities.

The 2023 TOC levels ranged from a high value of 12.0 mg/L in July at site M90 to a low of 1.6 mg/L in February at site T10. TOC concentrations were somewhat low at several sites, including site T10, in 2023. While TOC concentrations often increase after a wildfire (Rust et al. 2018), TOC concentrations at site T10 (North Fork of the Big Thompson River) declined somewhat in the years following the CPF compared to most years pre-fire. The watershed associated with site T10 was among the most severely burned areas of the CPF and in severely burned areas, organic carbon is often reduced compared to unburned areas immediately after a fire (Rhoades et al. 2019).

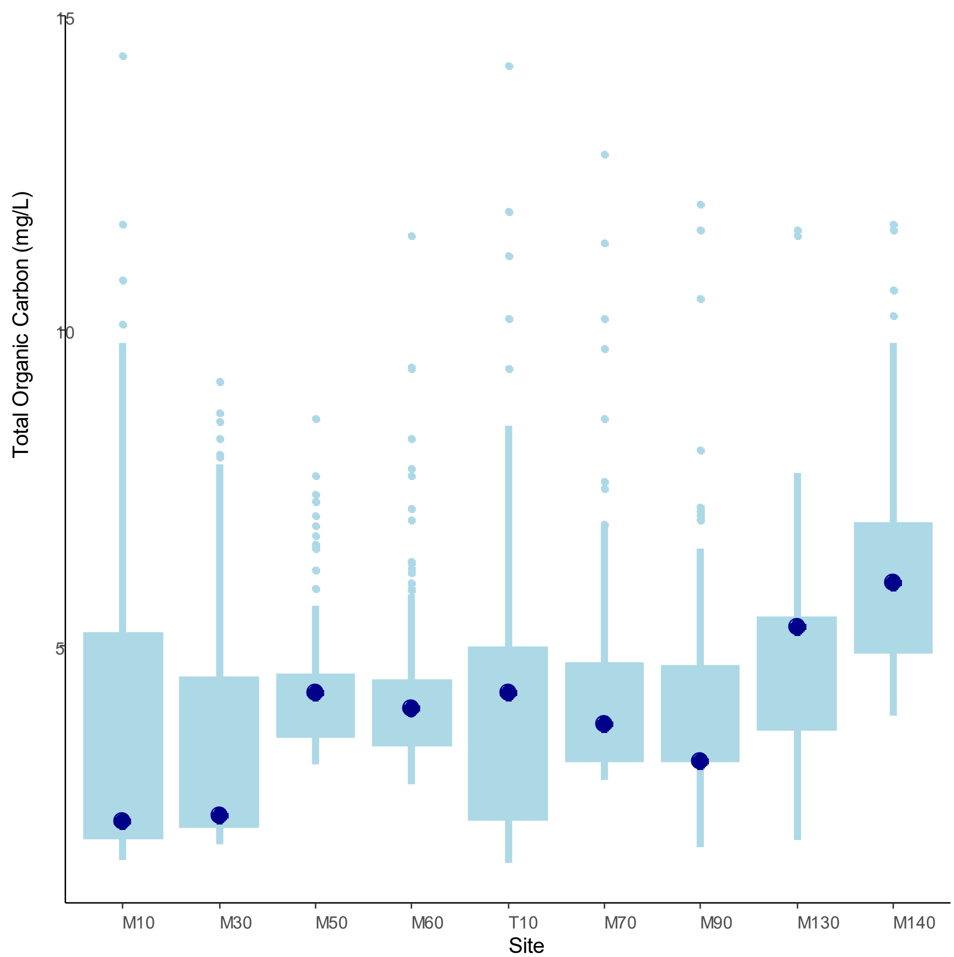

Figure 10. Box plot of total organic carbon data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Hardness

Hardness is a measure of the concentration of metal ions, primarily calcium and magnesium, measured as mg/L of $CaCO_3$. The presence of elevated hardness reduces the toxicity of dissolved metals such as copper (Chakoumakos et al. 1979) and manganese (Stubblefield et al. 1997) at a given concentration by decreasing the ability of these metals to bind to the gills of aquatic organisms. Therefore, even low levels of dissolved metals in water with low hardness can be an issue of concern. In 2023, hardness values ranged from 5.26 mg/L $CaCO_3$ at site M10 in July to 377 mg/L $CaCO_3$ at site M130 in February.

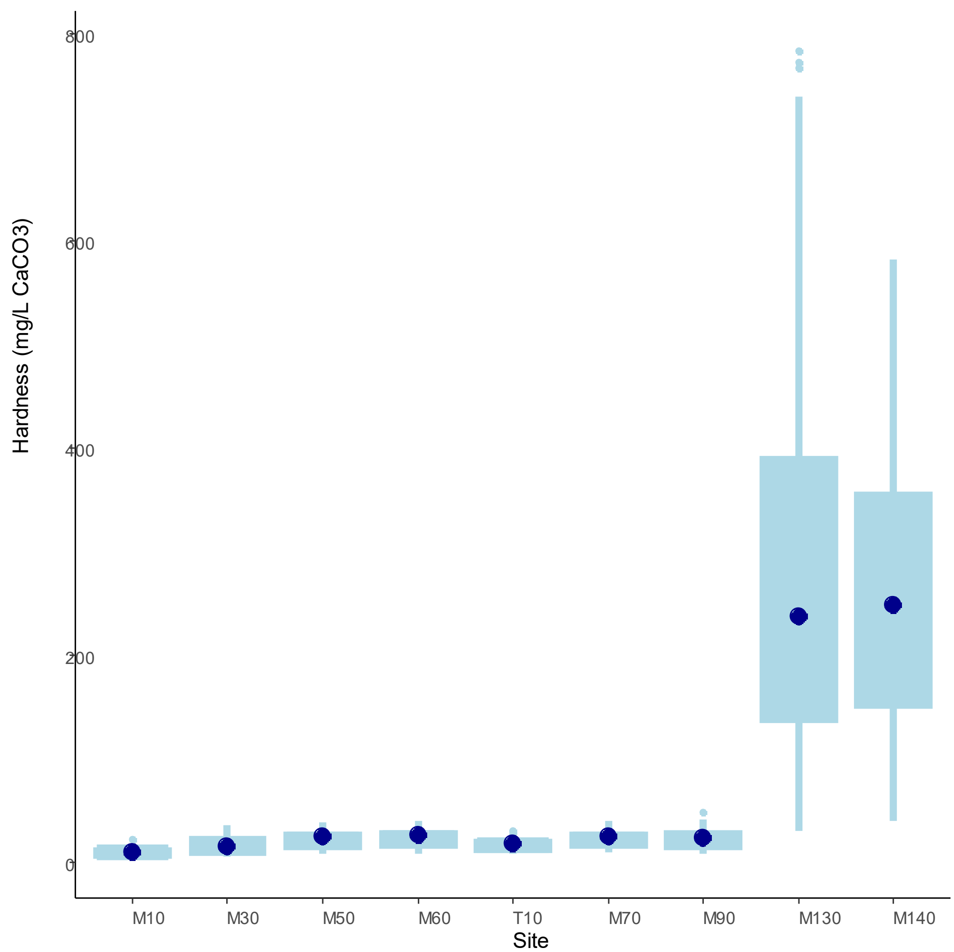

Figure 11. Box plot of hardness data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Sulfate

Sulfate is a common, naturally occurring ion and is the primary form that sulfur takes in oxygenated waters such as the Big Thompson River. Sulfate is of interest due to taste and gastrointestinal issues that elevated levels may cause in drinking water. A treated drinking water secondary standard (non-enforceable guidance level for aesthetic quality) of 250 mg/L has been adopted for sulfate. Sources of sulfate include the decay of organic matter, acid mine drainage, industrial effluent, runoff from fertilized agricultural lands, atmospheric deposition, and wastewater treatment plant effluent. Sulfate can also be present in surface and ground waters at elevated concentrations due to interactions with soluble evaporite minerals such as gypsum in sedimentary bedrock. Pierre Shale, a source of selenium within the lower portion of the watershed, is also a source of sulfate.

Sulfate values ranged from 1.23 mg/L to 275 mg/L at sites M10 in July and M130 in March, respectively. There were four occasions when the drinking water standard of 250 mg/L was exceeded. The exceedances occurred in the months of February-March at sites M130 and M140. Although the values at M140 (below the Wastewater Reclamation Facility outfall) were above the drinking water standard in the spring, the values during this time were lower at M140 than they were at M130 (above the Wastewater Reclamation Facility outfall) in both February and March. These results suggest that the WRF outfall dilutes sulfate levels in the Big Thompson River, at least during periods with elevated sulfate levels in the river.

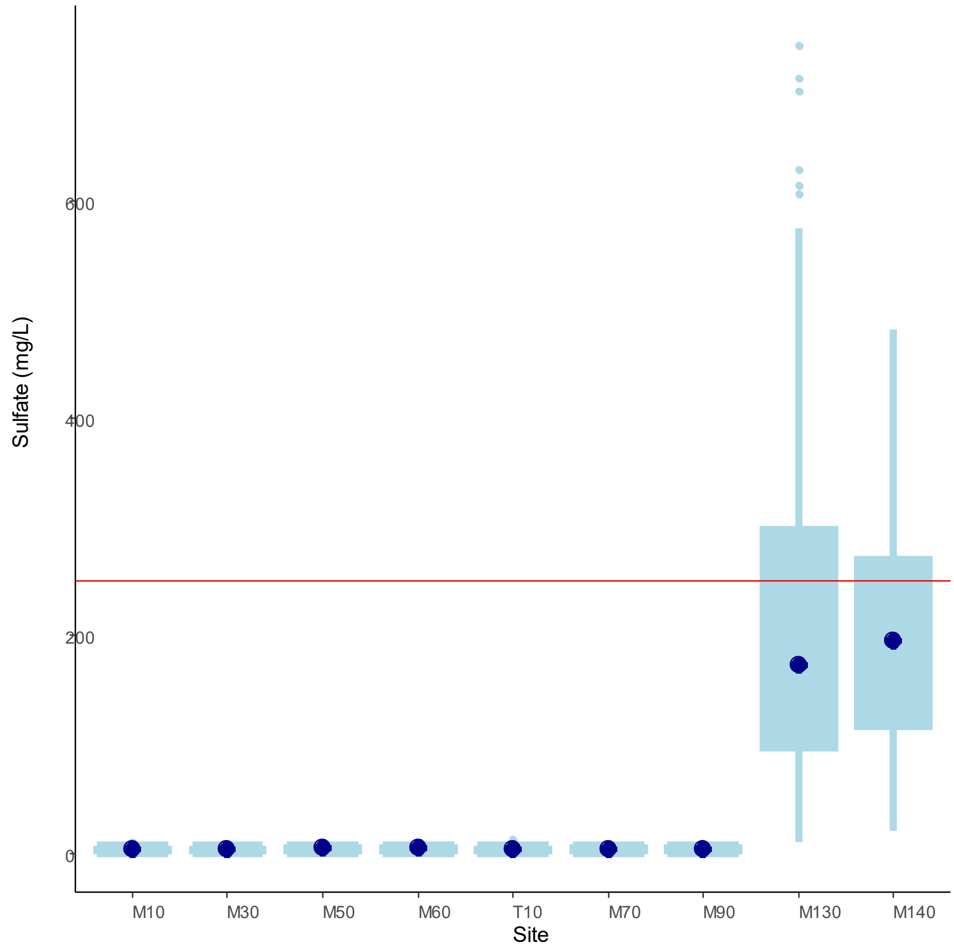

Figure 12. Box plot of sulfate data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the EPA secondary drinking water standard.

Turbidity

Turbidity is essentially a measure of water clarity. Water with higher turbidity levels is less clear because it contains a higher number of suspended particles. Elevated turbidity has negative impacts on municipal water treatment plants and aquatic communities. High turbidity generally means there is increased sediment in the water. Handling sediment is a challenge to drinking water utilities. Turbidity levels are also positively associated with TOC levels which require additional water treatment. LWP alters the location of their water collection when turbidity rises above 100 NTU. Elevated turbidity can have direct negative effects on aquatic organisms in addition to indirect effects such as increasing the levels of some dissolved metals. Elevated turbidity and suspended sediment can negatively affect macroinvertebrate and fish densities and can also negatively affect macroinvertebrate species richness. Effects of elevated turbidity become more severe with longer exposure.

Turbidity ranged from a low of 1 NTU at several stations and months (primarily during the low flow period (October-April) to a high of 99 NTU at site M140 in June. Median turbidity values were somewhat low compared to the previous ten-year period except at site T10. Among the sites included here, site T10 was most affected by the CPF and continues to exhibit elevated turbidity since the fire.

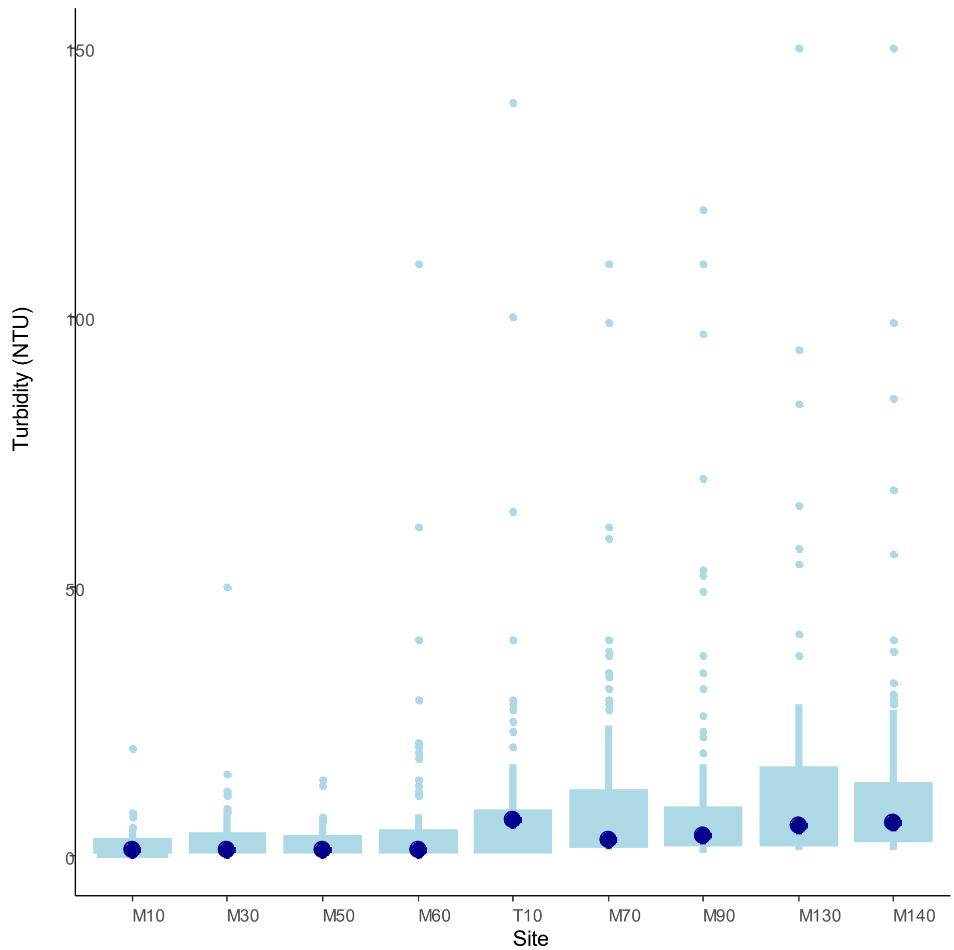

Figure 13. Box plot of turbidity data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. Several elevated values do not appear in this figure to improve readability.

Metals

Copper

Dissolved copper is important primarily due to its potential effects on aquatic life. While copper is an essential nutrient at low concentrations, it can be toxic at higher levels. Acute effects include mortality and chronic effects can lead to reduced survival, growth, and reproduction of aquatic organisms. Copper toxicity is determined in part by the hardness of the water. Toxicity to aquatic organisms is lower when hardness is higher because dissolved copper is less bioavailable when hardness is high.

Dissolved copper values ranged from 0.49 µg/L at site T10 in March to 3.1 µg/L at site M130 in June. While there were no instances of dissolved copper concentrations exceeding the hardness-based acute standard, there were six instances where measured values exceeded the chronic standard. All the measured values that exceeded the chronic standard occurred in the upper portion of the watershed (four at site M10 and two at site M30) in the summer months. Copper levels in the upper portion of the watershed are fairly low but are of concern because hardness values are also low enough to cause dissolved copper to be bioavailable.

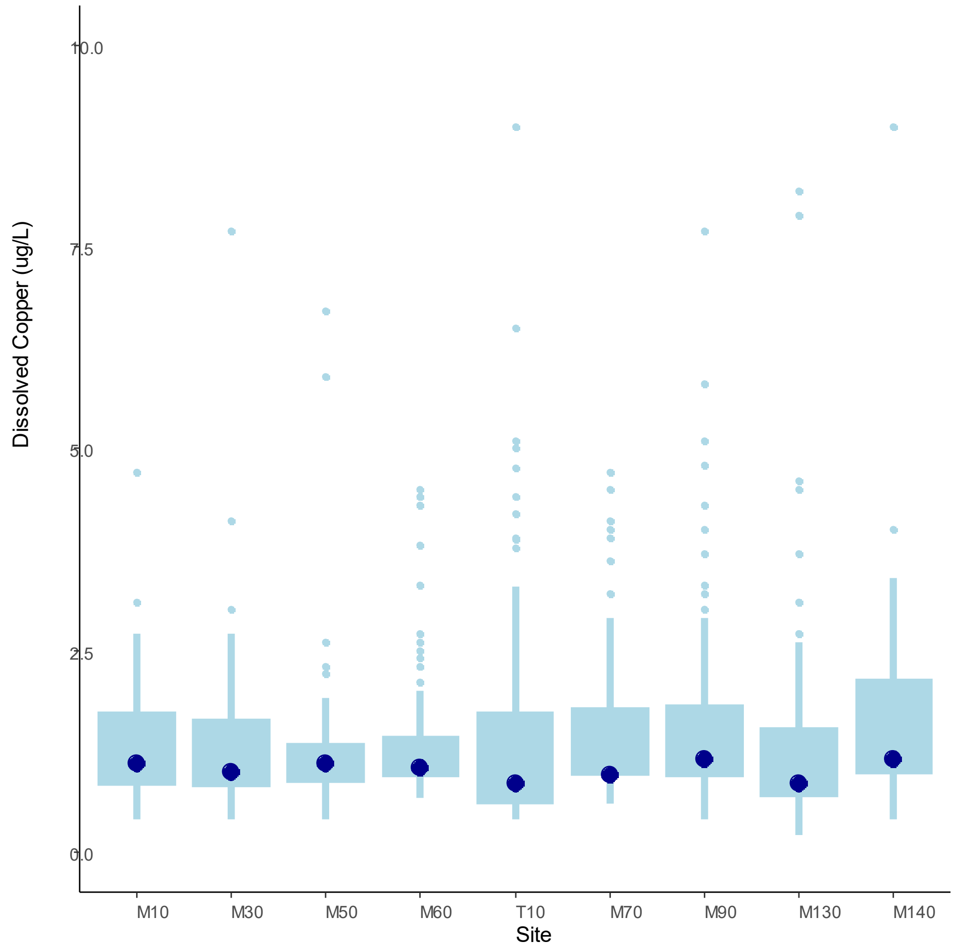

Figure 14. Box plot of dissolved copper data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value.

Manganese

Dissolved manganese is only a health concern in drinking water at very high levels (>300 µg/L), but a secondary standard of 50 µg/L exists due to the ability of dissolved manganese to produce reddish/black/brown stains on laundry, plumbing, sinks, and showers. In addition, drinking water with dissolved manganese levels greater than 50 µg/L can have a metallic taste. Aquatic organisms can be negatively affected by particularly elevated dissolved manganese levels that are based on the hardness of the water and are much higher than the secondary drinking water standard.

Dissolved manganese values in 2023 ranged from 1.36 µg/L at site M60 in February to 112 µg/L at site M130 in March 2023. There were no recorded instances of chronic or acute exceedances of hardness-based aquatic life standards but eight instances of exceeded the secondary drinking water standard (50 µg/L). All exceedances occurred in the lower portion of the river at sites M130 and M140.

Like dissolved copper, manganese values increased at site T10 and sites downstream after the CPF. Rust et al. (2018) also documented a general increase in dissolved manganese in surrounding waters after wildfire events. While the effects on manganese at downstream sites appear to have dissipated somewhat (lower values at sites M70 and M90), manganese values continue to be slightly elevated at the site most affected by the CPF (T10).

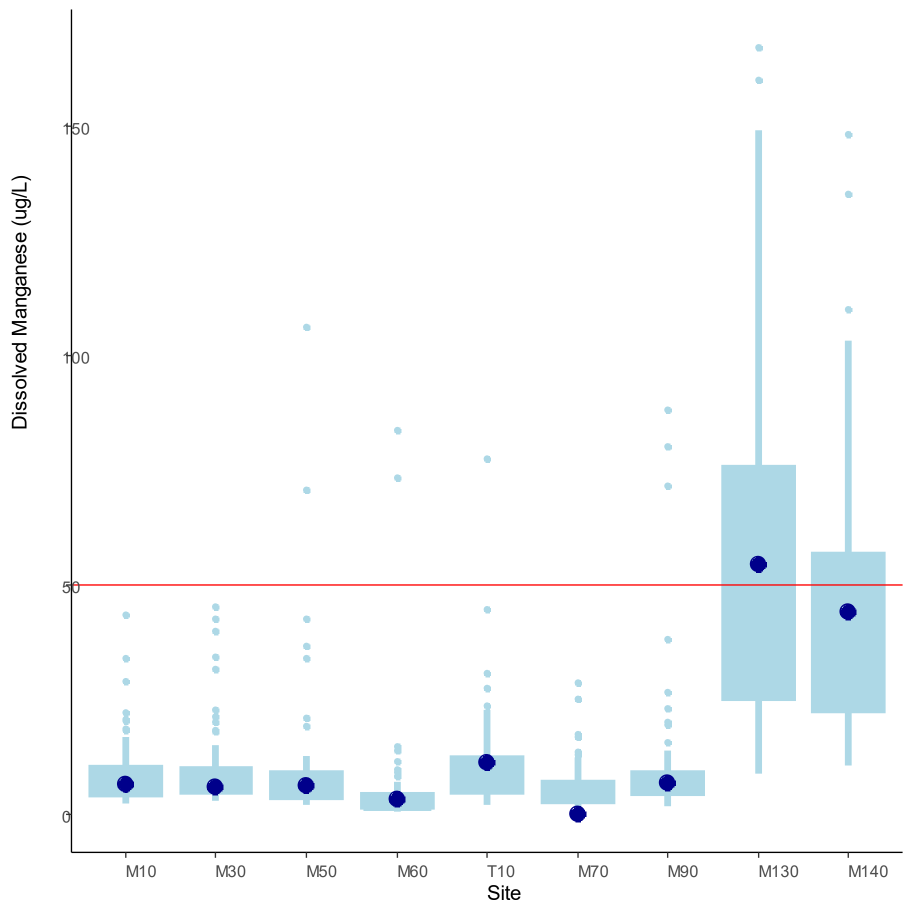

Figure 15. Box plot of flow dissolved manganese representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the EPA secondary drinking water standard.

Selenium

Elevated selenium levels in water can negatively affect aquatic organisms and are therefore included in this report. Acute and chronic aquatic life standards of 18.4 µg/L and 4.6 µg/L, respectively, have been adopted for all stream segments in the Big Thompson Watershed. Several segments of the Big Thompson River are listed as impaired for selenium on Colorado's 303(d) List. However, selenium occurs at elevated levels primarily due to the bedrock geology of the watershed. The lower portion of the watershed, below the canyon mouth, includes a type of bedrock called Pierre Shale (Hart 1974) which is enriched in selenium.

Selenium values reflected the prevalence of Pierre Shale bedrock with concentrations near zero at site M90 and as high as 3.5 µg/L at site M130 in the late winter months (February and March). Dissolved selenium levels are generally highest during low flow periods in December-April. Values during this time were lower at M140 than they were at M130 (above the Wastewater Reclamation Facility outfall) suggesting that the WRF outfall acts to dilute dissolved selenium levels in the Big Thompson River, at least during time periods with elevated selenium levels in the river. In general, selenium concentrations were somewhat low compared to the previous ten-year time period but similar to concentrations documented in 2021 and 2022.

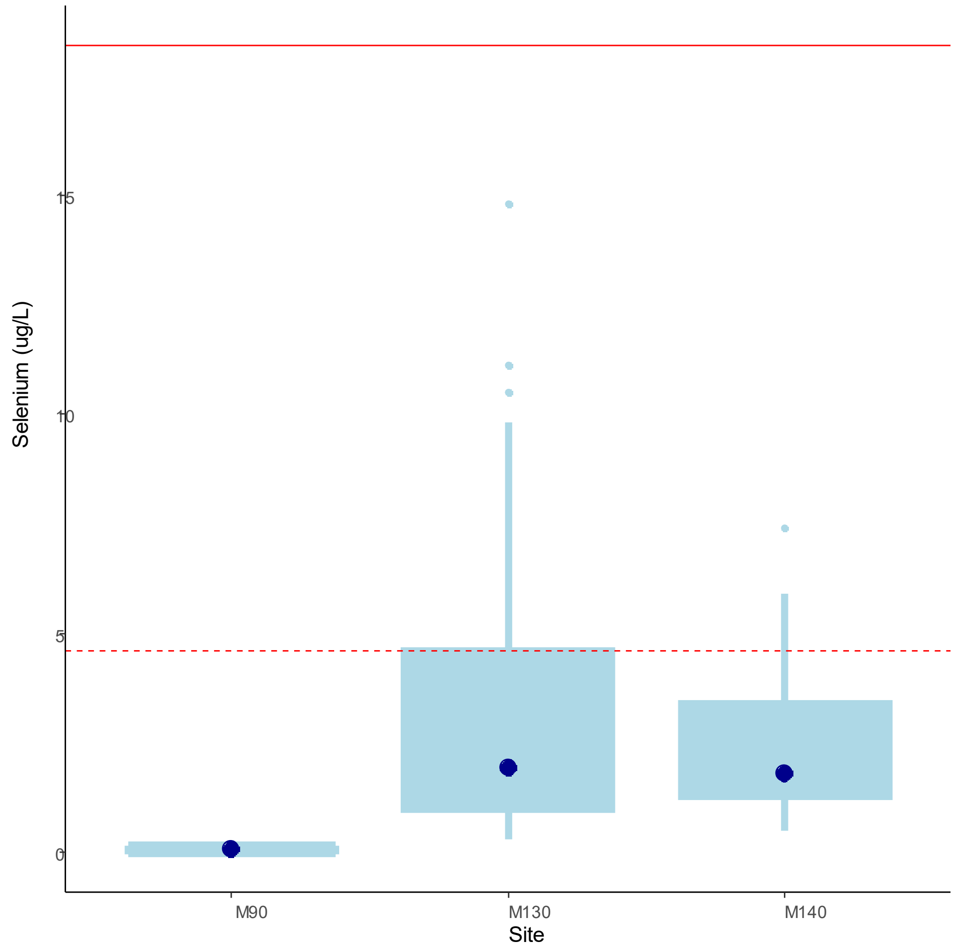

Figure 16. Box plot of dissolved selenium data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the CDPHE acute standard and the dashed line represents the CDPHE chronic standard.

Nutrients

Nitrate + Nitrite

Nitrate and nitrite are of interest due to their role in aquatic plant growth and their potential effects on human health. Nitrate, along with ammonia, is a form of nitrogen that is available for immediate uptake by algae and is of interest for its role in determining the productivity of waterbodies. At higher concentrations (e.g., >10 mg/L), nitrate can be of concern in drinking water because it can reduce the oxygen-carrying capacity of hemoglobin in humans and create a condition known as “methemoglobinemia” particularly in those under two years of age. Nitrite is also available for uptake by algae but is rarely present at significant concentrations. Inorganic nitrogen levels ranged from 3.25 mg/L at site M140 in June to a low of 0.05 mg/L at site M90 in April.

There were no recorded instances of inorganic nitrogen levels exceeding the drinking water standard of 10 mg/L. However, inorganic nitrogen levels continued to be elevated at sites located in the canyon portion of the Big Thompson River (M50-M90, T10) resulting from the CPF compared to the ten-year median values.

Conversely, inorganic nitrogen concentrations at site M140 (below the WRF discharge) were somewhat low in 2023 compared to both the ten-year median value (Figure 17) as well as median values from 2021 and 2022. In 2018, a Biological Nutrient Reduction (BNR) system was installed at the WRF resulting in reduced inorganic nitrogen concentrations. The BNR process utilizes anoxic and oxic environments to encourage the nutrient-reducing actions of particular bacteria. During the latter part of 2022 and all of 2023, the WRF employed a different and additional treatment methodology ("Step-Feed") to further reduce nutrients in the effluent. Based on 2023 results, this method of treatment appears to have been successful in reducing inorganic nitrogen loading from the WRF into the Big Thompson River from a median value of 3.25 mg/L in 2022 to a median value of 1.28 mg/L in 2023.

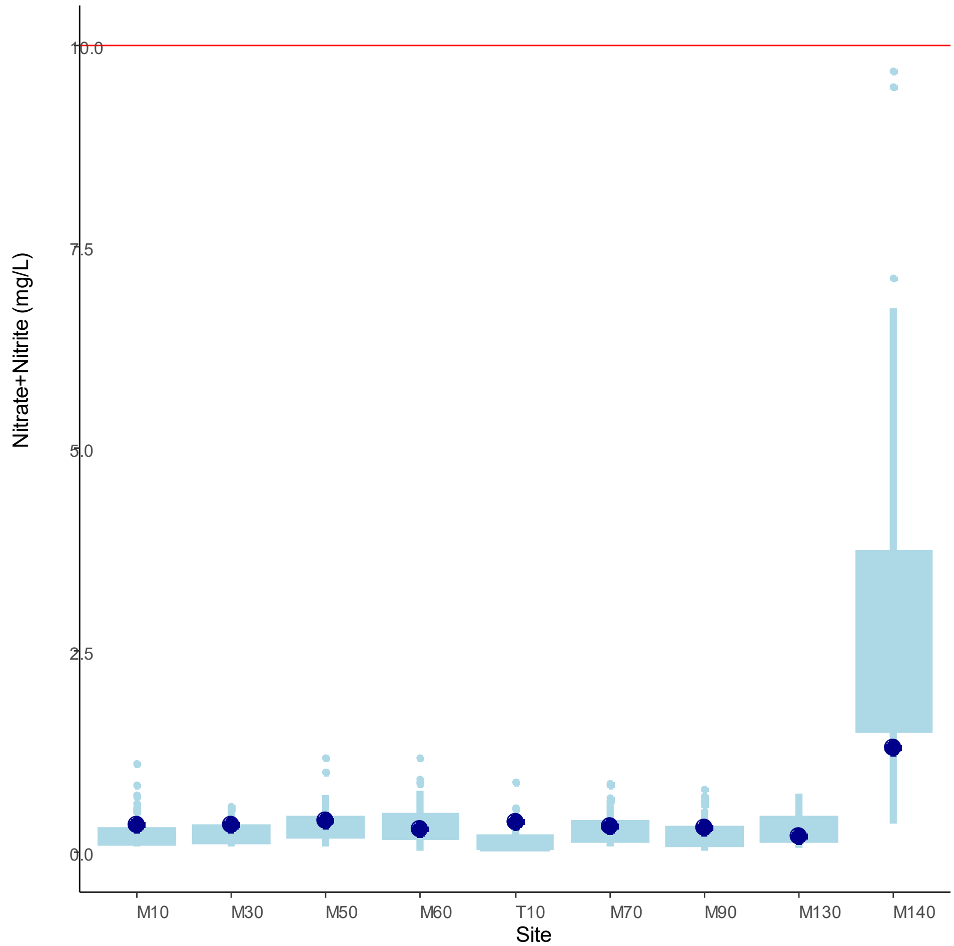

Figure 17. Box plot of nitrate + nitrite data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the EPA primary drinking water standard. Several elevated values do not appear in this figure to improve readability.

Orthophosphate (Ortho-P)

Orthophosphate is a dissolved form of phosphorus and is the only form that is immediately available for uptake by algae. Sources of orthophosphate include the decay of plant debris and other organic matter, the minerals that form rocks, soils, and sediments in the watershed, wastewater treatment plant effluent, failing individual sewage disposal systems, runoff from fertilized agricultural lands and urban areas, and erosion of stream channels, dirt roads, construction sites, and other land surfaces.

Orthophosphate levels ranged from 0.0085 mg/L (as P) at site T10 in July to a high of 0.545 mg/L at site M50 in March. Similar to inorganic nitrogen, orthophosphate concentrations were lower at site M140 in 2023 than the ten-year median value (Figure 18) but were as low as 2021 and 2022 median values.

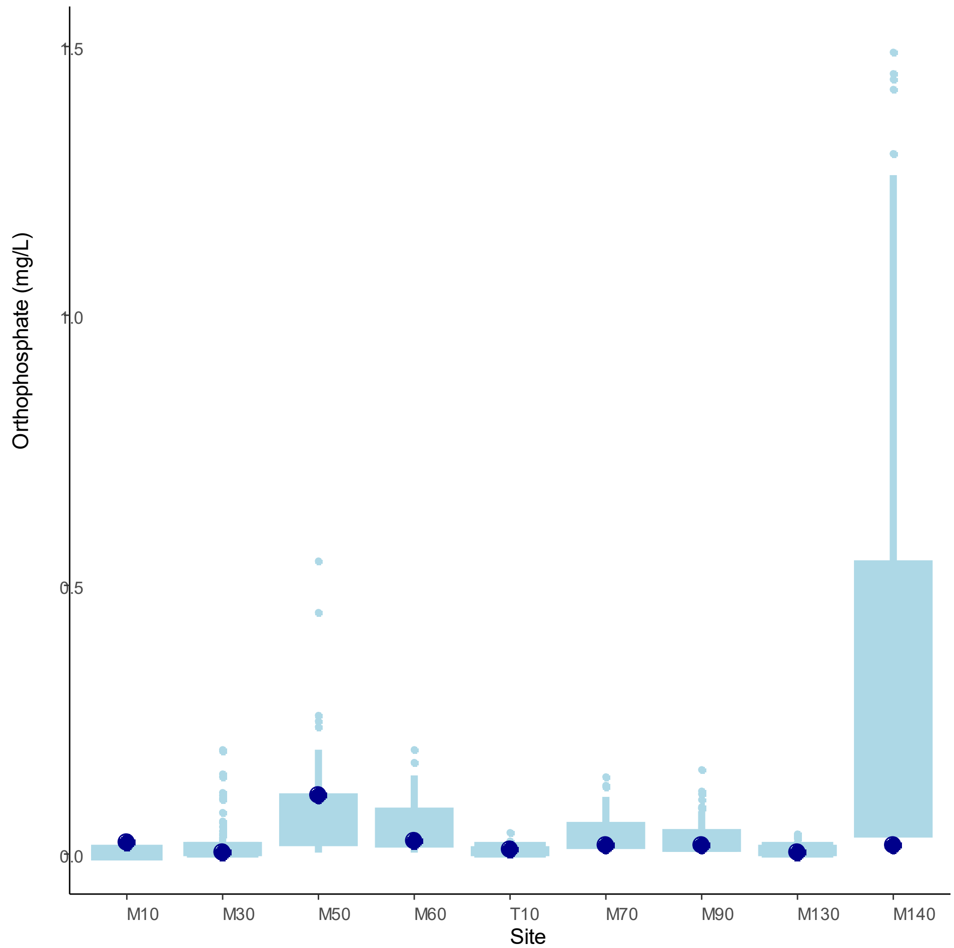

Figure 18. Box plot of orthophosphate data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. Several elevated values do not appear in this figure to improve readability.

Total Nitrogen

Total nitrogen consists of all available forms of nitrogen including inorganic nitrogen, ammonia, and organic nitrogen and is of interest due to its role in determining productivity in aquatic communities and the amount of algal growth.

Like inorganic nitrogen, total nitrogen concentrations were generally elevated in sites located in canyon portion of the river (sites M50-M90, T10) because of the CPF (Figure 19). Inorganic nitrogen often increases after a wildfire (Rust et al. 2018) and has remained elevated at sites affected by the CPF.

In 2023, six of the 55 available total nitrogen measures were above the Colorado Regulation 31 standards (1.25 mg/L coldwater, 2.01 mg/L warmwater). Only one of these values was obtained from a coldwater site (M50 February) and the remaining five were obtained from warmwater sites during the winter low flow period. Four of the five results above the standard were obtained from the site downstream of the WRF outfall (M140). While these values suggest that consistently achieving stream standards downstream of the WRF will require additional efforts, LWP has made substantial progress in reducing total nitrogen concentrations and will continue to do so.

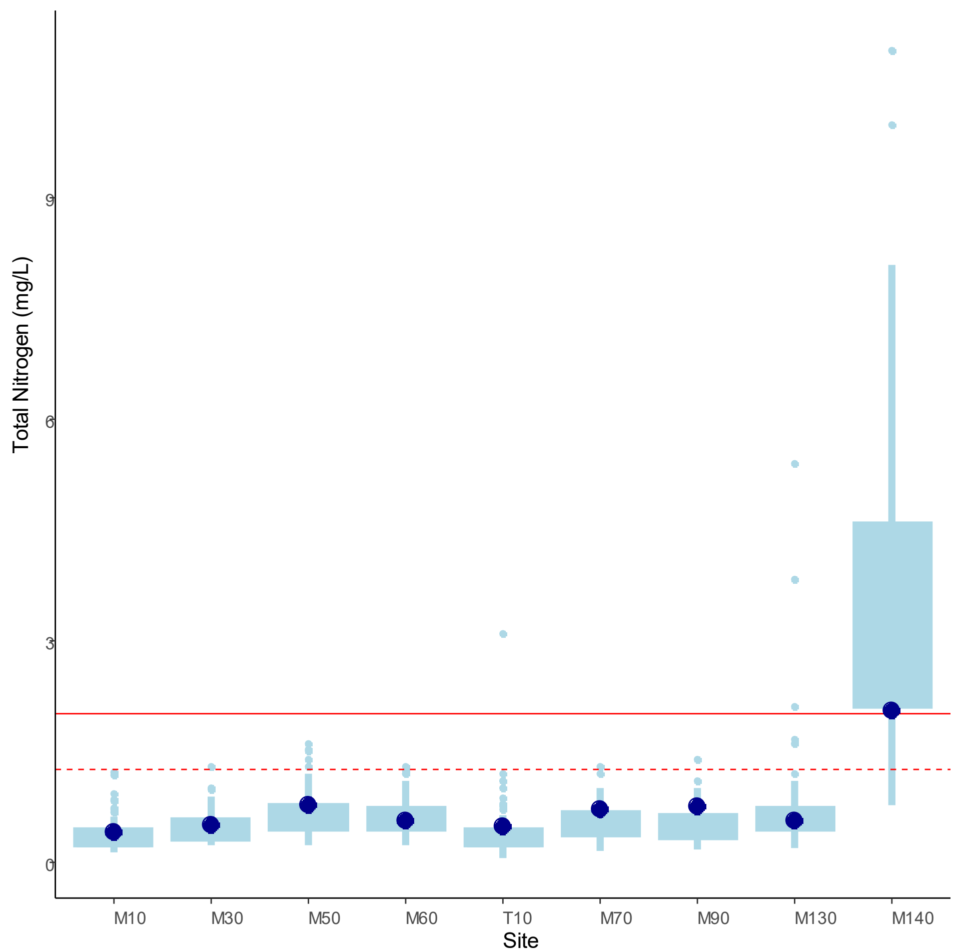

Figure 19. Box plot of total nitrogen data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the CDPHE standard for warmwater streams. The dashed red line represents the CDPHE standard for coldwater streams. Several elevated values do not appear in this figure to improve readability.

Total Phosphorus

Total phosphorus is a measure of both dissolved and particulate forms of phosphorus and includes orthophosphate. Along with total nitrogen, total phosphorus is of interest due to its role in determining productivity in aquatic communities and the amount of algal growth.

Ten of 55 concentrations were above Colorado Regulation 31 standard for either warmwater sites (0.17 mg/L) or coldwater sites (0.11 mg/L). Two results were above the Colorado Regulation 31 standard for warmwater sites (0.17 mg/L). These exceedances occurred in June when results from locations both upstream (M130) and downstream (M140) of the WRF outfall were elevated. However, in general, total phosphorus standards are being met at site M140 indicating that the WRF nutrient reduction strategies have been successful (Figure 20).

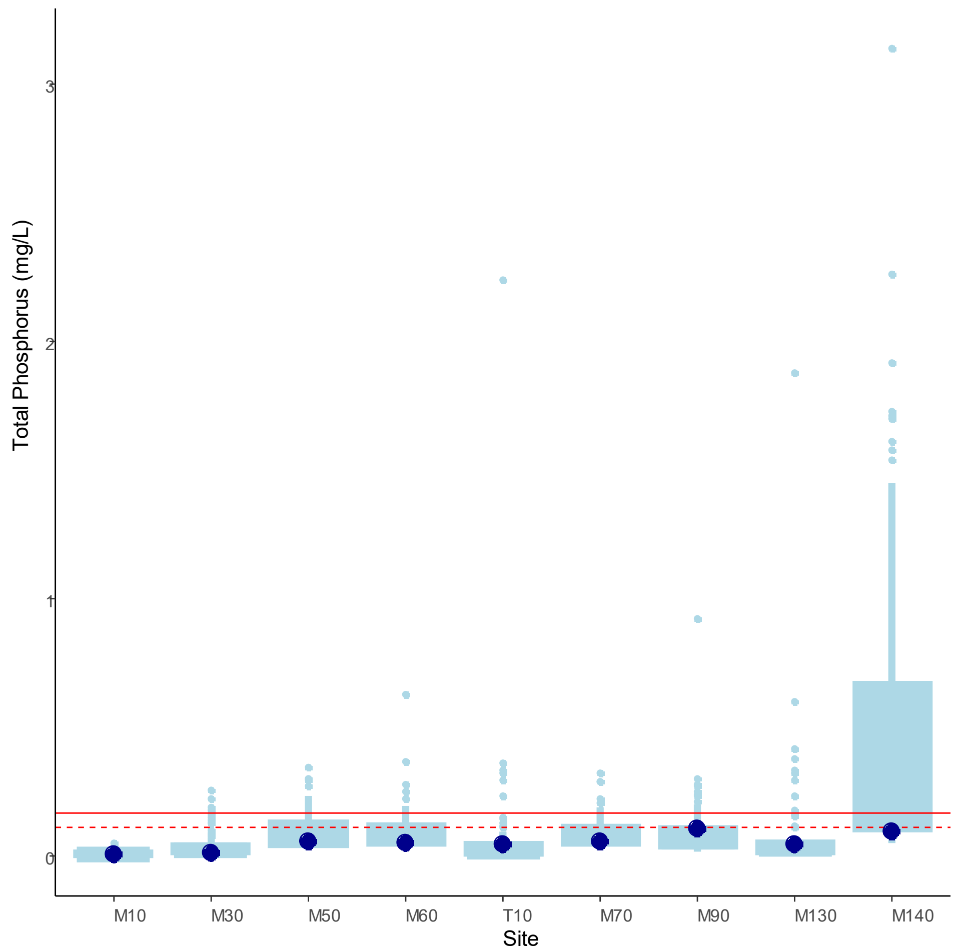

Figure 20. Box plot of total phosphorus data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the CDPHE standard for warmwater streams. The dashed red line represents the CDPHE standard for coldwater streams. Several elevated values do not appear in this figure to improve readability.

Biological

E. coli

E. coli is a species of bacteria that occurs in the intestines of animals and aids in the digestion of food. *E. coli* is usually not pathogenic but is used as an indicator of the potential presence of disease-causing bacteria, protozoa, and viruses. Water with elevated levels of *E. coli* may indicate a potential water consumption or contact risk for humans.

In 2023, *E. coli* densities were somewhat elevated across sampling locations. The high density of 1,842 CFU occurred at site M30 in September and the low density was <1 CFU at several sites in a number of different months.

There were six of a total of 195 samples above the “potential primary contact use” standard of 205 CFU (two at site M130, two at site M140, and two at site M30) and one above the “not primary contact use” standard of 630 CFU (1,842 CFU in September at site M30).

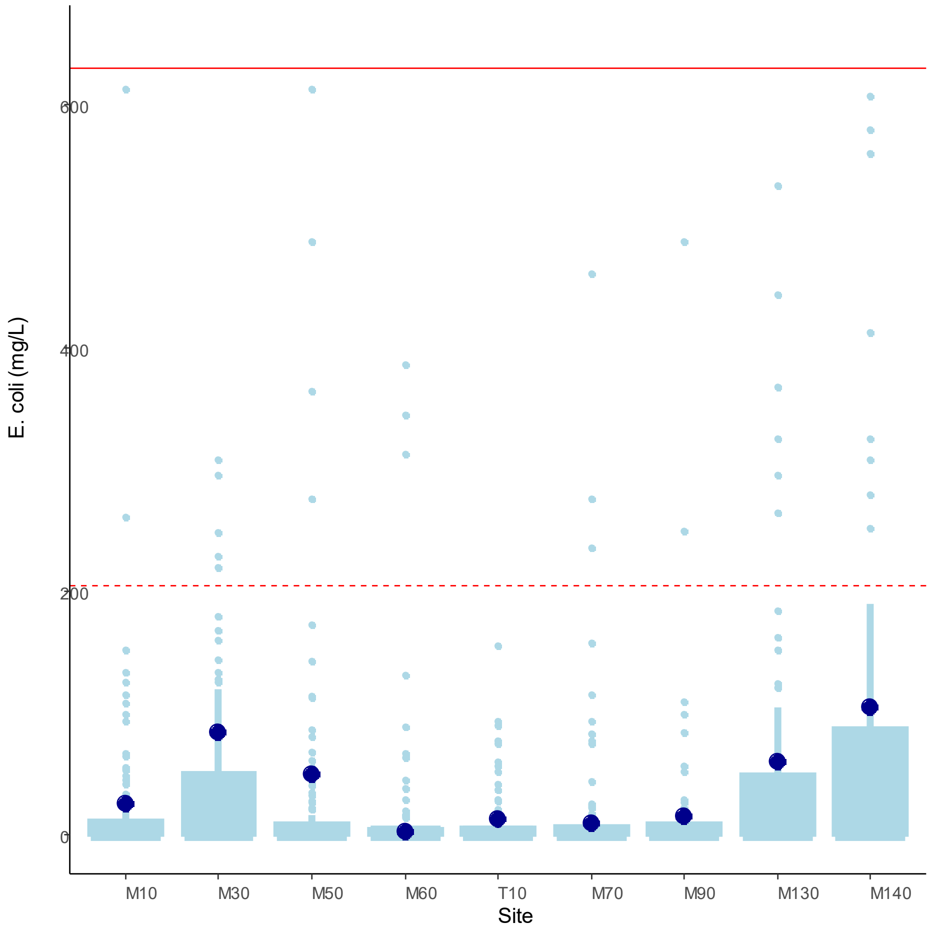

Figure 21. Box plot of *E. coli* data representing the 2013-2023 time period for each sampling location. Box represents 25th and 75th percentiles and blue circle represents 2023 median value. The solid red line represents the CDPHE standard for "not primary contact use." The dashed red line represents the CDPHE standard for "potential primary contact use."

Temporal Trends

Significant temporal trends over the previous ten-year period were detected for a number of parameters at each sampling location. However, given a p-value of 0.05 and more than 40 parameters examined at each site, one would expect one or two significant results at each site simply due to chance rather than any real increase or decrease over time. Consistent results among sites (or groups of sites) or additional site-specific information is useful in increasing confidence in

significant trend results. Trends of note are presented below. This summary is not meant to be comprehensive and significant trends at individual sites for particular parameters may be valid and of interest as well. Results of Mann-Kendall trend tests for each parameter at each site are in Appendix A.

Similar to 2022, dissolved copper concentrations declined significantly across all sites except the uppermost site (M10), where dissolved copper significantly increased, and the lowermost site (M140). The overall average change at sites with significant declines in dissolved copper concentration was -0.071 µg/L/year. The rate of decline in copper concentration in the upper sites in the mainstem was approximately half of the rate of decline at sites in the lower portion of the watershed. A decline in dissolved copper was also documented for several of these sites over a 15-year period ending in 2021 by Hawley & Rodriquez-Jeangros (2021). This result also matches the suggestion that somewhat lower tree mortality caused by bark beetles in recent years (USDA 2019) would result in decreased dissolved copper in the Big Thompson River. Tree mortality caused by bark beetles may result in copper that had been taken up and stored by trees being released into surface water upon their death (Fayram et al. 2019).

There were significant increases in chloride and sodium concentrations at sites most influenced by Highway 34 (M60-M130) and Highway 43 (T10; Appendix A). These patterns were also apparent in 2022. The average rate of increase in sodium concentration among sites with a significant increase was 0.078 mg/L/year for sodium and 0.11 mg/L/year for chloride. Taken together, these results suggest that the increases may be due to the use of sodium chloride (and potentially magnesium chloride) as a de-icing agent on area roads during the winter. Additionally, all the sites in the main section of the Big Thompson River canyon (M50-M90) had a corresponding increase in total dissolved solids (TDS) over the past decade. The increase in TDS reflects increases in chloride and sodium, which are both components of TDS measurements. Similarly, Kaushal et al. (2018) documented a mainstem-wide increase in sodium and chloride concentrations in the Big Thompson River in recent decades. Interestingly, two sites below water reclamation facility outfalls (M30 and M140) did not demonstrate a significant change in chloride or sodium suggesting the outfalls may dilute concentrations.

The CPF was substantial enough to dictate trends in the last decade for several sites and parameters. Although many water quality parameters can be affected by wildfire, the magnitude and duration of the effects can vary widely (Rust et al. 2019). In particular, the effects of the fire on TOC and inorganic nitrogen have been sustained and altered enough in years post-fire to affect the overall decadal trend. The North Fork (T10) was among the most severely burned areas of the CPF, and in severely burned areas organic carbon is often reduced compared to unburned areas immediately post-fire (Rhoades et al. 2019). Total organic carbon has been reduced at this site at least on a seasonal basis resulting in an overall significant decline in TOC at site T10 at the rate of 0.07 mg/L/year. Similarly, inorganic nitrogen levels can also be dramatically altered by wildfire (Rust et al. 2019). Both T10 and M10 (affected by the East Troublesome Fire in 2020) have had significant increases in inorganic nitrogen levels in the past decade (T10: 0.01 mg/L/year, M10: 0.006 mg/L/year), perhaps resulting from the fire. If these significant changes in water quality are due to fire, they should dissipate in the next several years as the watershed recovers.

Orthophosphate concentrations declined significantly at sites M130 and M140 in the past decade, although the rate of decline at M140 (-0.038 mg/L/year) was substantially greater than at M130 (-0.001 mg/L/year). Site M130 is located above the LWP WRF outfall and the downward trend at this site may indicate increasingly favorable conditions from a nutrient-loading standpoint in the Big Thompson River. The significant decline at M140 is primarily due to the biological nutrient reduction infrastructure that came online in 2018.

In addition to wildfire, climate change can be a major driver of changes in water quality. Site M10 is located within Rocky Mountain National Park and is therefore not subject to many of the potential stressors present at other sites. Several climate-related parameters appear to have significantly changed at this location in the past ten years including decreased flow (-0.64 cfs/year), decreased stream width (-0.5 ft/year), and decreased temperature (-0.03 ºC/year). The most intuitive explanation for decreasing flow and width is that precipitation declined and temperatures were elevated. However, while air temperatures were indeed elevated (six of the ten hottest years on record in Colorado occurred in the last decade), there was no obvious trend in precipitation, at least on the statewide scale. In addition, temperatures at site M10 seem to be decreasing while air temperatures are increasing. These counterintuitive results may be explained by changes in stream morphology. For example, an increased air temperature could increase evaporation, thereby reducing stream flow. Reduced stream flow would, in turn, reduce stream width, but the remaining water would be closer to the thalweg and not exposed to the warmest conditions in shallow water near the bank. As a result, this more constrained stream might have a lower mean temperature despite higher air temperatures. Alternatively, and perhaps more likely, these apparent trends may be caused by the significance of one or more of the statistical test results being spurious.

One somewhat surprising result is that dissolved silver appeared to increase significantly at all sites. This circumstance demonstrates the importance of understanding the origin of the data collected. In these cases, although the same analytical method was used for all samples, the significant increases were due to increasing minimum detection limits over time. Earlier years in the reference period had a very low detection limit described as the “long term method detection level” (0.005 mg/L). The middle years of the reference period had a higher minimum detection limit of 0.02 mg/L using “DQCalc” to estimate the limit. In recent years, the minimum detection limit was determined by a “blank adjusted” method which was relatively high (1 mg/L). Given the preponderance of “non-detect” values for dissolved silver, the increasing detection limit was the cause of the apparent significant increase in dissolved silver across sites.

Dissolved manganese concentrations demonstrated a significant decrease in the past decade at site T10 (-0.353 mg/L/year) despite relatively elevated concentrations since the CPF. This circumstance appears to be driven by particularly elevated dissolved manganese concentrations as this location in 2013 and 2014 after the 2013 flood event. Similar circumstances are present at sites M30 and M50 regarding elevated dissolved manganese levels in post-flood years driving significant downward trends over the previous decade.

There were significant increases in bacteriological parameters at several sites. Total coliform concentrations increased significantly at all sampling locations and *E. coli* concentrations increased significantly at two locations below water reclamation facility outfalls (M50 and M140). Although there was also a significant increase in *E. coli* above the LWP water reclamation facility outfall (M130), the magnitude of this rate of increase (0.833 CFU/year) was much lower than below the outfall (3.875 CFU/year)

Biological parameters increased significantly at several sampling locations in the past decade. *E. coli* levels increased at sites located below WRF outfalls, M50 (0.053 CFU/year) and M140 (3.875 CFU/year). Although these trends are notable, *E. coli* concentrations are still rarely above associated standards. In addition, *E. coli* concentrations also increased at the sampling location above the LWP WRF outfall (M130: 0.833 CFU/year), which suggests that factors other than WRF effluent contributed to observed increases. Total coliform concentrations increased significantly at all sampling locations in the past decade with an average rate of increase of

19.84 CFU/year. These increases seem to have generally started in 2020 and have continued through 2023. The effects of wildfire on biological parameters such as *E. coli* and total coliform are not well-studied and existing studies suggest variable results ranging from unknown (Paul et al. 2022), increased (Cira et al. 2022), or decreased (Valenca et al. 2020) concentrations post-fire. Therefore, it is possible that the effects of the CPF increased total coliform concentrations throughout the watershed. However, the fact that the increases generally started one year before the CPF and the ambiguous results of past studies on the effects of fire on total coliform leave this hypothesis in doubt.

Acknowledgements

We thank all USGS staff for collecting and analyzing data presented in this report. In particular, we thank Tanner Chapin from USGS. We also thank WQL staff who supported these efforts. The GIS support provided by Paige Richardson is very much appreciated. We also thank the Loveland City Council, Loveland Utilities Commission, former BTWF staff, and BTWF Board members for continuing these data collection efforts for many years.

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Appendix A.

Number of samples, Mann-Kendall trend test results, maximum value, minimum value, median value, and range of years represented for each water quality parameter at each sampling location. Yellow highlights represent significant ($p < 0.05$) trend.

	M10						
Parameter	**Slope**	**p value**	**Maximum**	**Minimum**	**Median**	**Date Range**	**Count**
Acidity, (H+) (mg/L)	<0.001	0.051	0.0005	0.00001	0.0001	2013-2023	104
Alkalinity, Dissolved (mg/L)	0.025	0.606	15.5	3.57	7.5	2013-2023	112
Ammonia and ammonium, Dissolved (mg/L)	0.000	<0.001	0.02	0.005	0.005	2013-2023	107
Ammonia as NH_4 (mg/L)	0.000	<0.001	0.03	0.0065	0.0065	2013-2023	101
Arsenic, Dissolved (mg/L)	0.000	<0.001	0.214	0.025	0.05	2013-2023	111
Barometric pressure (mm/Hg)	0.000	0.980	577	556	569	2013-2023	111
Cadmium, Dissolved (mg/L)	-	-	-	-	-	-	-
Calcium, Dissolved (mg/L)	0.002	0.797	6.075	1.335	2.57	2013-2023	116
Carbon dioxide, Total (mg/L)	0.090	0.008	5.5	0.1	1.4	2013-2023	97
Chloride, Dissolved (mg/L)	-0.001	0.520	1.295	0.095	0.35	2013-2023	116
Copper, Dissolved (mg/L)	-0.040	0.001	4.7	0.4	1.2	2013-2023	110
E. coli (cells/100 mL)	0.071	<0.001	613	0.5	0.5	2013-2023	101
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.006	0.898	22.75	4.64	9.315	2013-2023	116
Iron, Dissolved (mg/L)	0.479	0.653	312	49.4	89.55	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-0.002	0.147	0.44	0.035	0.135	2013-2023	104
Lead, Dissolved (mg/L)	0.000	0.012	0.097	0.01	0.25	2013-2023	110
Magnesium, Dissolved (mg/L)	0.001	0.798	1.845	0.316	0.702	2013-2023	116
Manganese, Dissolved (mg/L)	-0.123	0.115	43.3	2.3	5.84	2013-2023	110
Nickel, Dissolved (mg/L)	0.000	0.038	1.9	0.1	0.25	2013-2023	110
Nitrate + Nitrite, Dissolved (mg/L)	0.006	0.001	0.96	0.07	0.196	2013, 2015-23	116
Nitrate, Dissolved (mg/L)	0.011	0.001	0.958	0.0625	0.19625	2013, 2015-23	84
Nitrite, Dissolved (mg/L)	0.000	0.259	0.006	0.0005	0.0005	2013, 2015-23	79
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	0.003	0.203	1.22	0.13	0.304	2013-2023	116
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	0.063	0.112	1.3	0.135	0.31	2013-2023	115
Organic carbon, Total (mg/L)	-0.006	0.729	14.4	1.6	2.6	2013-2023	111
Organic Nitrogen, Total (mg/L)	-0.002	0.065	0.65	0.025	0.07	2013-2023	95
Orthophosphate, Dissolved as P (mg/L)	0.000	0.019	0.02	0.002	0.002	2013-2023	109
Orthophosphate, Dissolved as $P0_4$ (mg/L)	0.000	0.065	0.018	0.002	0.006	2013-2023	103
Oxygen, Dissolved (%)	-0.142	0.040	109	91	101	2013-2023	111
Oxygen, Dissolved (mg/L)	0.000	0.500	11.1	8	9.7	2013-2023	111
pH (SU)	-0.014	0.362	8.5	6.5	7	2013-2023	105
Phosphorus, Dissolved (mg/L)	0.000	0.942	0.013	0.0015	0.005	2013-2023	80
Phosphorus, Total (mg/L)	<-0.001	0.227	0.05	0.003	0.009	2013-2023	109
Potassium, Dissolved (mg/L)	0.003	0.089	1.25	0.189	0.372	2013-2023	121
RBP Stream width (ft)	-0.500	<0.001	41	12.4	30	2013-2023	111
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	
Silver, Dissolved (mg/L)	0.010	<0.001	0.5	0.0025	0.05	2013-2023	110
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.000	0.229	0.34	0.135	0.213	2013-2023	116
Sodium, Dissolved (mg/L)	0.004	0.397	3.33	0.685	1.559	2013-2023	116
Sodium, total cations (%)	0.000	0.563	29	19	25.42	2013-2023	116
Specific conductance (µS/cm)	0.113	0.226	62.5	13.33	27.58	2013-2023	119
Stream flow (cfs)	-0.640	0.001	513	1.6	22	2013-2023	111
Sulfate, Dissolved (mg/L)	-0.002	0.858	10.2	1.02	2.77	2013-2023	116
Temperature, water (℃)	-0.033	0.012	14.75	-0.1	4.975	2013-2023	120
Total Coliform (cells/100 mL)	5.562	<0.001	1733	0.5	0.5	2013-2023	101
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.667	<0.001	56	10	26.5	2013-2023	108
Total dissolved solids, Dissolved, Filtered (mg/L)	0.000	0.888	39	9.5	20	2013-2023	110
Turbidity (NTU)	0.000	0.034	19.85	1	1	2013-2023	110
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	-

Parameter	Slope	p value	Maximum	M30 Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	<0.001	0.001	0.0005	0.00001	0.00004	2013-2023	109
Alkalinity, Dissolved (mg/L)	-0.169	0.018	36	6.7	15.2	2013-2023	104
Ammonia and ammonium, Dissolved (mg/L)	0.002	<0.001	0.73	0.005	0.02	2013-2023	81
Ammonia as NH_4 (mg/L)	0.001	0.030	0.938	0.0065	0.015	2013-2023	105
Arsenic, Dissolved (mg/L)	0.000	0.967	1.1	0.05	0.105	2013-2023	74
Barometric pressure (mm/Hg)	-0.118	0.114	588	566	580	2013-2023	111
Cadmium, Dissolved (mg/L)	<0.001	<0.01	0.015	0.008	0.015	2013-14, 2022-23	38
Calcium, Dissolved (mg/L)	0.020	0.349	9.85	1.74	3.995	2013-2023	110
Carbon dioxide, Total (mg/L)	0.057	0.025	4.3	0.1	1.1	2013-2023	102
Chloride, Dissolved (mg/L)	0.015	0.430	42.4	0.53	3.17	2013-2023	110
Copper, Dissolved (mg/L)	-0.060	<0.001	7.7	0.48	1.15	2013-2023	108
E. col i (cfu)	0.000	<0.001	1842	0.5	0.5	2013-2023	102
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.055	0.362	36.1	6.25	14.75	2013-2023	110
Iron, Dissolved (mg/L)	-1.720	0.109	372	47.4	114	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-	2013-2023	-
Lead, Dissolved (mg/L)	<0.001	0.424	0.189	0.01	0.038	2013-2023	83
Magnesium, Dissolved (mg/L)	0.004	0.300	2.8	0.462	1.135	2013-2023	110
Manganese, Dissolved (mg/L)	-0.119	0.046	45.1	2.93	6.88	2013-2023	110
Nickel, Dissolved (mg/L)	0.007	0.047	1.6	0.1	0.29	2013-2023	82
Nitrate + Nitrite, Dissolved (mg/L)	0.005	0.019	0.57	0.06	0.2	2013-2023	107
Nitrate, Dissolved (mg/L)	-	-	-	-	-	2013-2023	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	2013-2023	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	2013-2023	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	0.009	0.007	1.3	0.22	0.4325	2013-2023	106
Organic carbon, Total (mg/L)	0.015	0.289	9.2	1.83	2.72	2013-2023	109
Organic Nitrogen, Total (mg/L)	0.000	0.920	0.39	0.45	0.1325	2013-2023	106
Orthophosphate, Dissolved as P (mg/L)	<-0.001	0.093	0.194	0.002	0.007	2013-2023	109
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.001	0.004	0.596	0.006	0.02	2013-2023	105
Oxygen, Dissolved (%)	-0.167	0.008	126	98	105	2013-2023	111
Oxygen, Dissolved (mg/L)	0.032	0.044	12.5	7.7	9.85	2013-2023	111
pH (SU)	-0.030	<0.001	8.9	6.6	7.4	2013-2023	109
Phosphorus, Dissolved (mg/L)	<-0.001	0.190	0.239	0.0045	0.011	2013-2023	107
Phosphorus, Total (mg/L)	<0.001	0.401	0.259	0.009	0.0265	2013-2023	106
Potassium, Dissolved (mg/L)	0.010	0.003	1.22	0.29	0.63	2013-2023	108
RBP Stream width (ft)	0.000	0.902	128	17	49.5	2013-2023	111
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	-
Silver, Dissolved (mg/L)	0.050	<0.001	0.5	0.0025	0.5	2013-14, 2022-23	38
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.001	0.319	2.35	0.18	0.37	2013-2023	110
Sodium, Dissolved (mg/L)	0.013	0.431	28.3	1.12	3.365	2013-2023	110
Sodium, total cations (%)	0.000	0.760	68	24	31	2013-2023	108
Specific conductance (µS/cm)	0.000	0.862	208	19.5	48	2013-2023	111
Stream flow (cfs)	-0.500	0.469	812	6.69	58.5	2013-2023	110
Sulfate, Dissolved (mg/L)	-0.010	0.257	7.32	1.29	2.72	2013-2023	110
Temperature, water (℃)	-0.254	<0.001	17	0	6	2013-2023	111
Total Coliform	0.000	<0.001	4840	0.5	0.5	2013-2023	102
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.414	0.068	117	10	39	2013-2023	109
Total dissolved solids, Dissolved, Filtered (mg/L)	0.310	0.096	104	6	29	2013-2023	103
Turbidity (NTU)	0.000	0.382	50	1	2.2	2013-2023	110
Zinc, Dissolved (mg/L)	0.023	0.542	11.9	0.7	2.8	2013-2023	71

	M50						
Parameter	Slope	p value	Maximum	Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.786	0.0005	0.00001	0.0003	2013-2023	108
Alkalinity, Dissolved (mg/L)	0.133	0.167	34.2	8.4	22.8	2013-2023	103
Ammonia and ammonium, Dissolved (mg/L)	0.000	0.204	0.47	0.005	0.03	2013-2023	104
Ammonia as NH_4 (mg/L)	-0.002	0.016	0.611	0.000605	0.036	2013-2023	105
Arsenic, Dissolved (mg/L)	0.000	0.111	1	0.05	0.16	2013-2023	110
Barometric pressure (mm/Hg)	-0.113	0.161	590	568	583	2013-2023	111
Cadmium, Dissolved (mg/L)	<0.001	0.001	0.015	0.008	0.015	2013-14, 2022-23	38
Calcium, Dissolved (mg/L)	0.068	0.013	10.6	2.24	6.505	2013-2023	110
Carbon dioxide, Total (mg/L)	0.020	0.273	6.4	0.1	1	2013-2023	101
Chloride, Dissolved (mg/L)	0.028	0.490	10.7	0.81	3.3	2013-2023	110
Copper, Dissolved (mg/L)	-0.025	0.044	28.3	0.4	1.1	2013-2023	110
E. col i (cells/100 mL)	0.053	<0.001	613	0.5	0.5	2013-2023	111
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.192	0.011	38.5	7.95	22.5	2013-2023	110
Iron, Dissolved (mg/L)	-2.122	0.002	1080	27.4	66.75	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-	-	-
Lead, Dissolved (mg/L)	-0.002	<0.001	0.529	0.01	0.025	2013-2023	110
Magnesium, Dissolved (mg/L)	0.008	0.348	2.93	0.551	1.425	2013-2023	110
Manganese, Dissolved (mg/L)	-0.266	0.008	106	1.9	6.315	2013-2023	110
Nickel, Dissolved (mg/L)	0.001	0.208	1.6	0.045	0.26	2013-2023	110
Nitrate + Nitrite, Dissolved (mg/L)	-0.003	0.516	1.17	0.06	0.27	2013-2023	107
Nitrate, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	-0.008	0.222	1.6	0.23	0.56	2013-2023	104
Organic carbon, Total (mg/L)	0.019	0.266	8.6	3.1	4.04	2013-2023	108
Organic Nitrogen, Total (mg/L)	-0.005	0.057	1	0.09	0.225	2013-2023	104
Orthophosphate, Dissolved as P (mg/L)	<0.001	0.916	0.545	0.002	0.054	2013-2023	106
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.003	0.325	0.784	0.006	0.1565	2013-2023	105
Oxygen, Dissolved (%)	0.000	0.423	120	98	105	2013-2023	111
Oxygen, Dissolved (mg/L)	0.007	<0.001	11.8	7.4	9.55	2013-2023	111
pH (SU)	-0.017	0.016	8.9	6.7	7.6	2013-2023	109
Phosphorus, Dissolved (mg/L)	-0.001	0.636	0.277	0.008	0.0605	2013-2023	106
Phosphorus, Total (mg/L)	-0.001	0.446	0.347	0.021	0.0725	2013-2023	106
Potassium, Dissolved (mg/L)	0.007	0.109	6.39	0.15	0.88	2013-2023	110
RBP Stream width (ft)	0.105	0.521	83	19	43.9	2013-2023	111
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	-
Silver, Dissolved (mg/L)	0.000	<0.001	0.5	0.0025	0.5	2013-2023	110
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.005	0.007	0.6	0.2	0.35	2013-2023	110
Sodium, Dissolved (mg/L)	0.064	0.016	7.41	1.42	3.725	2013-2023	110
Sodium, total cations (%)	0.250	0.008	35	19	27	2013-2023	109
Specific conductance (µS/cm)	0.667	0.048	117	25	66	2013-2023	111
Stream flow (cfs)	-1.470	0.020	621	5.655	74	2013-2023	110
Sulfate, Dissolved (mg/L)	0.035	0.043	5.85	1.56	3.545	2013-2023	110
Temperature, water (ºC)	-0.141	0.010	19.6	0	8.35	2013-2023	111
Total Coliform (cells/100 mL)	6.330	<0.001	2648	0.5	0.5	2013-2023	111
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.633	0.067	78	10	46.5	2013-2023	110
Total dissolved solids, Dissolved, Filtered (mg/L)	0.598	0.018	59	7	36	2013-2023	103
Turbidity (NTU)	-0.094	<0.001	14	1	2.2	2013-2023	110
Zinc, Dissolved (mg/L)	0.000	0.229	8.2	0.7	2	2013-2023	110

				M60			
Parameter	**Slope**	**p value**	**Maximum**	**Minimum**	**Median**	**Date Range**	**Count**
Acidity, (H+) (mg/L)	0.000	0.354	0.00031	0.00001	0.00002	2013-2023	105
Alkalinity, Dissolved (mg/L)	0.300	0.093	36.2	8.8	23.3	2013-2023	103
Ammonia and ammonium, Dissolved (mg/L)	0.000	0.441	0.24	0.005	0.01	2013-2023	104
Ammonia as NH_4 (mg/L)	0.000	0.274	0.306	0.0065	0.013	2013-2023	105
Arsenic, Dissolved (mg/L)	-0.003	0.027	0.28	0.05	0.165	2013-2023	108
Barometric pressure (mm/Hg)	-0.100	0.218	617	591	609	2013-2023	109
Cadmium, Dissolved (mg/L)	-	-	-	-	-	-	-
Calcium, Dissolved (mg/L)	0.070	0.085	11.1	2.47	6.69	2013-2023	109
Carbon dioxide, Total (mg/L)	0.000	0.835	11	0.3	1	2013-2023	99
Chloride, Dissolved (mg/L)	0.130	0.022	10.9	0.89	3.74	2013-2023	109
Copper, Dissolved (mg/L)	-0.046	<0.001	14.1	0.66	1.15	2013-2023	108
E. col i (cells/100 mL)	0	<0.001	1300	0.5	0.5	2013-2023	99
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.267	0.173	40.5	8.66	23.2	2013-2023	109
Iron, Dissolved (mg/L)	-1.600	0.015	487	15.7	52.5	2013-2023	109
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-	-	-
Lead, Dissolved (mg/L)	-0.001	0.101	0.206	0.01	0.027	2013-2023	109
Magnesium, Dissolved (mg/L)	0.014	0.117	3.07	0.606	1.5	2013-2023	109
Manganese, Dissolved (mg/L)	-0.040	0.238	83.7	0.56	2.17	2013-2023	109
Nickel, Dissolved (mg/L)	0.002	0.158	0.94	0.045	0.26	2013-2023	107
Nitrate + Nitrite, Dissolved (mg/L)	-0.012	0.031	1.16	0.02	0.28	2013-2023	105
Nitrate, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	-0.018	0.002	1.3	0.23	0.565	2013-2023	104
Organic carbon, Total (mg/L)	0.016	0.297	11.5	2.9	3.8	2013-2023	108
Organic Nitrogen, Total (mg/L)	-0.003	0.101	0.53	0.075	0.165	2013-2023	103
Orthophosphate, Dissolved as P (mg/L)	0.001	0.264	0.194	0.002	0.04	2013-2023	105
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.003	0.289	0.594	0.006	0.124	2013-2023	105
Oxygen, Dissolved (%)	0.000	0.014	110	98	102	2013-2023	108
Oxygen, Dissolved (mg/L)	-0.033	0.134	12	7.6	9.5	2013-2023	108
pH (SU)	0.000	0.231	8.2	6.5	7.6	2013-2023	106
Phosphorus, Dissolved (mg/L)	-0.001	0.368	0.208	0.007	0.049	2013-2023	105
Phosphorus, Total (mg/L)	-0.001	0.134	0.627	0.027	0.082	2013-2023	105
Potassium, Dissolved (mg/L)	0.003	0.571	1.4	0.34	0.88	2013-2023	109
RBP Stream width (ft)	-0.333	0.134	58	12.3	34	2013-2023	109
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	-
Silver, Dissolved (mg/L)	0.005	<0.001	0.5	0.0025	0.5	2013-2023	106
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.008	0.001	0.61	0.22	0.37	2013-2023	109
Sodium, Dissolved (mg/L)	0.113	0.006	8.1	1.59	4.05	2013-2023	109
Sodium, total cations (%)	0.333	<0.001	36	22	28	2013-2023	109
Specific conductance (µS/cm)	1.400	0.080	118	28	70	2013-2023	109
Stream flow (cfs)	0.250	0.788	987	9.6	74	2013-2023	106
Sulfate, Dissolved (mg/L)	0.047	0.065	6.44	1.63	3.64	2013-2023	109
Temperature, water (℃)	0.050	0.186	18.9	0	8.5	2013-2023	109
Total Coliform (cells/100 mL)	13.667	<0.001	9680	0.5	0.5	2013-2023	99
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.800	0.044	90	10	47	2013-2023	109
Total dissolved solids, Dissolved, Filtered (mg/L)	0.833	0.007	67	15	38	2013-2023	103
Turbidity (NTU)	-0.100	<0.001	470	1	2.2	2013-2023	109
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	-

Parameter	Slope	p value	M70 Maximum	Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.274	0.0005	0.00001	0.00002	2013-2023	106
Alkalinity, Dissolved (mg/L)	-0.183	0.030	38.6	9.7	23.2	2013-2023	102
Ammonia and ammonium, Dissolved (mg/L)	0.001	0.111	0.23	0.005	0.01	2013-2023	104
Ammonia as NH_4 (mg/L)	0.000	0.363	0.29	0.0065	0.013	2013-2023	106
Arsenic, Dissolved (mg/L)	-0.001	0.067	0.28	0.05	0.16	2013-2023	108
Barometric pressure (mm/Hg)	-0.031	0.541	635	606	623	2013-2023	108
Cadmium, Dissolved (mg/L)							
Calcium, Dissolved (mg/L)	0.038	0.181	11.4	2.68	6.45	2013-2023	108
Carbon dioxide, Total (mg/L)	-0.028	0.033	2.7	0.2	0.9	2013-2023	101
Chloride, Dissolved (mg/L)	0.122	<0.001	8.35	1.06	3.44	2013-2023	108
Copper, Dissolved (mg/L)	-0.100	<0.001	4.7	0.59	1.2	2013-2023	107
E. col i (cells/100 mL)	0.000	<0.001	461	0.5	0.5	2013-2023	107
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.141	0.143	39.8	9.33	21.9	2013-2023	108
Iron, Dissolved (mg/L)	-1.313	0.106	418	22.2	64.75	2013-2023	108
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-	-	-
Lead, Dissolved (mg/L)	0.000	0.959	0.444	0.01	0.035	2013-2023	108
Magnesium, Dissolved (mg/L)	0.011	0.090	8.73	0.639	1.51	2013-2023	108
Manganese, Dissolved (mg/L)	-0.014	0.800	28.6	1.69	5.355	2013-2023	108
Nickel, Dissolved (mg/L)	0.007	0.022	0.97	0.045	0.26	2013-2023	108
Nitrate + Nitrite, Dissolved (mg/L)	0.010	<0.001	0.85	0.005	0.225	2013-2023	105
Nitrate, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	0.009	0.048	1.3	0.15	0.525	2013-2023	104
Organic carbon, Total (mg/L)	-0.020	0.188	11.6	2.8	3.515	2013-2023	110
Organic Nitrogen, Total (mg/L)	-0.003	0.085	0.58	0.03	0.1475	2013-2023	104
Orthophosphate, Dissolved as P (mg/L)	0.000	0.038	0.143	0.002	0.0295	2013-2023	104
Orthophosphate, Dissolved as $P0_4$ (mg/L)	0.000	0.061	0.439	0.006	0.0905	2013-2023	104
Oxygen, Dissolved (%)	0.000	0.451	110	55.7	102.5	2013-2023	107
Oxygen, Dissolved (mg/L)	0.000	0.642	12.5	7.5	9.5	2013-2023	107
pH (SU)	0.000	0.163	8.3	7.1	7.65	2013-2023	107
Phosphorus, Dissolved (mg/L)	0.000	0.870	0.146	0.007	0.36	2013-2023	105
Phosphorus, Total (mg/L)	0.000	0.917	0.3225	0.024	0.073	2013-2023	105
Potassium, Dissolved (mg/L)	0.010	0.043	1.48	0.43	0.885	2013-2023	108
RBP Stream width (ft)	0.708	0.028	126	14.4	53	2013-2023	108
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	-
Silver, Dissolved (mg/L)	0.055	<0.001	1.500	0.003	0.5	2013-2023	108
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.008	<0.001	0.6	0.24	0.38	2013-2023	108
Sodium, Dissolved (mg/L)	0.088	<0.001	7.25	1.77	4.13	2013-2023	108
Sodium, total cations (%)	0.354	<0.001	35	22	28	2013-2023	108
Specific conductance (µS/cm)	1.000	0.004	115	28.5	67.258	2013-2023	108
Stream flow (cfs)	0.500	0.608	761	7.71	89	2013-2023	107
Sulfate, Dissolved (mg/L)	0.056	0.009	8.59	1.66	3.58	2013-2023	108
Temperature, water (℃)	-0.089	0.135	19.9	0	9.8	2013-2023	108
Total Coliform (cells/100 mL)	0.000	<0.001	3972	0.5	0.5	2013-2023	107
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.667	0.040	86	10	47.5	2013-2023	108
Total dissolved solids, Dissolved, Filtered (mg/L)	0.746	0.003	64	16	37	2013-2023	101
Turbidity (NTU)	0.000	0.659	210	1	3.65	2013-2023	108
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	-

Parameter	Slope	p value	Maximum	M90 Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.205	0.00011	0.00001	0.00002	2013-2023	106
Alkalinity, Dissolved (mg/L)	0.047	0.493	42.2	9.4	23.3	2013-2023	105
Ammonia and ammonium, Dissolved (mg/L)	0.000	0.317	0.11	0.005	0.01	2013-2023	107
Ammonia as NH_4 (mg/L)	0.000	0.977	0.142	0.0065	0.013	2013-2023	105
Arsenic, Dissolved (mg/L)	-0.002	0.069	0.33	0.05	0.165	2013-2023	110
Barometric pressure (mm/Hg)	0.000	0.311	640	606	628.5	2013-2023	110
Cadmium, Dissolved (mg/L)	-	-	-	-	-	-	-
Calcium, Dissolved (mg/L)	0.056	0.108	13.8	2.51	6.625	2013-2023	110
Carbon dioxide, Total (mg/L)	0.005	0.337	3	0.3	0.9	2013-2023	101
Chloride, Dissolved (mg/L)	0.106	<0.001	11.7	0.94	3.22	2013-2023	110
Copper, Dissolved (mg/L)	-0.120	<0.001	7.7	0.05	1.3	2013-2023	110
E. col i (cells/100 mL)	0.000	0.001	488	0.5	0.5	2013-2023	109
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.200	0.039	47.8	8.73	22.5	2013-2023	110
Iron, Dissolved (mg/L)	-1.107	0.108	4670	24.3	65.4	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-		-
Lead, Dissolved (mg/L)	-0.001	0.270	3.12	0.01	0.037	2013-2023	110
Magnesium, Dissolved (mg/L)	0.018	0.019	3.3	0.596	1.43	2013-2023	110
Manganese, Dissolved (mg/L)	0.120	0.273	88.1	1.76	6.42	2013-2023	110
Nickel, Dissolved (mg/L)	0.000	0.350	2.6	0.045	0.27	2013-2023	90
Nitrate + Nitrite, Dissolved (mg/L)	-0.001	0.410	0.78	0.01	0.18	2013-2023	107
Nitrate, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	-0.005	0.365	1.4	0.18	0.44	2013-2023	107
Organic carbon, Total (mg/L)	-0.014	0.320	12	1.8	3.43	2013-2023	110
Organic Nitrogen, Total (mg/L)	-0.003	0.112	0.92	0.05	0.01	2013-2023	104
Orthophosphate, Dissolved as P (mg/L)	<0.001	0.118	0.157	0.002	0.018	2013-2023	107
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.001	0.132	0.48	0.006	0.057	2013-2023	107
Oxygen, Dissolved (%)	-0.142	0.037	127	55.85	103	2013-2023	107
Oxygen, Dissolved (mg/L)	-0.014	0.270	12.6	7.5	9.5	2013-2023	109
pH (SU)	0.000	0.980	8.2	7	7.7	2013-2023	110
Phosphorus, Dissolved (mg/L)	-0.001	0.219	0.161	0.006	0.025	2013-2023	107
Phosphorus, Total (mg/L)	0.000	1.000	0.922	0.02	0.056	2013-2023	107
Potassium, Dissolved (mg/L)	0.006	0.239	2.8	0.33	0.845	2013-2023	110
RBP Stream width (ft)	0.500	0.319	86	1.26	48.25	2013-2023	110
Selenium, Dissolved (mg/L)	-0.001	0.014	0.21	0.025	0.07	2013-2023	110
Silver, Dissolved (mg/L)	-	-	-	-	-	-	-
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.006	<0.001	0.62	0.21	0.355	2013-2023	110
Sodium, Dissolved (mg/L)	0.075	<0.001	8.07	1.5	3.85	2013-2023	110
Sodium, total cations (%)	0.333	<0.001	35	21	26.5	2013-2023	110
Specific conductance (µS/cm)	1.381	<0.001	132	27	65.5	2013-2023	110
Stream flow (cfs)	-2.125	0.261	1310	11	117	2013-2023	110
Sulfate, Dissolved (mg/L)	0.068	0.001	8.71	1.56	3.53	2013-2023	110
Temperature, water (℃)	0.000	0.774	20.6	0	10.9	2013-2023	108
Total Coliform (cells/100 mL)	0.000	<0.001	2937	0.5	0.5	2013-2023	109
Total dissolved solids, Dissolved, Dried 180 (mg/L)	1.000	0.003	121	10	44	2013-2023	110
Total dissolved solids, Dissolved, Filtered (mg/L)	0.857	0.001	70	14	37	2013-2023	105
Turbidity (NTU)	0.000	0.586	560	0.5	3.9	2013-2023	110
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	

	M130						
Parameter	Slope	p value	Maximum	Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.748	0.0005	0.00001	0.00001	2013-2023	131
Alkalinity, Dissolved (mg/L)	-0.210	0.812	219	18.5	89.2	2013-2023	105
Ammonia and ammonium, Dissolved (mg/L)	0.000	0.014	0.07	0.005	0.01	2013-2023	126
Ammonia as NH_4 (mg/L)	0.000	0.204	0.091	0.0065	0.014	2013-2023	129
Arsenic, Dissolved (mg/L)	0.005	0.277	1.3	0.15	0.35	2013-2023	110
Barometric pressure (mm/Hg)	-0.167	0.183	651	627	638	2013-2023	131
Cadmium, Dissolved (mg/L)	-	-	-	-	-	-	-
Calcium, Dissolved (mg/L)	0.061	0.922	188	8.24	55.95	2013-2023	110
Carbon dioxide, Total (mg/L)	0.050	0.002	6.2	0.5	1.6	2013-2023	104
Chloride, Dissolved (mg/L)	0.395	0.005	97.5	2.34	13	2013-2023	110
Copper, Dissolved (mg/L)	-0.090	<0.001	10.6	0.04	1	2013-2023	109
E. col i (cells/100 mL)	0.833	<0.001	24196	0.5	0.5	2013-2023	105
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.408	0.902	784	30	220	2013-2023	110
Iron, Dissolved (mg/L)	-0.470	0.402	902	5	29.2	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-0.006	0.018	5.2	0.017	0.29	2013-2023	126
Lead, Dissolved (mg/L)	0.000	0.979	3.78	0.01	0.028	2013-2023	110
Magnesium, Dissolved (mg/L)	0.058	0.767	86.6	2.228	19.5	2013-2023	110
Manganese, Dissolved (mg/L)	1.933	0.001	167	8.93	42.6	2013-2023	110
Nickel, Dissolved (mg/L)	-0.023	0.003	2.1	0.27	0.76	2013-2023	110
Nitrate + Nitrite, Dissolved (mg/L)	-0.010	0.002	0.73	0.05	0.255	2013-2023	126
Nitrate, Dissolved (mg/L)	-0.009	0.025	0.72	0.51	0.2355	2014-2023	112
Nitrite, Dissolved (mg/L)	0.000	0.881	0.009	0.001	0.003	2014-2023	112
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	-0.013	0.013	5.4	0.2	0.58	2013-2023	126
Organic carbon, Total (mg/L)	0.023	0.549	11.6	1.9	4.4	2013-2023	109
Organic Nitrogen, Total (mg/L)	-0.005	0.092	3.6	0.035	0.22	2013-2023	126
Orthophosphate, Dissolved as P (mg/L)	<-0.001	<0.001	0.037	0.002	0.006	2013-2023	126
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.001	0.001	0.113	0.002	0.019	2013-2023	126
Oxygen, Dissolved (%)	-0.667	0.005	149	84	106	2013-2023	130
Oxygen, Dissolved (mg/L)	-0.067	<0.001	13..3	7.3	10.35	2013-2023	130
pH (SU)	-0.011	0.012	8.5	7.4	8	2013-2023	131
Phosphorus, Dissolved (mg/L)	<-0.001	0.029	0.112	0.0015	0.01	2013-2023	126
Phosphorus, Total (mg/L)	<0.001	0.278	1.88	0.004	0.032	2013-2023	126
Potassium, Dissolved (mg/L)	0.007	0.640	4.36	0.64	1.82	2013-2023	110
RBP Stream width (ft)	0.123	0.508	63	12	30	2013-2023	131
Selenium, Dissolved (mg/L)	-0.033	0.091	14.8	0.25	1.9	2013-2023	92
Silver, Dissolved (mg/L)	0.055	<0.001	2.5	0.0025	0.5	2013-2023	110
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.006	0.287	1.77	0.3	0.615	2013-2023	110
Sodium, Dissolved (mg/L)	0.150	0.475	113	3.83	20.95	2013-2023	110
Sodium, total cations (%)	0.000	1.000	28	13	18	2013-2023	110
Specific conductance (µS/cm)	0.913	0.750	1710	82	535	2013-2023	131
Stream flow (cfs)	0.000	0.964	1460	1.5	34	2013-2023	131
Sulfate, Dissolved (mg/L)	0.125	0.902	744	9.99	155.5	2013-2023	110
Temperature, water (℃)	-0.085	0.375	23.4	0.1	11.5	2013-2023	131
Total Coliform (cells/100 mL)	16.550	<0.001	24200	0.5	0.5	2013-2023	105
Total dissolved solids, Dissolved, Dried 180 (mg/L)	1.000	0.768	1380	55	334.5	2013-2023	110
Total dissolved solids, Dissolved, Filtered (mg/L)	1.071	0.693	1270	42	322	2013-2023	105
Turbidity (NTU)	0.000	0.576	1020	1	6.3	2013-2023	110
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	-

	M140						
Parameter	Slope	p value	Maximum	Minimum	Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.006	0.0005	0.00001	0.00001	2013-2023	131
Alkalinity, Dissolved (mg/L)	0.225	0.752	193	24.8	96.5	2013-2023	105
Ammonia and ammonium, Dissolved (mg/L)	0.003	<0.001	5.97	0.005	0.03	2013-2023	125
Ammonia as NH_4 (mg/L)	0.003	<0.001	7.69	0.0065	0.035	2013-2023	125
Arsenic, Dissolved (mg/L)	0.003	0.400	1	0.125	0.37	2013-2023	110
Barometric pressure (mm/Hg)	-0.118	0.198	651	627	638.6	2013-2023	131
Cadmium, Dissolved (mg/L)	0.000	0.182	0.075	0.008	0.015	2013-2023	110
Calcium, Dissolved (mg/L)	0.288	0.475	134	11.2	58.55	2013-2023	110
Carbon dioxide, Total (mg/L)	0.133	<0.001	6.8	0.5	2	2013-2023	104
Chloride, Dissolved (mg/L)	0.357	0.121	89.8	3.62	22.2	2013-2023	110
Copper, Dissolved (mg/L)	-0.115	0.167	16.2	0.6	1.5	2013-2023	109
E. col i (cells/100 mL)	3.875	<0.001	24196	0.500	0.050	2013-2023	105
Hardness, Ca, Mg (mg/L $CaCO_3$)	2.000	0.325	583	40.6	238.5	2013-2023	110
Iron, Dissolved (mg/L)	0.200	0.863	584	8.7	36.95	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	0.014	0.070	7.3	0.31	0.645	2013-2023	119
Lead, Dissolved (mg/L)	-0.004	<0.001	0.536	0.015	0.0865	2013-2023	110
Magnesium, Dissolved (mg/L)	0.265	0.324	60.2	3.08	33.05	2013-2023	110
Manganese, Dissolved (mg/L)	2.413	<0.001	148	10.5	33.5	2013-2023	110
Nickel, Dissolved (mg/L)	-0.013	0.009	2	0.38	0.91	2013-2023	110
Nitrate + Nitrite, Dissolved (mg/L)	-0.099	0.008	9.68	0.354	2,25	2013-2023	126
Nitrate, Dissolved (mg/L)	-0.094	0.043	9.63	0.35	2.195	2013-20, 2022-23	114
Nitrite, Dissolved (mg/L)	0.003	<0.001	1.1	0.002	0.018	2013-20, 2022-23	114
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	-0.039	0.374	11	0.77	3.15	2013-2023	126
Organic carbon, Total (mg/L)	0.000	1.000	11.7	3.88	5.64	2013-2023	109
Organic Nitrogen, Total (mg/L)	0.000	0.961	5	0.165	0.58	2013-2023	125
Orthophosphate, Dissolved as P (mg/L)	-0.038	<0.001	2.66	0.008	0.25	2013-2023	126
Orthophosphate, Dissolved as $P0_4$ (mg/L)	-0.115	<0.001	8.15	0.023	0.7675	2013-2023	126
Oxygen, Dissolved (%)	-1.750	<0.001	132	66	106.75	2013-2023	130
Oxygen, Dissolved (mg/L)	-0.133	<0.001	13.9	6.1	9.5	2013-2023	130
pH (SU)	-0.02	<0.001	8.4	7.4	7.9	2013-2023	131
Phosphorus, Dissolved (mg/L)	-0.042	<0.001	2.97	0.019	0.2805	2013-2023	126
Phosphorus, Total (mg/L)	-0.041	<0.001	3.14	0.049	0.3595	2013-2023	126
Potassium, Dissolved (mg/L)	-0.041	0.267	10.6	0.92	3.285	2013-2023	110
RBP Stream width (ft)	-1.495	<0.001	63.5	20	37	2013-2023	131
Selenium, Dissolved (mg/L)	-0.040	0.142	7.4	0.3	2.1	2013-2023	92
Silver, Dissolved (mg/L)	0.054	<0.001	2.5	0.0025	0.5	2013-2023	108
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.000	0.090	2.04	0.37	0.955	2013-2023	110
Sodium, Dissolved (mg/L)	-0.042	0.980	104	5.64	33.05	2013-2023	110
Sodium, total cations (%)	0.000	0.186	35	18	24	2013-2023	110
Specific conductance (µS/cm)	4.750	0.276	1420	118	641	2013-2023	131
Stream flow (cfs)	-1.292	0.007	1155.5	11	50	2013-2023	131
Sulfate, Dissolved (mg/L)	0.665	0.730	482	20.2	176	2013-2023	110
Temperature, water (℃)	-0.093	0.203	23.55	1	12.8	2013-2023	131
Total Coliform (cells/100 mL)	73.785	<0.001	24200	0.500	0.500	2013-2023	105
Total dissolved solids, Dissolved, Dried 180 (mg/L)	1.283	0.554	1040	79	398	2013-2023	110
Total dissolved solids, Dissolved, Filtered (mg/L)	2.211	0.581	987	63	391	2013-2023	105
Turbidity (NTU)	-0.100	0.189	480	1	6.2	2013-2023	110
Zinc, Dissolved (mg/L)	-0.382	0.002	40	1	7.1	2013-2023	109

Parameter	Slope	p value	Maximum	Minimum	T10 Median	Date Range	Count
Acidity, (H+) (mg/L)	0.000	0.779	0.0001	0.00001	0.00003	2013-2023	110
Alkalinity, Dissolved (mg/L)	-0.183	0.030	32.6	9.7	18.15	2013-2023	104
Ammonia and ammonium, Dissolved (mg/L)	0.001	<0.001	0.02	0.005	0.01	2013-16, 2017, 2019-23	42
Ammonia as NH_4 (mg/L)	0.000	<0.001	0.03	0.0065	0.0065	2013-2023	106
Arsenic, Dissolved (mg/L)	0.000	0.302	0.32	0.05	0.12	2013-2023	110
Barometric pressure (mm/Hg)	-0.167	0.128	618	592	608	2013-2023	110
Cadmium, Dissolved (mg/L)	-	-	-	-	-	-	-
Calcium, Dissolved (mg/L)	0.020	0.349	9.02	2.44	4.765	2013-2023	110
Carbon dioxide, Total (mg/L)	0.000	0.884	3	0.4	1	2013-2023	99
Chloride, Dissolved (mg/L)	0.084	<0.001	6.19	0.59	1.75	2013-2023	110
Copper, Dissolved (mg/L)	-0.059	<0.001	9	0.4	0.98	2013-2023	110
E. col i (cells/100 mL)	0.000	<0.001	155	0.5	0.5	2013-2023	100
Hardness, Ca, Mg (mg/L $CaCO_3$)	0.085	0.445	3	8.36	16.6	2013-2023	110
Iron, Dissolved (mg/L)	-5.400	<0.001	439	35.9	84.9	2013-2023	110
Kjeldahl nitrogen, Total (mg/L)	-	-	-	-	-	-	-
Lead, Dissolved (mg/L)	0.000	0.265	0.704	0.01	0.032	2013-2023	110
Magnesium, Dissolved (mg/L)	0.010	0.246	2.28	0.529	1.135	2013-2023	110
Manganese, Dissolved (mg/L)	-0.353	0.022	77.5	2.07	6.7	2013-2023	110
Nickel, Dissolved (mg/L)	0.000	0.183	0.72	0.045	0.23	2013-2023	109
Nitrate + Nitrite, Dissolved (mg/L)	0.010	<0.001	0.87	0.02	0.11	2013-2023	105
Nitrate, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrite, Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH3), (NH4), organic, (NO2) and (NO3), Dissolved (mg/L)	-	-	-	-	-	-	-
Nitrogen, mixed forms (NH_3), (NH_4), organic, (NO_2) and (NO_3),Total (mg/L)	0.009	0.048	3.1	0.06	0.305	2013-2023	106
Organic carbon, Total (mg/L)	-0.070	0.004	14.2	1.55	2.9	2013-2023	109
Organic Nitrogen, Total (mg/L)	-0.003	0.085	3	0.03	0.085	2013-2023	96
Orthophosphate, Dissolved as P (mg/L)	0.000	0.038	0.038	0.002	0.006	2013-2023	105
Orthophosphate, Dissolved as $P0_4$ (mg/L)	<0.001	0.061	0.117	0.006	0.0185	2013-2023	102
Oxygen, Dissolved (%)	0.000	0.516	106	98	102	2013-2023	109
Oxygen, Dissolved (mg/L)	-0.057	0.002	12	7.3	9.4	2013-2023	109
pH (SU)	0.000	0.376	7.9	7	7.5	2013-2023	105
Phosphorus, Dissolved (mg/L)	0.000	0.870	0.044	0.003	0.008	2013-2023	103
Phosphorus, Total (mg/L)	0.000	0.917	2.24	0.006	0.0205	2013-2023	106
Potassium, Dissolved (mg/L)	0.010	0.032	1.42	0.41	0.69	2013-2023	110
RBP Stream width (ft)	-0.113	0.275	66	8.75	23.5	2013-2023	110
Selenium, Dissolved (mg/L)	-	-	-	-	-	-	-
Silver, Dissolved (mg/L)	0.009	<0.001	0.5	0.0025	0.5	2013-2023	110
Sodium adsorption ratio [(Na)/(sq root of 1/2 Ca + Mg)]	0.004	<0.001	0.51	0.25	0.34	2013-2023	110
Sodium, Dissolved (mg/L)	0.046	0.002	5.25	1.71	3.25	2013-2023	110
Sodium, total cations (%)	0.211	0.004	36	21	29	2013-2023	110
Specific conductance (µS/cm)	0.555	0.060	87	27	51	2013-2023	110
Stream flow (cfs)	0.000	0.980	352	2.8	20	2013-2023	110
Sulfate, Dissolved (mg/L)	0.050	0.153	12.9	1.38	2.84	2013-2023	110
Temperature, water (℃)	0.231	0.002	19.8	0	8.8	2013-2023	110
Total Coliform (cells/100 mL)	3.150	<0.001	3227	0.5	0.5	2013-2023	101
Total dissolved solids, Dissolved, Dried 180 (mg/L)	0.267	0.335	78	10	40.5	2013-2023	110
Total dissolved solids, Dissolved, Filtered (mg/L)	0.750	0.008	58	14	27	2013-2023	103
Turbidity (NTU)	0.000	0.396	1060	1	3.45	2013-2023	110
Zinc, Dissolved (mg/L)	-	-	-	-	-	-	-

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Loveland Water and Power