2023 ANNUAL REPORT

# Upper Cache la Poudre Watershed

## Collaborative Water Quality Monitoring Program

June 14th, 2024

PREPARED FOR
City of Fort Collins
City of Greeley
City of Thornton
Soldier Canyon Water Treatment Authority

PREPARED BY:
Diana Schmidt, Watershed Specialist
Jared Heath, Senior Watershed Specialist
Richard Thorp, Watershed Program Manager

City of Fort Collins Utilities

# EXECUTIVE SUMMARY

## BACKGROUND

The Upper Cache la Poudre Collaborative Water Quality Monitoring Program (hereafter referred to as the Upper CLP monitoring program) is designed to assist the City of Fort Collins, City of Greeley, City of Thornton and Soldier Canyon Water Treatment Authority in meeting current and future drinking water treatment goals by reporting current water quality conditions, trends within the Upper Cache la Poudre River (CLP) watershed and summarizing issues that potentially impact watershed health and source water quality.

## SCOPE OF ANNUAL REPORT

This annual report summarizes climatic and hydrologic conditions in the Upper CLP watershed over the 2023 water year and water quality data collected as part of the Upper CLP monitoring program. Spatial trends in water quality are evaluated at key monitoring locations throughout the Mainstem and North Fork CLP watershed, and temporal trends are evaluated at monitoring sites located near water treatment facility intakes on the Poudre River. This report compares water quality information from 2023 to baseline conditions defined as the period of record from 2008 to 2012.

## UPPER CACHE LA POUDRE WATERSHED WATER QUALITY

The Upper CLP watershed continues to provide a high-quality drinking water supply to the City of Fort Collins, City of Greeley and surrounding communities served by the Soldier Canyon Water Treatment Authority; however, the Cameron Peak Wildfire continues to impact water quality in the Mainstem CLP River. No water quality concerns were identified in the North Fork CLP River.

The typical challenges for water treatment were observed on the Mainstem and the North Fork during snowmelt runoff, exacerbated by remobilization of sediments from the Cameron Peak Fire within the CLP River. This resulted in elevated turbidity, specific conductivity, and nutrients. Like prior years, snowmelt driven impacts diminished in June.

The most notable impacts to water quality over the 2023 water year were associated with post-fire water quality impacts to the Mainstem CLP River from the Cameron Peak Fire burn scar during runoff and after high-intensity storm events in the summer monsoon season. Erosion from high-intensity precipitation events that occurred over the Cameron Peak Wildfire burn scar resulted in periodic occurrences of degraded water quality in the CLP River including elevated turbidity. The largest impacts were observed in the Poudre below Rustic (PBR) downstream to the City of Greeley's Diversion (PBD). Seven of the post-fire storm events in 2023 exceeded turbidity thresholds for water treatment indicating poor water quality, which resulted in the shutdown of Poudre River water supply intakes and reliance on alternate water sources. However, the magnitude, duration, and frequency of these events has decreased in years following the Cameron Peak Wildfire.

Elevated nitrate concentrations were observed at Joe Wright Creek (JWC) and in the Mainstem above Joe Wright Creek (PJW). High elevation reservoirs may act as a buffer between the severely burned hillslopes and the Mainstem CLP River, delaying the timing of the post-fire nutrient response. While nutrient concentrations may decrease in coming years in downstream sites on the CLP River, sites directly below high elevation reservoirs may see prolonged post-fire effects.

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# LIST OF ABBREVIATIONS & ACRONYMS

| | |
|---|---|
| cfs | cubic feet per second |
| CLP | Cache la Poudre River |
| DO | Dissolved Oxygen |
| DBP | Disinfection By-Product |
| EPA | Environmental Protection Agency |
| FCWQL | Fort Collins Water Quality Lab |
| FCWTF | Fort Collins Water Treatment Facility |
| JWC | Joe Wright Creek above the Poudre River (key monitoring site) |
| mg/L | milligrams per liter |
| NBH | North Fork of the Poudre River below Halligan Reservoir (key monitoring site) |
| NDC | North Fork of the Poudre River above Dale Creek Confluence (key monitoring site) |
| NFG | North Fork of the Poudre River below Seaman Reservoir (key monitoring site) |
| NFL | North Fork of the Poudre River at Livermore (key monitoring site) |
| ng/L | nanograms per liter |
| NTU | Nephelometric Turbidity Units |
| $^{o}C$ | degrees Celsius |
| PBD | Poudre River at the Bellvue Diversion (key monitoring site) |
| PBR | Poudre River below Rustic (key monitoring site) |
| PJW | Poudre River above the confluence with Joe Wright Creek (key monitoring site) |
| PNF | Poudre River above the North Fork (key monitoring site) |
| PSF | Poudre River below confluence with South Fork (key monitoring site) |
| ppt | parts per trillion |
| SCWTA | Soldier Canyon Water Treatment Authority |
| SNOTEL | Snow telemetry network |
| SWE | Snow water equivalent |
| T&O | Taste & Odor |
| TKN | Total Kjeldahl Nitrogen |
| TN | Total Nitrogen |
| TOC | Total Organic Carbon |
| TP | Total Phosphorus |
| µg/L | micrograms per liter |
| µS/cm | microSiemens per centimeter |
| USGS | United States Geological Survey |
| WTP | Water Treatment Plant |

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

The Upper Cache la Poudre (CLP) River is an important source of high-quality drinking water supplies for communities served by the City of Fort Collins Water Treatment Facility (FCWTF), the City of Greeley-Bellvue Water Treatment Plant (WTP), and the Soldier Canyon Water Treatment Authority's (SCWTA) Soldier Canyon Filter Plant (SCFP). In the shared interest of sustaining this high-quality water supply, the City of Fort Collins, the City of Greeley, and the SCWTA partnered in 2007 to design the Upper CLP Collaborative Water Quality Monitoring Program (Program). The Program was subsequently implemented in spring 2008. The goal of this collaborative partnership is to assist the participants in meeting current and future drinking water treatment goals by providing up-to-date information about water quality and trends within the Upper CLP watershed.

Raw CLP River water quality parameters that have historically had the most impact on treatment at the three treatment plants include:

- turbidity
- total organic carbon (TOC)
- pH
- alkalinity
- temperature
- taste and odor (T&O) compounds (geosmin and 2-methlyisoborneol)

Seasonal updates, annual water quality reports, and five-year reports for the Program are prepared by City of Fort Collins' Watershed Program staff to keep participants informed of current conditions, spatial trends, and short- and long-term trends in water quality of the Upper CLP watershed. Seasonal updates are provided during spring, summer, and fall of the monitoring season. These updates include a summary of the Upper CLP watershed, highlighting precipitation, streamflow, and water quality conditions . The purpose of annual reports is to summarize hydrologic, climatic, and water quality conditions for the previous water year. For the purposes of this report the water year is defined as the months of December through November as opposed to the months of October through September. Five-year trend reports provide a more in-depth analysis of both spatial and temporal trends in watershed hydrology, climate, and water quality. The first five-year trend report was completed for the years 2008-2012 (Oropeza & Heath, 2013). The second five-year trend report was prepared in 2018 and evaluated trends for the 10-year period of record from 2008 through 2017 (Heath et al., 2018). The third five-year trend report was prepared in 2022 and evaluated trends for the 15-year period of record from 2008 through 2022 (Heath et al., 2022). The Program's reports are available on the City of Fort Collins Utilities Source Water Monitoring website:

*https://www.fcgov.com/utilities/what-we-do/water/water-quality/source-water-monitoring/water-quality-reports* .

> The goal of this monitoring program is to assist the participants in meeting current and future drinking water treatment goals…

## 1.2 WATERSHED DESCRIPTION AND SAMPLING LOCATIONS

Sampling efforts are divided between the Mainstem CLP River watershed (including Joe Wright Creek, the Big South, and the Little South Fork Cache la Poudre River) and North Fork CLP River watershed. Collectively these watersheds encompass approximately 645,500 acres of forest, other natural land types, and agricultural land (**Table 1**). An additional 4,700 acres, representing less than 1% of land surface, is developed for commercial, industrial, utility, urban or residential purposes.

**Table 1** – Land use comparison between Upper North Fork and Mainstem CLP watersheds. Areas were calculated using US Geological Survey Seamless Geographic Information System data sets.

| Land Use Comparison | North Fork (acres) | North Fork (%) | Mainstem (acres) | Mainstem (%) |
|---|---|---|---|---|
| Developed land (commercial, industrial, residential, urban, and utilities) | 2,817 | 0.8 | 1,945 | 0.7 |
| Agricultural use and grassland (cropland, pasture, other agriculture, scrub and grasses) | 183,719 | 52.3 | 54,765 | 18.3 |
| Forest (forest and brush) | 154,654 | 44.1 | 213,879 | 71.5 |
| Natural lands (exposed rock, bare ground, wetlands, tundra, lakes) | 9,926 | 2.8 | 28,473 | 9.5 |
| **Total** | **351,116** | **100** | **299,062** | **100** |

The monitoring network consists of 18 sampling locations selected to characterize the headwaters, major tributaries, and downstream locations of the Upper CLP River near the City of Fort Collins, SCWTA, and City of Greeley raw water intake structures (**Figure 1.1**). A description and rationale for each location is provided in Attachment 1.

## 1.3 SAMPLING SCHEDULE AND PARAMETERS

The sampling frequency for the Program was determined based on both statistical performance and cost considerations. Parameters were selected based on analyses of historical data and aim to provide the best information possible within current budgetary constraints. Complete discussions of parameter selection and sampling frequency are provided in Sections 5.3 and 5.4, respectively, of the Program design document by Billica, Loftis and Moore (2008). The 2023 sampling schedule is provided in Attachment 4 of this report.

## 1.4 SAMPLE COLLECTION AND ANALYSIS

Field sampling is conducted by staff members from the City of Fort Collins' Watershed Program and Timberline Aquatics, Inc. Sampling methods, including those for the collection of physical field measurements for temperature, pH, conductivity, turbidity, and dissolved oxygen are documented in the Watershed Program's Standard Operating Procedures.

All water samples are analyzed by the City of Fort Collins Water Quality Lab (FCWQL) except macroinvertebrate samples, which are analyzed by Timberline Aquatics. The analytical methods and detection limits for the FCWQL parameters are included in Attachment 3.

Consistent with the quality assurance guidelines outlined in Section 5.5 of Billica, Loftis and Moore (2008), field blanks and field duplicates are collected alongside at least ten percent of samples for a subset of parameters, which are identified in the Annual Operating Plan (Attachment 4). A summary of quality assurance and quality control field blanks and field duplicates is discussed in Section 4 of this document.

## 1.5 SCOPE OF 2023 ANNUAL REPORT

This annual report summarizes climate and hydrology in the Upper CLP watershed over the 2023 water year and water quality data collected as part of the Upper CLP Collaborative Water Quality Monitoring Program. For this report, the water year is defined as December 1, 2022, to November 30, 2023. Spatial trends in water quality are evaluated at key monitoring locations throughout the Upper Mainstem and North Fork CLP watersheds, and temporal trends are evaluated at monitoring sites located near water treatment facility intakes on the Poudre River. The report compares water quality information from 2023 to baseline conditions, defined as the period of record from 2008 to 2012.

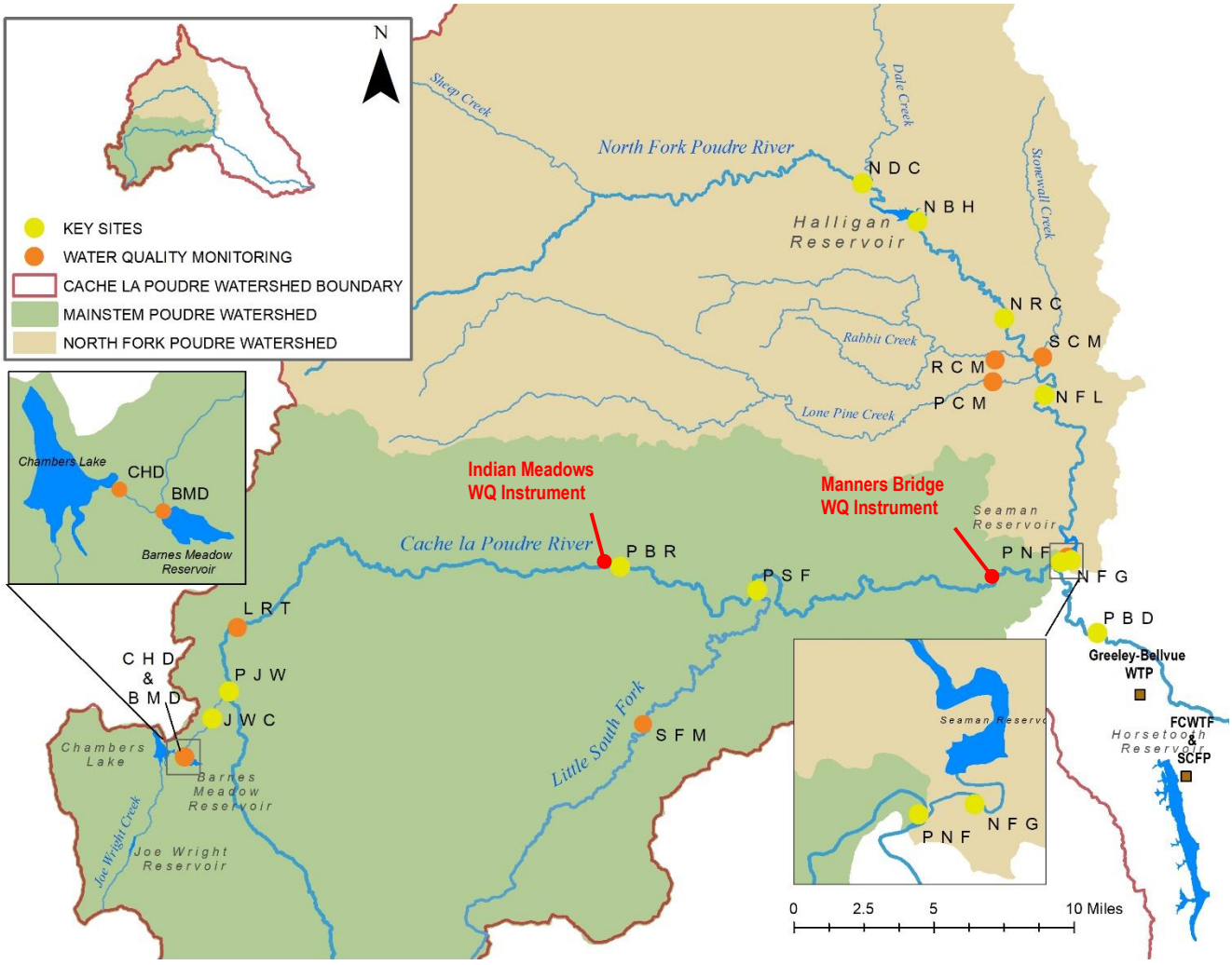


**Figure 1.1** – Map of the Upper CLP collaborative water quality monitoring network.

## 1.6 CAMERON PEAK WILDFIRE

The Cameron Peak Fire ignited on Thursday, August 13th, 2020, near Chambers Lake in the upper elevations of the CLP watershed near Cameron Pass. The Cameron Peak Fire was the largest wildfire in Colorado's history, burning just under 209,000 acres across both the Cache la Poudre and Big Thompson watersheds.

Several long-term water quality monitoring sites associated with the Upper CLP Collaborative Water Quality Monitoring Program are located either within or downstream of the area impacted by the wildfire. Water quality data collected as part of this monitoring program have been very useful in understanding the impacts from the 2020 Cameron Peak Fire on water quality and watershed recovery. Water quality impacts that have been observed following the fire include:

1) Abrupt changes in turbidity and suspended sediment during snowmelt run-off, and especially during and following monsoonal storm events.
2) Elevated background (non-storm event) concentrations in alkalinity, hardness, and total dissolved solids.
3) Increased background (non-storm event) concentrations in nutrients.
4) Elevated turbidity, total organic carbon, nutrients, and metals (dissolved and total) during snowmelt runoff and storm events.

Water quality monitoring instruments were installed at two locations upstream of the Poudre supply intake facility in early April 2021. The Poudre at Indian Meadows site is located one mile downstream of the Town of Rustic and the Manners Bridge site is located approximately one mile upstream of the City of Fort Collins' raw water intake (**Figure 1.1**). This monitoring system provides water treatment operations near real-time water quality data to quickly respond to changes in Poudre River water quality that result from runoff from the Cameron Peak burn area or other upstream events.

Both sites were valuable in detecting post-fire impacts from the Cameron Peak Fire during 2021, 2022, and 2023. Like prior years, post-fire water quality impacts to the Poudre River in 2023 were first observed during the spring snowmelt runoff and then during the summer monsoon season (July – August) before receding in mid-September. Sediments from the Cameron Peak Fire within the Poudre River were resuspended during snowmelt, resulting in increased turbidity. However, less sediment was delivered from burnt catchments to the river during the 2022 monsoon season and less was available for resuspension during the 2023 snowmelt. The combination of less sediment available for remobilization and the high volume of water in the river during snowmelt diluted impacts downstream resulting in less extreme post-fire water quality impacts observed during the spring months of 2023 compared to 2022 (**Figure 1.2**).

High-intensity precipitation events driven by the summer monsoon caused several significant poor water quality events in 2023. The typical response in water quality during these events included a drastic increase in river turbidity and as well as a slight decrease in pH corresponding to elevated amounts of sediment and ash being delivered from burned hillslopes and tributary drainages into the Poudre River. Over the summer season, the Manners Bridge real-time water quality instrument captured post-fire poor water quality events characterized by turbidity exceeding or equal to 100 NTU, the threshold requiring the City of Fort Collins water treatment plant to shut down its raw water intake on the Poudre River (**Figure 1.2**). These events were preceded by baseline turbidity values ranging between 3 and 10 NTU and the average time exceeding the 100 NTU threshold was three hours per event.

The maximum turbidity was measured at 941 NTU on August 1st following a storm event that occurred over the burn scar. In addition to this spike in turbidity, the water quality instruments also measured a sudden decrease in pH. Despite returning to near baseline conditions 24 hours after peak turbidity, another storm on August 3rd caused another poor water quality event (**Figure 2.1**). This and other significant poor water quality events required water treatment plants to shut down their raw water intakes on the Poudre River for a short time.

A similar number of post-fire storm events were observed during the 2023 monsoon season compared to previous years. These storm events prompted the shutdown of raw water intakes on the Poudre River. However, the duration of the events in 2023 was short, which lead to quicker water quality recovery after each event (**Figure 1.2**). There were seven post-fire events in the monsoon season of 2023 that prompted the shutdown of raw water intakes on the Poudre River, compared to six shutdowns in 2021 and 2022, respectively. The average duration of post-fire events in 2023 was three hours per event. This is a significant decrease from the 27- and 24-hour average event durations in 2021 and 2022, respectively. Shortened post-fire storm event duration indicates quicker water quality recovery.

High turbidity and poor water quality events continued to occur after high-intensity storms in the 2023 water year. However, the magnitude, duration, and frequency of these events have decreased substantially. The specific water quality impacts of these events are detailed in Section 3.

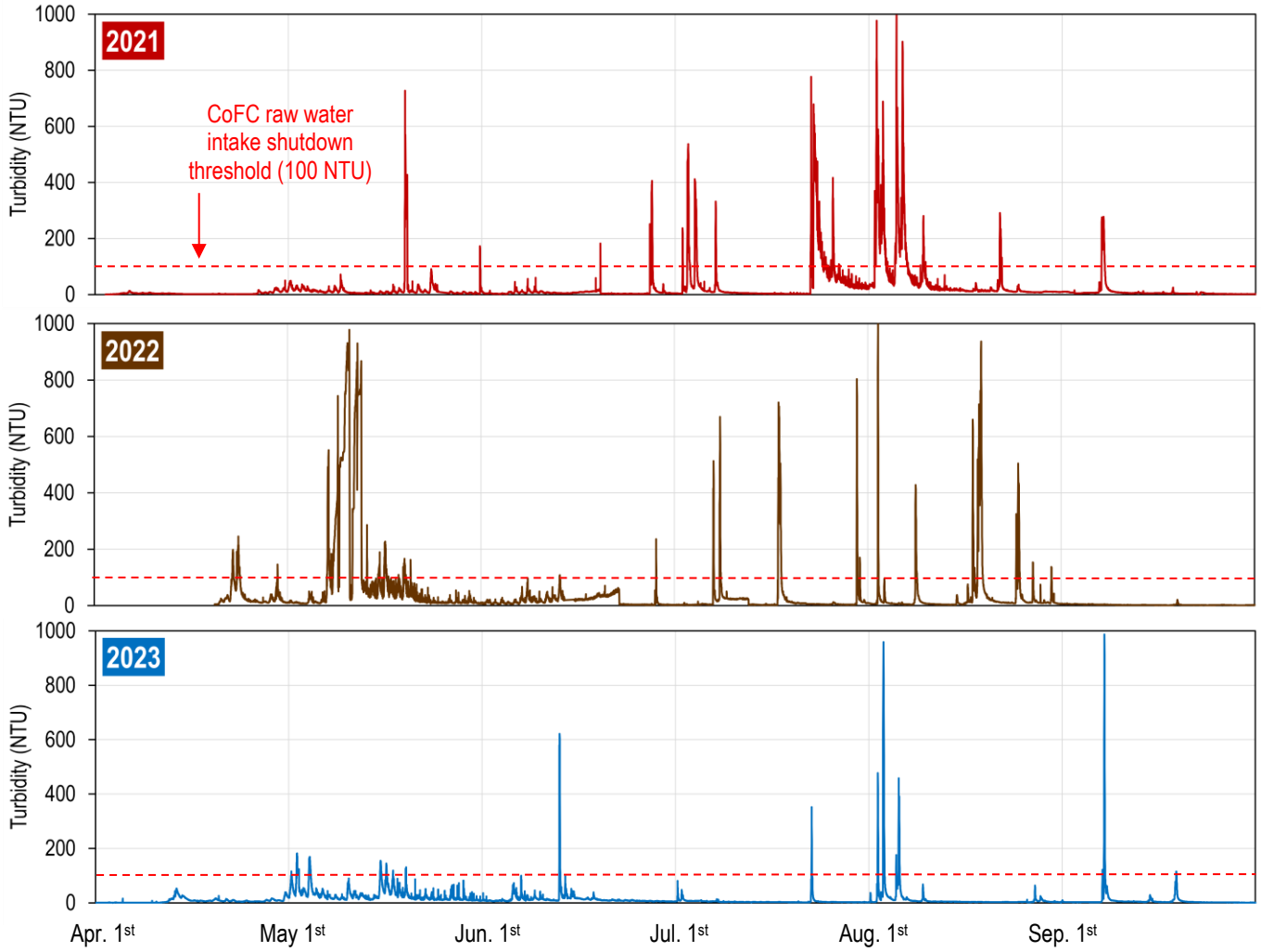


**Figure 1.2** – Turbidity measured in the Poudre River at the Manners Bridge real-time water quality instruments during 2021, 2022, and 2023 between the months of April and September.

# 2.0 HYDROLOGY & CLIMATE

Hydrology and climate play an important role in regulating the water quantity and quality in the Upper CLP watershed. Precipitation events and snowmelt runoff largely control the quantity and timing of deliveries of material to the river. The amount or volume of water in the system at a given time influences the concentration of most water quality constituents. Changes to the timing, magnitude, frequency and duration of snowmelt runoff and the associated effects on water quality have implications to water treatment operations.

*Hydrologic and Climatic Data Sources*

The snow telemetry (SNOTEL) network, managed by the Natural Resource Conservation Service, includes approximately 600 automated monitoring sites located in remote mountain watersheds throughout the United States that measure snow water equivalent (SWE), total precipitation and air temperature. Joe Wright SNOTEL is located near Joe Wright Reservoir at an elevation of 10,120 feet and contains the longest record of continuous measurements in the Cache la Poudre Watershed dating back to 1978.

The Cache la Poudre at Canyon Mouth near Fort Collins (CLAFTCCO) streamflow monitoring station is managed by the Colorado Department of Water Resources and contains the longest record of continuous streamflow in the Upper CLP watershed, dating back to 1883. The streamflow monitoring station is located at the Canyon Mouth and includes streamflow contributions from both the Mainstem and North Fork watersheds.

*Evaluating annual and seasonal trends*

Average monthly mean air temperature, monthly total precipitation and total monthly streamflow volume for the 2023 water year were compared to the average calculated over the baseline period of record from 2008 to 2012. Seasonal statistics were calculated for winter (DJF), spring (MAM), summer (JJA), and fall (SON).

## 2.1 AIR TEMPERATURE

The average mean air temperature in 2023 was 34.3°F and measured -0.4°F cooler than baseline (**Table 2**). The water year ranked as the 13th warmest on record (32 years; 1990 to 2022) at the Joe Wright SNOTEL. Air temperature measured near baseline over the winter and summer seasons, warmer than baseline over the fall, and colder than the baseline over the spring.

The average mean air temperature over the winter season was 18.5°F and measured 0.1°F warmer than baseline (**Table 2**). Temperature in the months of December, January, and February measured 1.2°F warmer, 0.7°F cooler, and 0.3°F cooler than baseline, respectively (**Figure 2.1**).

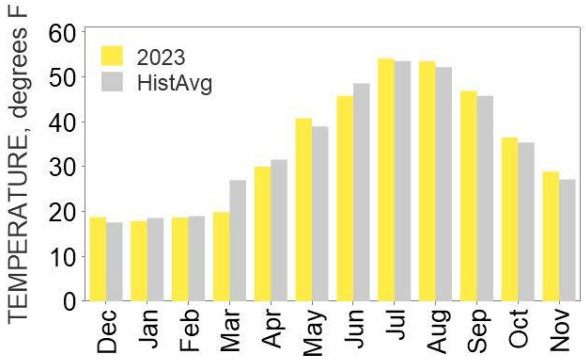


**Figure 2.1** –Monthly mean air temperature compared to baseline air temperature measured at the Joe Wright Snow Telemetry Station near Cameron Pass.

The average mean air temperature over the spring season was 30.2°F and measured 2.3°F cooler than baseline (**Table 2**). The month of May measured 1.8°F warmer than baseline and was ranked the 7th warmest on record. Contrastingly, the month of March measured 7.1°F cooler than baseline, making it the coldest on record. Additionally, the month of April measured 1.6°F cooler than baseline and was ranked as the 11th coldest. (**Figure 2.1**). As a result, the spring 2023 season ranked as the 10th coldest on record.

The average mean air temperature over the summer season was 51.1°F and measured 0.4°F cooler than baseline (**Table 2**). The month of June measured 2.8°F

**Table 2** – Seasonal summary statistics for temperature, precipitation, and streamflow in Upper CLP watershed in 2023 compared to baseline (period of record is 2008 – 2012).

| Season | Period of Record | Temperature (deg F) | | Precipitation (in) | | Streamflow (acre-ft) | |
|---|---|---|---|---|---|---|---|
| | | *Average* | *Departure* | *Total* | *% Average* | *Total* | *% Average* |
| **Winter** | 2023 | 18.5 | 0.1 | 15.0 | 118% | 10,512 | 138% |
| | Baseline | 18.4 | | 12.7 | | 7,602 | |
| **Spring** | 2023 | 30.2 | -2.3 | 12.3 | 82% | 73,551 | 155% |
| | Baseline | 32.5 | | 15.0 | | 47,547 | |
| **Summer** | 2023 | 51.1 | -0.4 | 8.0 | 119% | 174,912 | 104% |
| | Baseline | 51.5 | | 6.7 | | 168,506 | |
| **Fall** | 2023 | 37.4 | 1.1 | 6.3 | 57% | 11,457 | 86% |
| | Baseline | 36.3 | | 11.0 | | 13,295 | |
| **Annual (WY)** | 2023 | 34.3 | -0.4 | 41.6 | 92% | 269,862 | 114% |
| | Baseline | 34.7 | | 45.3 | | 236,949 | |

cooler and ranked near baseline. The months of July and August measured 0.5°F and 1.3°F warmer than baseline and ranked as the 9th and 7th warmest on record **(Figure 2.1**).

The average mean air temperature over the fall season was 37.4°F and measured 1.1°F warmer than baseline (**Table 2**). The months of September and October measured 1.1°F warmer than baseline. Warmer temperatures were observed in the month of November which measured 1.7°F warmer than baseline and ranked as the 10th warmest on record **(Figure 2.1**). The unseasonably warm temperatures resulted in the 8th warmest fall on record.

## 2.2 PRECIPITATION

### Total Precipitation

Total precipitation over the 2023 water year was 92% of baseline with a total of 41.6 inches of water measured at the Joe Wright SNOTEL (**Table 2**). Precipitation measured above baseline over the winter and summer months and below baseline over the spring and fall months.

The total precipitation measured over the winter season was 118% of baseline and totaled 15.0 inches (**Table 2**). December was the wettest winter month and measured 196% of baseline, making it the 2nd wettest December on record. January measured near baseline at 110%. Contrastingly, February was the driest winter month and measured 57% of baseline (**Figure 2.2**). The month of February ranked as the 5th driest on record (1979 to 2023; 44 years).

The total precipitation measured over the spring season was 82% of baseline and totaled 12.3 inches (**Table 2**). The highest amount of precipitation was observed during the month of March, which measured 143% of baseline. The months of April and May were notably drier than baseline and measured only 67% and 53% of baseline, respectively (**Figure 2.2**). The month of May ranked as the 5th driest on record.

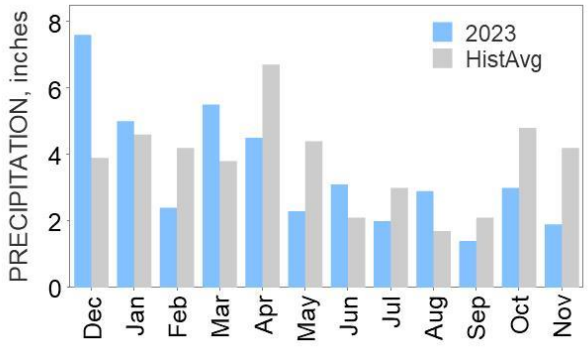


**Figure 2.2** – Monthly precipitation totals compared to baseline totals measured at the Joe Wright Snow Telemetry Station near Cameron Pass.

The total precipitation measured over the summer season was 119% of baseline and totaled 8.0 inches (**Table 2**). Precipitation measured over the months of June and

August were above baseline and measured 148% and 173% of baseline, respectively. In contrast, precipitation in the month of July measured 68% of baseline. Wet conditions observed over the months of June and August resulted in the 12th wettest summer on record.

However, dry conditions persisted during the fall season. The total precipitation measured over the fall season was only 57% of baseline and totaled 6.3 inches (**Table 2**). Precipitation during all fall months fell below baseline. The month of November was the driest fall month and measured 45% of baseline, making it the 4th driest on record. Precipitation over the months of September and November measured at 67% and 62% of baseline, respectively. These dry conditions resulted in the 2nd driest fall on record (**Figure 2.2**).

**Cache la Poudre Basin Snowpack**

Snow water equivalent (SWE) data were analyzed from five NRCS SNOTEL stations to evaluate differences across the basin as well as between years (**Figure 2.3**). Deadman Hill and Black Mountain SNOTELs represent snow conditions in the North Fork watershed; Hourglass Lake SNOTEL represents conditions in the South Fork watershed; and Joe Wright and Long Draw SNOTELs represent conditions in the Upper Mainstem CLP watershed (**Figure 2.3**).

The maximum amount of water contained in the snowpack, referred to as peak SWE, across the entire Cache la Poudre Watershed was 113% of the expected peak SWE based on the long-term median (1981-2010). The Mainstem and North Fork Poudre basins were above the long-term median at 117% and 115%, while the South Fork Poudre

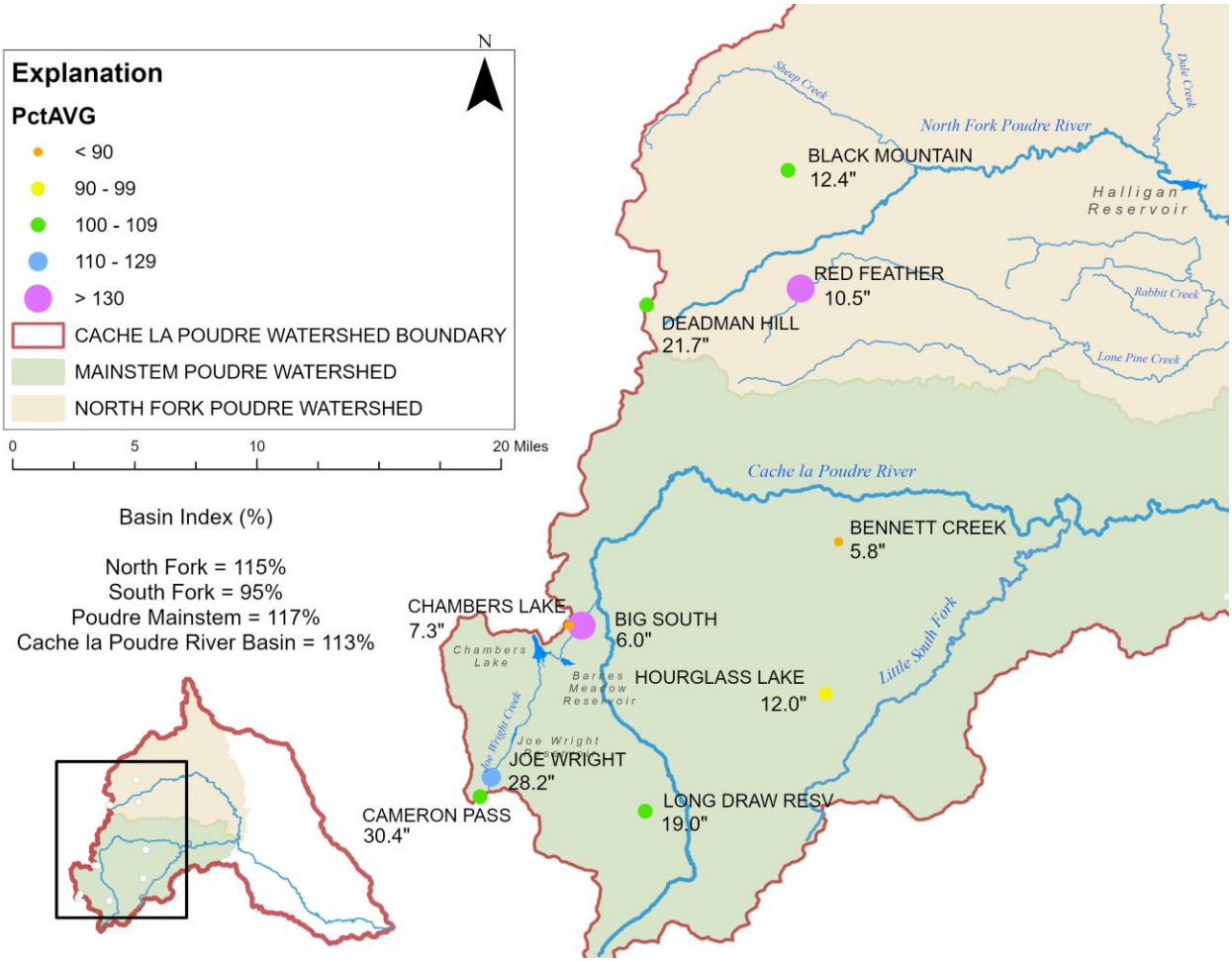


**Figure 2.3** – Locations of SNOTEL and snow course monitoring sites in the UCLP and percent of median peak snow water equivalent (SWE) in for the 2023 water year.

was slightly below the long-term median at 95% (**Figure 2.3**).

Peak SWE measured 124% of baseline at the Joe Wright SNOTEL and was observed close to normal on May 1st. Snowmelt began as expected, but the rate of snowmelt was slightly slower over the 2023 snowmelt season. The snowpack at the Joe Wright SNOTEL station was completely melted by June 20th, which was 10 days later than normal.

## 2.3 STREAMFLOW

The Mainstem and North Fork watersheds exhibit snowmelt-dominated hydrographs. Water is stored in the snowpack as snow accumulates through the winter and is subsequently released as runoff in the spring and summer as the snowpack melts.

**Mainstem Cache la Poudre River**

The total volume of water that flowed down the Mainstem CLP River over the 2023 water year (as measured at the Canyon Mouth stream gage) was 269,862 acre-feet, which was 114% of baseline (**Table 2**). Streamflow was above baseline over the winter, spring, and summer seasons and below baseline over the fall season.

Streamflow over the winter season measured 138% of baseline and totaled 10,512 acre-feet (**Table 2**). The months of December, January, and February all measured notably above baseline at 119%, 134%, and 172%, respectively. The highest streamflow contribution over the winter season was measured in the month of January at 3,535 acre-feet.

Streamflow over the spring season measured 155% of baseline and totaled 73,551 acre-feet (**Table 2**). Streamflow exceeded baseline during all spring months with March, April, and May at 114%, 110%, and 165%, respectively. Consistent with the historical trends, the highest streamflow contribution over the spring season was measured in the month of May at 63,287 acre-feet. Streamflow contributions over the spring season were notably higher than baseline, especially during the month of May (**Figure 2.4).**

Streamflow over the summer season measured 104% of baseline and totaled 174,912 acre-feet (**Table 2**). Streamflow in the months of June and August were above baseline at 105% and 140%, respectively. Streamflow in

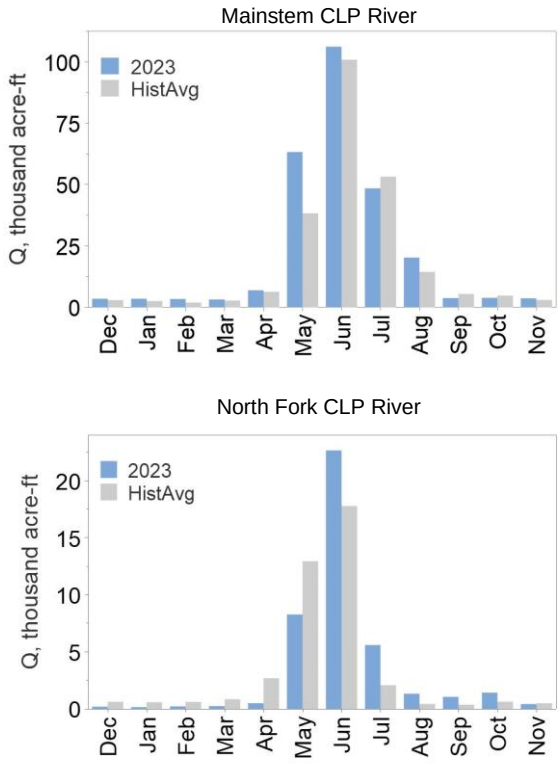


**Figure 2.4** –Total monthly streamflow in 2023 compared to average total monthly mean streamflow measured on the Mainstem CLP River near the Canyon Mouth (top) and North Fork CLP River near Livermore (bottom).

the month of July was below baseline and measured 91% of baseline (**Figure 2.4).** The peak streamflow in 2023 was 121% of the historical average peak streamflow (1991 – 2020) and occurred ten days later than average. Consistent with the historical trends, the highest streamflow contribution over the summer season was measured in the month of June at 106,155 acre-feet (**Figure 2.4).**

Streamflow over the fall season measured 86% of baseline and totaled 11,458 acre-feet (**Table 2**). Streamflow over the months of September and October were lower than baseline and measured 70% and 82% of baseline, respectively. Streamflow over the month of November measured above baseline at 123%. Unlike historical trends, the highest fall streamflow contributions were measured over the month of October at 3,916 acre-feet (**Figure 2.4).**

## North Fork Cache la Poudre River

The total volume of water that flowed down the North Fork CLP River near Livermore (NFL) over the 2023 water year was 42,016 acre-feet, which was 105% of baseline (**Figure 2.4**). Streamflow was well below baseline over the winter and spring seasons, and notably higher than baseline over the summer and fall seasons.

Streamflow measured over the winter season was 31% of baseline with a total of 559 acre-feet of water. All winter months were well below baseline at 30%, 26% and 36% for the months of December, January, and February, respectively (**Figure 2.4**).

Streamflow measured over the spring season was 55% of baseline and totaled 8,993 acre-feet. The months of March and April were notably below baseline at 28% and 18%, respectively. The month of May was also below baseline at 64% (**Figure 2.4**).

However, streamflow increased in the summer months. The summer season measured 146% of baseline and totaled 29,571 acre-feet. Streamflow in all summer months were well above baseline and measured 127%, 269%, and 310% for June, July, and August, respectively (**Figure 2.4)**.

Streamflow measured over the fall season was 192% of baseline and totaled 2,892 acre-feet. The months of September and October measured well above baseline at 284% and 222%, respectively, while the month of November measured below baseline at 84% (**Figure 2.4).**

## Streamflow Contributions

There are several tributaries, diversions, and water storage reservoirs that contribute to the overall streamflow and water quality on the Mainstem CLP River above the North Fork. The two highest elevation trans-basin diversions in the Upper CLP include Michigan Ditch, which diverts water from the Upper North Platte basin to Joe Wright Reservoir and the Grand Ditch, which diverts water from the Upper Colorado River basin into Long Draw Reservoir. The contributions of these diversions are not presented in the report, but contributions released from the reservoirs in which these waters are stored are addressed. A summary of 2023 water contributions to the Mainstem CLP River above the Munroe Tunnel is presented in **Table 3**.

During snowmelt runoff, from April through June, most of the streamflow originated from the Big South and Mainstem tributaries. Contributions were more evenly distributed across the basin in July, August, and September. The highest contributions were from the Big South and associated releases from Long Draw Reservoir. Flow contributions over the fall season were dominated by mostly native flows from the Big South and Mainstem tributaries.

The combined volume of water from the Mainstem and North Fork, as measured at the City of Greeley's Diversion (PBD) on the CLP River was 301,941 acre-feet (**Figure 2.5**). The North Fork contributed 16% (47,890 acre-feet) of the total volume and the Mainstem contributed 84% (254,051 acre-feet) of the total volume (**Figure 2.5**). Approximately 23,673 acre-feet of water was diverted at the Poudre Valley Canal located upstream of the City of Greeley's Diversion.

An estimated 293,248 acre-feet of water flowed down the Poudre River above the Munroe Tunnel and North Fork in 2023 and a combined 38,968 acre-feet of water was diverted through the Munroe and City of Fort Collins diversions.

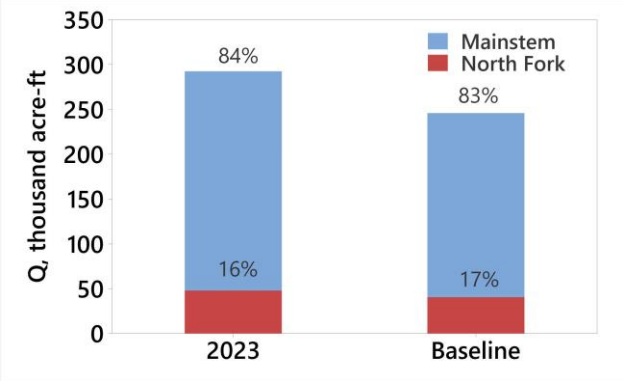


**Figure 2.5** – Proportion of average Mainstem and North Fork contributions at PBD in 2023 compared to average.

**Table 3** – Tributary contributions by month to the Mainstem Cache la Poudre River above the Munroe Tunnel in WY2023. Contributions highlighted in red indicated the greatest monthly contribution to the Mainstem. Note: AF = acre-feet.

*Total volume does not include water contributions from Long Draw Reservoir, which releases water to the Big South.

**Includes contributions from the Little South Fork Cache la Poudre River

| Month | Barnes Meadow | | Chambers Lake | | Laramie River Tunnel | | Long Draw Reservoir | | Big South* & Mainstem Tributaries** | | Poudre above Munroe | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AF | % | AF | % | AF | % | AF | % | AF | % | AF | % |
| Dec | 81 | 2% | 712 | 20% | - | - | - | - | 2,758 | 78% | 3,550 | ------ |
| Jan | 113 | 3% | 610 | 16% | - | - | - | - | 3,122 | 81% | 3,845 | ------ |
| Feb | 149 | 4% | 658 | 17% | - | - | - | - | 2,998 | 79% | 3,805 | ------ |
| Mar | 247 | 7% | 715 | 21% | - | - | - | - | 2,376 | 71% | 3,338 | ------ |
| Apr | 80 | 1% | 890 | 11% | - | - | - | - | 6,963 | 88% | 7,934 | ------ |
| May | 631 | 1% | 4,949 | 7% | - | - | - | - | 67,829 | 92% | 73,409 | ------ |
| Jun | 60 | 0% | 11,960 | 12% | 76 | 0% | 5,133 | 5% | 84,283 | 83% | 101,511 | ------ |
| Jul | 61 | 0% | 6,949 | 13% | 147 | 0% | 10,596 | 19% | 37,702 | 68% | 55,455 | ------ |
| Aug | 30 | 0% | 3,776 | 14% | 5,017 | 18% | 7,731 | 28% | 10,640 | 39% | 27,193 | ------ |
| Sep | - | - | 3,581 | 28% | 2,510 | 20% | 1,350 | 11% | 5,143 | 41% | 12,584 | ------ |
| Oct | - | - | 1,389 | 24% | 1,061 | 18% | 37 | 1% | 3,423 | 58% | 5,911 | ------ |
| Nov | - | - | 820 | 20% | - | - | 3 | 0% | 3,304 | 80% | 4,126 | ------ |
| **Total** | **1,451 (0.5%)** | | **37,008 (12%)** | | **8,811 (3%)** | | **24,850 (8%)** | | **230,540 (76%)** | | **302,660** | |

# 3.0 SPATIAL TRENDS IN UPPER CACHE LA POUDRE WATER QUALITY

Spatial water quality trends discussed in the 2023 Annual Report focus primarily on monitoring sites located on the Mainstem and North Fork CLP Rivers that are considered representative of water quality conditions throughout the Mainstem and North Fork CLP watersheds. The following lists key sites from upstream to downstream:

- **Mainstem CLP River**
  - JWC – Joe Wright Creek above the Poudre River
  - PJW – Poudre above Joe Wright Creek
  - PBR – Poudre below Rustic
  - PSF – Poudre below South Fork
  - PNF – Poudre above North Fork
  - PBD – Poudre at Bellvue Diversion

- **North Fork CLP River**
  - NDC – North Fork above Dale Creek
  - NBH – North Fork below Halligan Reservoir
  - NRC – North Fork above Rabbit Creek
  - NFL – North Fork at Livermore
  - NFG – North Fork at Gage

Discussion of the results will focus primarily on these key sites; however, data from all sites were reviewed and analyzed and any notable water quality events and trends are included in the discussion.

*Presentation of Results*

Boxplots presented in this report display summary statistics (maximum, median, and minimum) for the current monitoring year compared to baseline conditions defined as the period of record from 2008 through 2012. Arrows represent median values for the current monitoring year. A full list of monitoring sites, abbreviations and location descriptions is available in Attachment 1. Finalized raw data are available upon request from the City of Fort Collins Watershed Program.

*Selected Variables and Monitoring Sites*

Data review and analyses were performed on all monitoring sites throughout the Upper CLP watershed for the water quality parameters listed below:

- **Field Parameters** – temperature, pH, specific conductivity, turbidity
- **General** – alkalinity, hardness, total dissolved solids
- **Total Organic Carbon**
- **Nutrients** – nitrogen and phosphorus
- **Biological** – *E. coli* and total coliforms
- **Metals**
- **Taste & Odor Compounds**
- **Macroinvertebrates**

These water quality parameters were selected because they either have a direct impact on water treatment processes or serve as key indicators for pollutants that may influence water treatment and source water quality.

## 3.1 FIELD PARAMETERS

**Water Temperature**

Water temperature influences other water quality parameters and is a major driver of biological activity, including algal growth in reservoirs and rivers. Some species of cyanobacteria can produce the taste and odor compounds, geosmin and 2-Methylisoborneol (2-MIB), which are discussed in Section 3.5.

Water temperature throughout the Mainstem and North Fork CLP watersheds were within baseline in 2023 at nearly all monitoring sites (**Figure 3.1**).

*Mainstem*

Water temperature increased with decreasing elevation in the Mainstem over the monitoring season and ranged from a minimum temperature of 0°C in the Mainstem Poudre above Joe Wright Creek (PJW) to a maximum temperature of 18.6°C at the City of Greeley's Diversion (PBD). Minimum water temperatures were warmer than baseline at all monitoring sites except in the Mainstem Poudre above Joe Wright Creek (PJW). Minimum water temperatures in the Mainstem were measured in early-April and mid-November. Median water temperatures were above baseline at all monitoring sites. The largest departure from baseline was measured from the Mainstem Poudre above Joe Wright Creek (PJW) with a 1.8°C increase from the

baseline median. Maximum water temperatures were cooler than baseline at all monitoring sites. The timing of maximum water temperature varied between June and September across the Mainstem. Maximum water temperature at the Laramie River Tunnel (LRT) occurred in June while the maximum water temperature at the Poudre above Joe Wright Creek (PJW) occurred in September.

*North Fork*

Water temperature in the North Fork ranged from a minimum temperature of 0.2°C in the North Fork above Dale Creek (NDC) to a maximum temperature of 23.5°C in the North Fork below Seaman Reservoir (NFG). Minimum water temperatures were above baseline at all sites except in the North Fork above Dale Creek (NDC) and the North Fork below Halligan Reservoir (NBH). Minimum water temperature at these sites were at baseline and 2.6°C cooler than baseline minimums, respectively. Median water temperatures were above baseline at all monitoring sites. Maximum water temperatures were below baseline at all sites except on the North Fork below Seaman Reservoir (NFG). The maximum temperature at this site was 0.2°C warmer than the baseline maximum. The timing of maximum water temperature varied across the North Fork. Maximum water temperature in the North Fork above Dale Creek (NDC) was measured in July, while the maximum water temperature in the North Fork near Livermore (NFL) was measured in August.

**pH**

pH is a measure of the amount of free hydrogen ($H^+$) and hydroxide ($OH^-$) ions in water and is measured on a logarithmic scale ranging from 0 to 14. Water with a pH near 7 is considered neutral, with more acidic conditions occurring below 7 and more basic, or alkaline conditions, occurring above 7. pH is an important water quality parameter to monitor because it influences the solubility and biological availability of chemical constituents, including nutrients and heavy metals.

pH values throughout the Mainstem and North Fork CLP watersheds were near or above baseline in 2023 at most monitoring sites (**Figure 3.1**).

*Mainstem*

pH values along the Mainstem followed expected seasonal trends. pH values were generally higher in the early-spring and decreased during the snowmelt runoff season. pH slowly increased over the late-summer and fall seasons but remained lower than values observed in early spring. In general, pH increased from the top of the watershed downstream to lower elevation monitoring locations. pH values ranged from 6.88 in Joe Wright Creek above the Poudre River (JWC) to 8.41 at the City of Greeley's Diversion (PBD). In general, pH values at the higher elevation monitoring sites (JWC and PJW) were lower compared to mid- and lower elevation monitoring sites. Minimum pH values were notably higher than baseline at all monitoring sites. Median pH values were below baseline in Joe Wright Creek (JWC) and in the Mainstem above Joe Wright Creek (PJW). Median pH values were above baseline from the Mainstem below Rustic (PBR) downstream to City of Greeley's Diversion (PBD). The largest departures from the baseline median pH were observed from the Mainstem below the South Fork (PSF) downstream to the City of Greeley's diversions (PBD). The median pH values at these sites were approximately 0.2-0.3 pH units greater than baseline. The cause of this notable shift in baseline at these sites is unclear. Maximum pH values were notably higher than baseline in the Mainstem below the South Fork (PSF) at 0.3 pH units above baseline. This departure from baseline was observed in April.

*North Fork*

pH in the North Fork was slightly more alkaline compared to the Mainstem especially in the North Fork above Rabbit Creek (NRC) downstream to the North Fork below Seaman Reservoir (NFG). Seasonal trends are less apparent in the North Fork. pH values in the North Fork ranged from a minimum pH of 7.30 in the North Fork below Halligan Reservoir (NBH) to 8.80 in the North Fork below Seaman Reservoir (NFG). There was slightly more variability between monitoring sites along the North Fork, specifically from the North Fork below Halligan Reservoir (NBH) downstream to the North Fork above Rabbit Creek (NRC). Minimum pH values were higher than baseline at all monitoring sites. Median pH was below baseline in the North Fork above Dale Creek (NDC) and below Halligan Reservoir (NBH). Median pH was above baseline from the North Fork below Rabbit Creek (NRC) downstream to the North Fork below Seaman Reservoir (NFG). The largest departure from the baseline median was the North Fork below Halligan at approximately 0.3 pH units below the baseline median. Maximum pH values were above baseline in the North Fork below Seaman Reservoir (NFG) at 0.2 pH units above baseline. This departure from baseline was

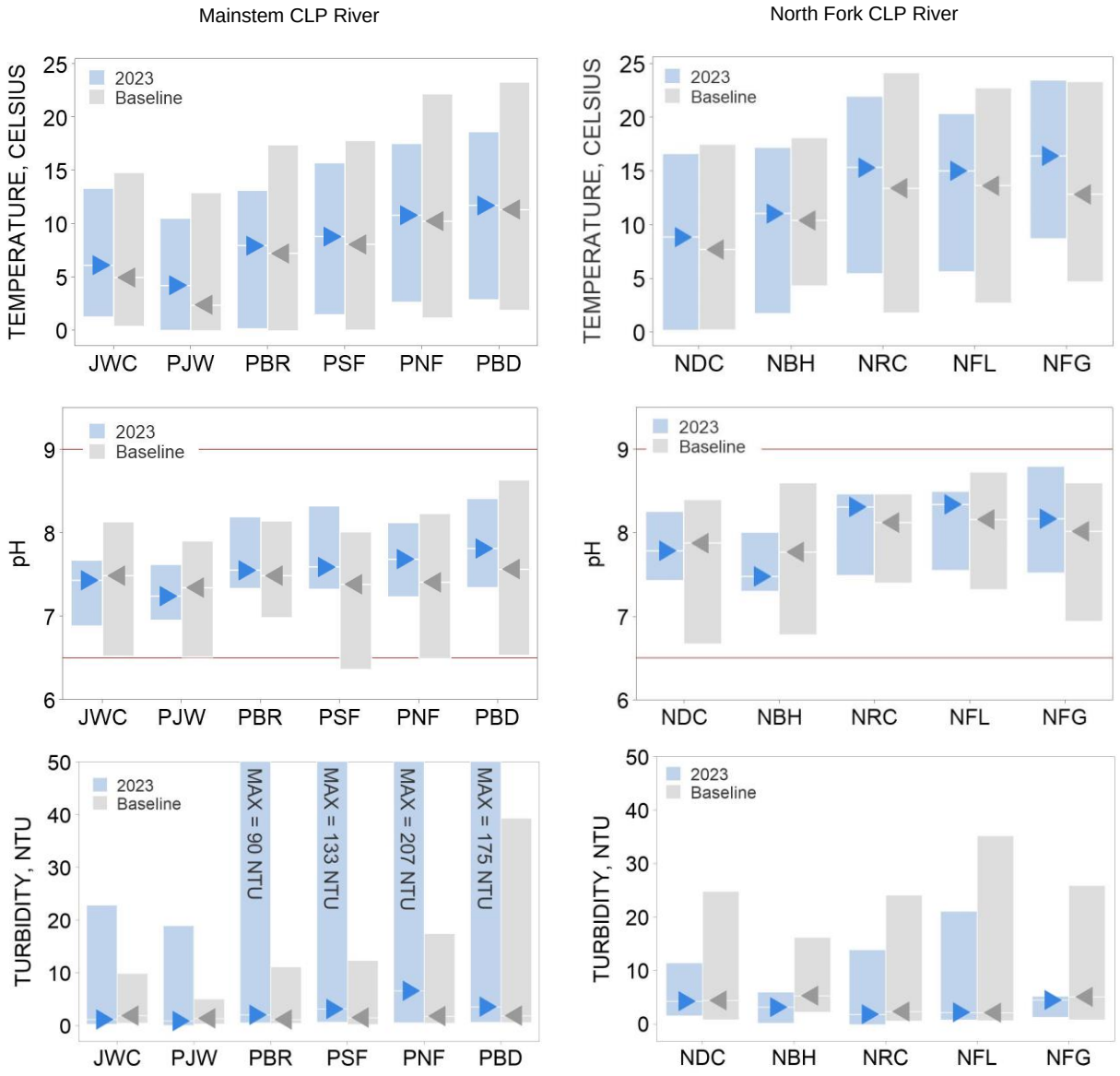


**Figure 3.1** – Water temperature, pH, and turbidity measured at key monitoring locations on the Mainstem CLP River (left) and North Fork CLP River (right) in 2023 compared to the baseline period of record. The red reference lines for pH indicate the Colorado Department of Public Health and Environment water quality standard to protect aquatic life.

observed in May. Maximum pH values were near or above baseline for all other monitoring sites.

### Turbidity

Turbidity is a measurement of the amount of light capable of passing through water. This water quality parameter is often monitored to track changes in water clarity, which is influenced by the presence of algae and/or suspended solids introduced to surface waters through various land use activities, including runoff and erosion, and urban storm water runoff and drainage from agricultural lands. Turbidity concentrations can signal changes in land use activity. For water treatment, turbidity is an important indicator of the amount of suspended materials in water, which can harbor pollutants such as heavy metals, bacteria and other pathogens, nutrients, and organic matter.

Turbidity in the Mainstem CLP River was well outside of the expected baseline range of values at all monitoring sites, while turbidity in North Fork CLP River was within the expected baseline range of values at all monitoring sites (**Figure 3.1**).

*Mainstem*

Turbidity was consistently higher than baseline in the Mainstem at nearly all monitoring sites except in Joe Wright Creek (JWC) and in the Mainstem above Joe Wrigth Creek (PJW) **(Figure 3.1)**. Turbidity ranged from a minimum of less than 1 NTU at all monitoring sites to a maximum of 207 NTU at the City of Fort Collins' Diversion (PNF). Minimum turbidity values were near baseline at all monitoring sites in 2023. Median turbidity values were slightly below baseline in Joe Wright Creek (JWC) and in the Mainstem above Joe Wright Creek (PJW). This could be due to the sediment buffering effects of the reservoirs upstream of both sites. In contrast, median turbidity values from the Poudre below Rustic (PBR) downstream to the City of Greeley's Diversion (PBD) were higher than baseline. The largest departure from baseline was observed at the City of Fort Collins' Diversion (PNF) where median concentrations were nearly four times greater than baseline. The elevated turbidity at these sites was driven primarily by unseasonably high turbidity levels observed in early spring, mid-summer, and fall. Turbidity values during these periods are generally low, but elevated concentrations were observed due to persisting post-fire impacts observed throughout most of the 2023 monitoring year. Similarly, maximum turbidity was much higher than baseline at all sites monitoring sites. Notably high turbidity concentrations occurred at the Mainstem Poudre below Rustic and downstream to the City of Greeley's Diversion. The highest turbidity value was measured at the City of Fort Collins' Diversion (PNF) at 207 NTU, which was 12 times higher than the baseline. Maximum turbidity concentrations at all sites were measured on June 12$^{th}$, 2023, during a post-fire storm event.

*North Fork*

In contrast to pre-fire years, turbidity was lower in the North Fork compared to the Mainstem. Turbidity values ranged from a minimum of less than 1 NTU at nearly all monitoring sites to a maximum of 21 NTU in the North at Livermore (NFL). Minimum and median turbidity values were near or below baseline at all monitoring sites. Turbidity was generally higher with more variably in the North Fork above Rabbit Creek (NRC) and near Livermore (NFL). Less variability was observed in the North Fork above Dale Creek (NDC), below Halligan Reservoir (NBH), and in the North Fork below Seaman Reservoir (NFG). The differences in turbidity between the North Fork above Rabbit Creek (NRC) and the North Fork near Livermore (NFL) highlight the influence of the tributaries (PCM and RCM) on turbidity in the North Fork, especially during snowmelt runoff when turbidity values are high in these tributaries, and the influence of Halligan and Seaman Reservoirs on reducing turbidity along the North Fork (NBH and NFG). Median turbidity values were generally consistent across monitoring locations but decreased slightly from the North Fork above Dale Creek (NDC) to the North Fork near Livermore (NFL). Median concentrations at these monitoring locations did not exceed 5 NTU. Median turbidity was slightly increased from the North Fork near Livermore (NFL) to the North Fork below Seaman Reservoir (NFG) but did not exceed 5 NTU. Maximum turbidity was lower than baseline at all monitoring sites. A maximum turbidity of 21 NTU was measured in June. This value was still 14 NTU lower than the maximum turbidity measured in the North Fork at Livermore (NFL) over the baseline period of record.

## 3.2 GENERAL PARAMETERS

**Alkalinity, Hardness & Specific Conductance**

Specific conductance is an index of dissolved ionic solids in water, and hardness is an index of the total calcium (Ca) and magnesium (Mg) in water. Alkalinity is a measure of the effective acid buffering capacity of water and is derived from the dissociation of mineral carbonates ($CO_3^-$), bicarbonates ($HCO_3^-$), and hydroxides ($OH^-$). Conductivity, hardness, and alkalinity are influenced by local geology, as well as other dissolved constituents derived from land use practices throughout the watershed.

Concentrations of these constituents are influenced by the magnitude and timing of streamflow and by the size of the contributing watershed area. The highest concentrations are typically observed during times of low flow in late fall

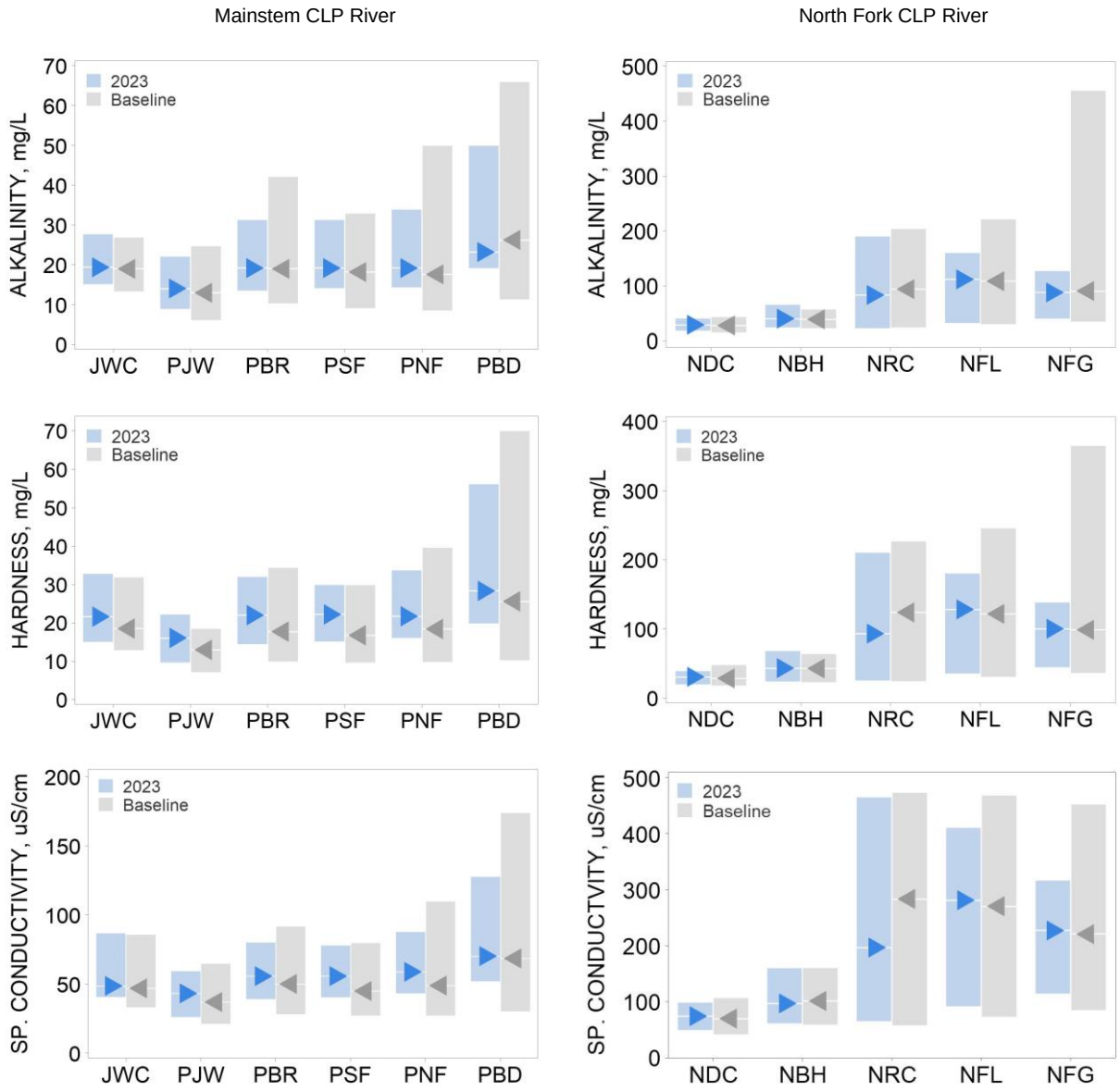


**Figure 3.2** – Alkalinity, hardness and specific conductivity measured at key monitoring locations on the Mainstem CLP River (left) and North Fork CLP River (right) in 2023 compared to the baseline period of record.

and winter, while minimum concentrations are observed during snowmelt runoff. In general, concentrations increase with decreasing elevation and increasing contributing watershed area.

Alkalinity, hardness, and specific conductivity concentrations in the Mainstem and North Fork CLP watersheds were within baseline at most monitoring sites in 2023 (**Figure 3.2**).

*Mainstem*

Alkalinity, hardness, and specific conductivity concentrations increased slightly from Joe Wright Creek (JWC) downstream to the City of Greeley's Diversion (PBD). Alkalinity concentrations ranged from 8.80 mg/L $CaCO_3$ to 50.0 mg/L $CaCO_3$; hardness concentrations ranged from 9.5 mg/L to 56.2 mg/L; and specific conductivity ranged from 25.9 µS/cm to 127.9 µS/cm. Minimum concentrations of these parameters were

observed in the Mainstem above Joe Wright Creek (PJW) and maximum concentrations were observed at the City of Greeley's Diversion (PBD). Minimum concentrations were well above baseline at all monitoring sites. Minimum concentrations were measured in early June at all monitoring sites corresponding with high streamflow during snowmelt runoff. Median concentrations for all parameters were near or slightly above baseline for almost all sites. Median alkalinity at the City of Greeley's Diversion (PBD) was slightly below baseline. Maximum alkalinity and specific conductivity concentrations were below baseline at all monitoring sites except in Joe Wright Creek (JWC). Maximum hardness concentrations were above baseline at all monitoring sites except in Joe Wright Creek (JWC) and in the Mainstem above Joe Wright Creek (PJW). Maximum concentrations were mostly observed in April, however higher concentrations were observed in late fall when streamflow was low.

*North Fork*

Notable increases in alkalinity, hardness and specific conductivity concentrations were measured between the North Fork below Halligan Reservoir (NBH) to the North Fork above the confluence with Rabbit Creek (NRC). This change is likely associated with significant changes in streamflow downstream of the North Poudre Canal; groundwater and return flows from agricultural land use practices on the North Fork as it enters and passes through the Livermore Valley; and contributions from the North Fork tributaries, Rabbit Creek (RCM), Stonewall Creek (SCM) and Lone Pine Creek (PCM). Concentrations slightly increased from the North Fork above Rabbit Creek (NRC) downstream to the North Fork near Livermore (NFL) due to contributions from North Fork tributaries. Concentrations were generally higher in Rabbit Creek (RCM), Stonewall Creek (SCM) and Lone Pine Creek (PCM). Alkalinity, hardness, and specific conductivity concentrations were lower and less variably in the North Fork below Seaman Reservoir (NFG) compared to upstream in the North Fork near Livermore (NFL).

Alkalinity concentrations at key sites ranged from 17.8 mg/L $CaCO_3$ to 212.0 mg/L $CaCO_3$; hardness concentrations ranged from 18.8 mg/L to 243.0 mg/L; and specific conductivity ranged from 48.4 µS/cm to 465.8 µS/cm. Minimum concentrations were measured in the North Fork above Dale Creek (NDC) and maximum concentrations were measured in the North Fork above Rabbit Creek (NRC). Minimum concentrations were near or above baseline at all monitoring sites. Median concentrations were near baseline above and below Halligan Reservoir (NDC and NBH) and below baseline at the North Fork above Rabbit Creek (NRC). Downstream, median concentrations returned near baseline at the North Fork near Livermore (NFL) and below Seaman Reservoir (NFG). Median concentrations were lower in the North Fork above Rabbit Creek (NRC). The lower concentrations at these monitoring sites were likely correlated to above average streamflow conditions observed in the North Fork during the summer and fall months. Maximum concentrations were below baseline at all monitoring sites except in the North Fork below Halligan Reservoir (NBH). Maximum concentrations were markedly lower than baseline in the North Fork near Livermore (NFL) and in the North Fork below Seaman Reservoir (NFG). The highest concentrations were generally observed in April and November in the North Fork above Rabbit Creek (NRC) and downstream to the North Fork below Seaman Reservoir (NFG), and in the late-summer and early-fall above and below Halligan Reservoir (NDC and NBH)

**Total Dissolved Solids**

Total dissolved solids (TDS) provide a qualitative measure of dissolved ions comprised of inorganic salts (calcium, magnesium potassium, sodium, bicarbonates, chlorides, and sulfates) and a small portion of organic matter. Sources of TDS in surface water consist of natural weathering and erosion of geologic material, mining, industrial and sewage effluent, groundwater, and agriculture.

Elevated TDS concentrations in drinking-water sources do not pose a health risk, but high levels can cause aesthetic risks including corrosion, salty or brackish taste, and scale formation. Because of these potential risks the Environmental Protection Agency established a secondary TDS standard for surface waters with a drinking water supply designated use. Elevated TDS concentrations may also be used as an indicator of elevated ions; some of which have primary or secondary drinking water standards.

Total dissolved solids (TDS) were above baseline along the Mainstem CLP River and near or below baseline along the North Fork CLP River (**Figure 3.3**).

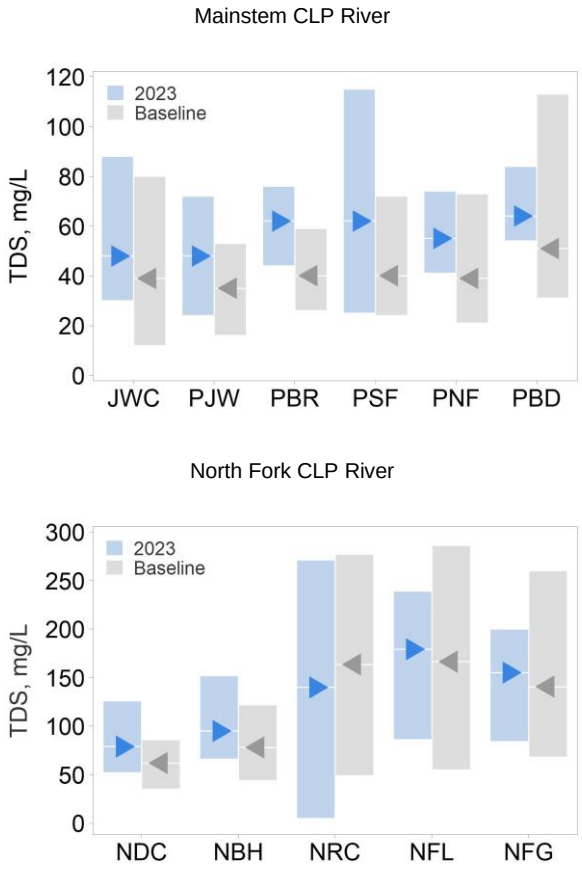


**Figure 3.3** – Total dissolved solids (TDS) measured at key monitoring locations on the Mainstem CLP River (top) and North Fork CLP River (bottom) in 2023 compared to the baseline period of record.

*Mainstem*

Total dissolved solids were elevated in 2023, with maximum values greater than the baseline maximum at all monitoring sites except at the City of Greeley's Diversion (PBD). Total dissolved solids concentrations generally increased from Joe Wright Creek (JWC) downstream to the City of Greeley's Diversion (PBD). Total dissolved solids ranged from a minimum of 24 mg/L in the Mainstem above Joe Wright Creek (PJW) to a maximum of 115 mg/L measured in the Mainstem below the South Fork (PSF). Minimum total dissolved solids concentrations were higher than baseline at all monitoring sites, especially in the Mainstem below Rustic (PBR), and the cities of Fort Collins' and Greeley's Diversions (PNF and PBD) where minimum total dissolved solids concentrations exceeded baseline median concentrations. Median total dissolved solids concentrations were also higher than baseline at all monitoring sites. Concentrations were 1.2 to 1.6 times higher than baseline. The largest differences were observed at the Mainstem below Rustic (PBR) and below the South Fork (PSF). Maximum total dissolved solids concentrations were notably higher than baseline at all monitoring sites except at the Cities of Fort Collins' and Greeley's Diversions (PNF and PBD). The largest difference was observed in the Mainstem below South Fork (PSF) where maximum concentrations were 1.6 times higher than the baseline maximum. The highest concentrations were generally observed in the early spring and late fall; however, elevated concentrations were periodically observed over the summer due to post-fire events impacting water quality in the Mainstem CLP River. The elevated TDS concentrations in the upper Mainstem watershed indicate increased erosion and a greater delivery of dissolved ions to the Poudre River from the Cameron Peak Fire burn scar. All major ions (calcium, magnesium potassium, sodium, bicarbonates, chlorides, and sulfates) were comparably elevated and followed similar spatial and temporal trends to TDS, which confirms the notable changes observed in TDS.

*North Fork*

In general, total dissolved solids increased from the North Fork above Dale Creek (NDC) downstream to the North Fork above Rabbit Creek (NRC) before decreasing slightly downstream to the North Fork below Seaman Reservoir (NFG). Total dissolved solids concentrations increased slightly between the North Fork above Rabbit Creek (NRC) and North Fork near Livermore (NFL) suggesting influence from the North Fork tributaries where total dissolved solids concentrations were generally higher. Total dissolved solids concentrations ranged from a minimum 5 mg/L to a maximum 271 mg/L, both occurring in the North Fork above Rabbit Creek (NRC) during October and November, respectively. There was a notable increase in the variability of total dissolved solids concentrations between the North Fork below Halligan Reservoir (NBH) and the North Fork above Rabbit Creek (NRC) downstream to the North Fork below Seaman Reservoir (NFG). This trend is likely associated with changes in hydrology below the North Poudre Canal, groundwater and return flow contributions, and contributions from the North Fork tributaries. Minimum concentrations were above baseline at all monitoring sites, except from the North Fork above Rabbit Creek (NRC). Median total dissolved solids concentrations were above baseline at all monitoring sites, except from the North Fork above Rabbit Creek (NRC). Maximum total dissolved solids concentrations were lower than baseline at all monitoring

sites except in the North Fork above and below Halligan Reservoir (NDC and NBH). Maximum concentrations at both sites were significantly higher than baseline, exceeding baseline by 40 and 30 mg/L, respectively. These concentrations were observed in the late fall, indicating that his departure from baseline is likely due to low flows primarily being sustained by groundwater at these sites. At all North Fork monitoring sites, the highest concentrations were generally observed in April and November.

## 3.3 TOTAL ORGANIC CARBON

Total organic carbon (TOC) is a measure of the total concentration of dissolved and particulate organic matter in water. TOC is derived from both terrestrial and aquatic sources. Terrestrial TOC originates from soils and plant materials that are leached and/or delivered to surface waters during storms and spring snowmelt runoff, whereas aquatic-derived TOC originates from algal production and subsequent decomposition within surface waters.

Total organic carbon is an important indicator of water quality, particularly as it relates to water treatment. Water treatment requires the effective removal of TOC because the interaction between residual TOC and chlorine during treatment can form disinfection by-products (DBPs). DBPs are strictly regulated in finished water due to their carcinogenic potential. Increases in source water TOC concentrations pose concern due to the potential for higher residual TOC (post-filtration) and increased DBP formation potential. In addition, increased levels of TOC in source waters require additional removal requirements at the water treatment facility based on alkalinity levels (**Table 4**).

**Table 4** – Total organic carbon removal requirements for water treatment facilities based on source water alkalinity and total organic carbon concentrations.

| TOC (mg/L) | Source water alkalinity (mg/L as $CaCO_3$) | | |
|---|---|---|---|
| | <60 | 60-120 | >120 |
| 2-4 | 40% | 30% | 20% |
| 4-8 | 45% | 35% | 25% |
| >8 | 50% | 40% | 30% |

Total organic carbon concentrations were near baseline along the Mainstem CLP River and above baseline on the North Fork CLP River (**Figure 3.4**).

*Mainstem*

Total organic carbon concentrations were similar across most monitoring sites on the Mainstem and ranged from a minimum 1.97 mg/L to a maximum 9.59 mg/L, both occurring in the Mainstem above Joe Wright Creek (PJW). Minimum concentrations at all monitoring sites were between 2 – 4 mg/L and above minimum baseline concentrations. Minimum concentrations were observed in the fall from September through November. Median total organic carbon concentrations were near baseline at all sites. Median concentrations ranged from 0.3 mg/L below baseline to 0.2 mg/L above baseline in the Mainstem above

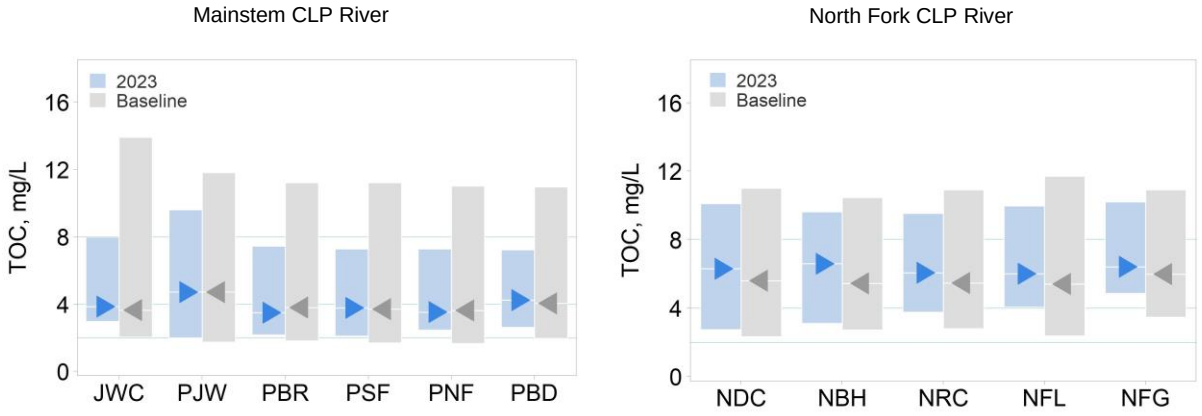


**Figure 3.4** – Total organic carbon (TOC) measured at key monitoring locations on the Mainstem CLP River (left) and North Fork CLP River (right) in 2023 compared to the baseline period of record. The green reference lines indicate thresholds for TOC removal requirements set by the Environmental Protection Agency. Note that the removal requirements also consider raw water alkalinity concentrations.

Rustic (PBR) and below the City of Greeley's diversion (PBD), respectively. Like baseline, median concentrations were measured between 2 – 4 mg/L at all sites, except in the Mainstem above Joe Wright Creek (PJW) and below the City of Greeley's diversion (PBD) where the median concentration was between 4 – 8 mg/L. Maximum total organic carbon concentrations were much lower than baseline at all monitoring sites. Maximum total organic carbon concentrations were measured in the late spring at almost all sites and measured between the 4 – 8 mg/L threshold at all sites, except in the Mainstem above Joe Wright Creek (PJW) where maximum concentrations were slightly higher than 8 mg/L. In keeping with prior years, maximum TOC concentrations at almost all sites coincided with snowmelt runoff. In general, maximum total organic carbon concentrations were approximately 2 – 5 mg/L lower than baseline in 2023. The largest difference was observed in Joe Wright Creek (JWC). This decrease in range could be attributed to a decrease in available TOC in the surrounding catchment due to the Cameron Peak Fire.

*North Fork*

Total organic carbon concentrations were similar across most monitoring sites in the North Fork CLP River but slightly higher medians and closer variability to baseline. Concentrations ranged from a minimum of 2.73 mg/L in the North Fork above Dale Creek (NDC) to a maximum 10.20 mg/L in the North Fork below Seaman Reservoir (NFG). The North Fork above Dale Creek (NDC), North Fork below Halligan Reservoir (NBH), and the North Fork near Livermore (NFL) had the greatest variability. The higher variability in the North Fork above Dale Creek (NDC) was likely associated with the more natural streamflow conditions above the water supply reservoirs. The highest total organic carbon concentrations were observed in the North Fork above Dale Creek (NDC) and below Seaman Reservoir (NFG) during runoff. Minimum total organic carbon concentrations were higher than baseline at all monitoring sites and fell within the 2 – 4 mg/L removal requirement threshold except in the North Fork at Livermore (NFL) and below Seaman Reservoir (NFG) where minimum concentrations fell within the 4 – 8 mg/L removal requirement threshold. The minimum concentration at these sites was much higher than baseline and closer to the baseline median values. Minimum total organic carbon concentrations in the North Fork were measured in the early spring and late fall. Median total organic carbon concentrations were above baseline at all monitoring sites and fell within the 4 – 8 mg/L removal requirement threshold. The greatest departure from baseline was observed in the North Fork below Halligan Reservoir where concentrations were 1.1 mg/L higher. Maximum total organic carbon concentrations were lower than baseline at all monitoring sites and were observed in May and June. The maximum concentration of total organic carbon was greater than the 8 mg/L threshold at all sites.

## 3.4 NUTRIENTS

Nutrients are an important component of source water quality monitoring. In high concentrations and under certain environmental conditions, nutrients can lead to excessive algal growth. Elevated nutrients can also cause cyanobacteria blooms, which can produce cyanotoxins and taste and odor compounds in drinking water supplies. Potential sources of nutrients in aquatic systems include animal waste, leaking septic systems, fertilizer run-off, soil erosion, and atmospheric deposition.

**Nitrogen**

Total nitrogen (TN) is the sum of Total Kjeldal Nitrogen (TKN) and inorganic nitrogen. TKN is a measure of ammonia plus organic nitrogen and comprises the largest fraction of TN. Inorganic nitrogen includes nitrate and nitrite, which constitute a lesser fraction of TN. Nitrate and nitrite are of particular interest for water quality because they can be consumed by aquatic plants and algae. Concentrations of TN below the reporting limit were reported as half the reporting limit (Helsel and Hirsch, 2002).

*Mainstem*

Total nitrogen concentrations were elevated at nearly all monitoring sites on the Mainstem (**Figure 3.5)**. Concentrations ranged from a minimum 165 µg/L at almost all monitoring sites to a maximum 1,370 µg/L at the City of Greeley's Diversion (PBD). Minimum total nitrogen concentrations were higher than baseline (reporting limit) at all monitoring sites. The minimum total nitrogen concentration at the Mainstem above Joe Wright Creek (PJW) had the largest departure from baseline and measured near the baseline median. Minimum concentrations were measured over the fall season. Median total nitrogen concentrations were near or above baseline at all monitoring sites, except at the City of Greeley's Diversion (PBD). The largest departure from baseline was observed at the Mainstem above Joe Wright Creek (PJW), where concentrations were 131 ug/L above baseline. Median concentrations were still well below the

interim water quality standard for total nitrogen of 1,250 µg/L at all monitoring sites. Contrastingly, maximum total nitrogen concentrations were above baseline at almost all monitoring sites and exceeded the interim water quality concentrations were 3 – 7 times higher than baseline at all monitoring sites. Maximum nitrate concentrations ranged from 3 – 12 times higher than baseline at all monitoring sites except in the Mainstem above Joe Wright Creek (PJW).

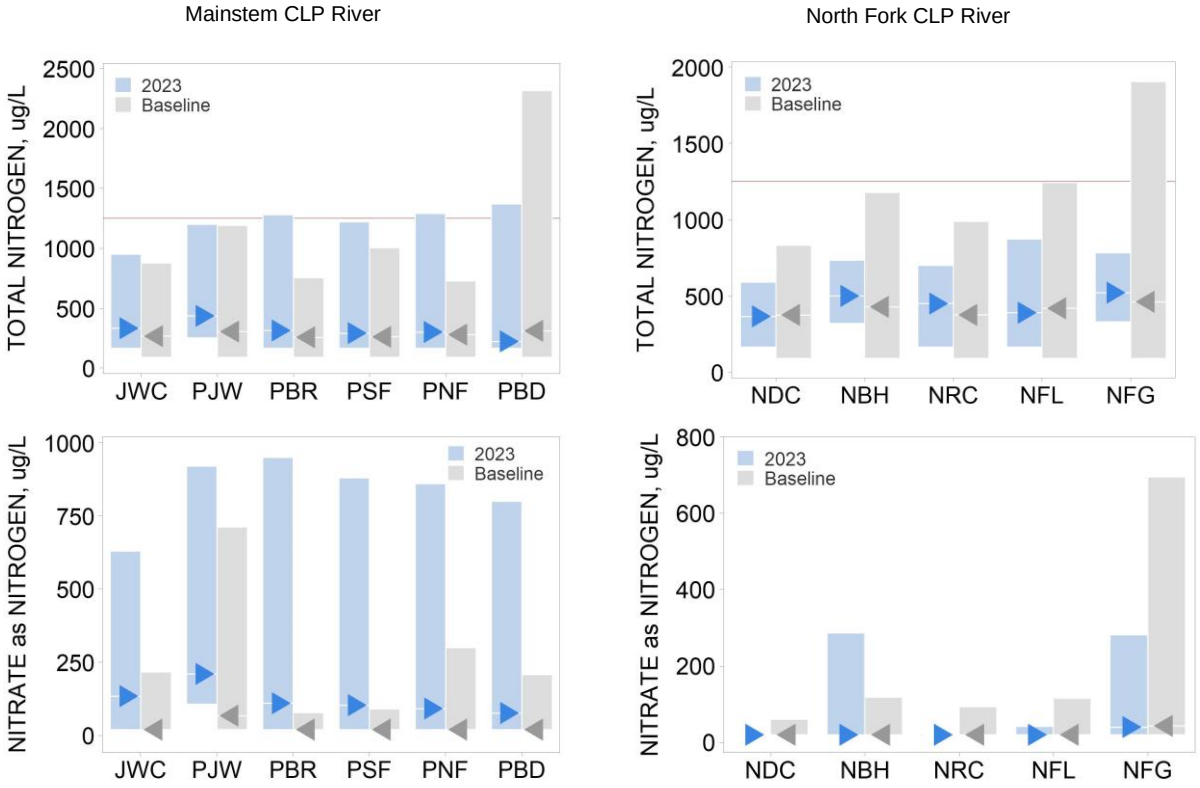


**Figure 3.5** – Total nitrogen (top) and nitrate (bottom) concentrations measured at key monitoring locations on the Mainstem CLP River (left) and North Fork CLP River (right) in 2023 compared to the baseline period of record. The red reference line indicates the interim TN water quality standard (TN = 1,250 µg/L) set by the Colorado Department of Public Health and Environment to protect aquatic life.

standard at the Poudre below Rustic (PBR), above the North Fork (PNF), and at the City of Greeley's Diversion (PBD). Maximum concentrations were typically measured during snowmelt runoff in the spring; however, elevated concentrations were also observed in July in the upper Poudre watershed following a post-fire storm event.

Nitrate concentrations were significantly elevated at all monitoring locations (**Figure 3.5**). Minimum nitrate concentrations were near baseline and reported below the reporting limit (20 µg/L) at all sites except the Mainstem above Joe Wright Creek (PJW) in which minimum concentrations exceeded the baseline median by 40 ug/L. Minimum nitrate concentrations were generally measured in the early spring and fall seasons. Median nitrate Maximum concentrations at this location were around 1.5 times higher than the baseline. Maximum concentrations were observed at most key sites in May when nitrate that has been accumulated on post-fire barren hillslopes is flushed into the Poudre River during snowmelt runoff.

As expected, nitrite concentrations were measured below the reporting limit (40 µg/L) at all monitoring sites.

Ammonia concentrations were within the baseline range of values at all monitoring sites. Median ammonia concentrations were below the reporting limit (10 µg/L) at all sites. Detectable concentrations were measured in the spring and early-summer, but no discernable trends were observed between sites. The highest concentrations were measured at monitoring locations in the upper elevations of

the watershed (BMR and PJW) and at the City of Greeley's Diversion (PBD). The higher concentrations of ammonia at these locations are likely due to their proximity to water storage reservoirs and the release of ammonia from these water bodies.

*North Fork*

Total nitrogen concentrations were similar across monitoring sites on the North Fork (**Figure 3.5)**. Concentrations ranged from 165 µg/L in the North Fork above Dale Creek (NDC), above Rabbit Creek (NRC), and at Livermore (NRC) to a maximum 872 µg/L in the North Fork at Livermore (NFL). Minimum total nitrogen concentrations were higher than baseline at all monitoring sites. The minimum concentrations in the North Fork below Halligan and Seaman Reservoir (NBH and NFG) were notably higher and measured 3.5 times greater than the baseline minimum. Minimum concentrations were observed in early April and in the early fall season. Median total nitrogen concentrations were above or near baseline at all monitoring sites, except in the North Fork at Livermore (NFL) which was 30 ug/L below baseline. Concentrations at all sites were well below the interim water quality standard for total nitrogen of 1,250 µg/L. Median total nitrogen concentrations in the North Fork below Halligan (NBH), above Rabbit Creek (NRC), and below Seaman Reservoir were 60 – 75 ug/L above the baseline. Maximum total nitrogen concentrations were well below baseline at all monitoring sites. The greatest variation occurred in the North Fork below Seaman Reservoir (NFG) in which concentrations were 1,121 ug/L lower than the baseline maximum. Typically, higher concentrations are measured in the fall season at monitoring sites located below reservoirs (NBH and NFG). In contrast, maximum concentrations at other sites along the North Fork CLP River were observed in May and June.

Nitrate concentrations were generally low across North Fork sites (**Figure 3.5**). Minimum and median concentrations were near baseline and below the reporting limit (20 µg/L) at all monitoring sites except in the North Fork below Seaman Reservoir (NFG). Detectable concentrations were measured at all sites except in the North Fork above Dale and Rabbit Creek (NDC and NRC). Concentrations in the North Fork at Livermore (NFL) peaked in early summer. Concentrations in the North Fork below Seaman and Halligan Reservoirs (NFG and NBH) were measured throughout the monitoring season. Elevated nitrate concentrations were measured in the fall which were likely caused by anoxic conditions in the reservoirs and the release of nutrients from reservoir sediments into the North Fork. Maximum nitrate concentrations were below baseline at all monitoring sites except in the North Fork below Halligan Reservoir (NBH) where maximum concentrations measured nearly 2.5 times higher than baseline.

Nitrite concentrations were measured below the reporting limit (40 µg/L) at all monitoring sites.

Ammonia concentrations were near baseline at all monitoring sites. The highest concentrations were observed in the North Fork below Halligan and Seaman Reservoirs (NBH and NFG). Concentrations were consistently above the reporting limit at these sites, but the highest concentrations were measured in the early spring and fall when the reservoirs were anoxic. Maximum concentrations of 54.6 µg/L and 81 µg/L were measured below Halligan and Seaman Reservoirs (NBH and NFG) in October and April, respectively.

**Phosphorus**

Total phosphorus (TP) is a measure of dissolved phosphorus as well as phosphorus bound to sediments and organic matter. Orthophosphate is more readily available for plant and algae uptake.

*Mainstem*

Total phosphorus concentrations were slightly elevated at nearly all monitoring sites along the Mainstem CLP (**Figure 3.6)**. Concentrations ranged from near the reporting limit (10 µg/L) at all key monitoring sites to a maximum 73.9 µg/L at the City of Fort Collins' Diversion (PNF). Minimum total phosphorus concentrations were near baseline at all monitoring sites. Minimum concentrations were measured in November at all monitoring sites. Median total phosphorus concentrations were near baseline at all sites. The greatest difference was observed at the City of Fort Collins' Diversion (PNF) where median total phosphorus concentrations were 1.6 times higher than baseline. In general, total phosphorus concentrations were the highest during snowmelt runoff in May; however, total phosphorus was detected at all sites from April through October. Total phosphorus concentrations were also elevated in September in the Poudre at the cities of Greeley's and Fort

Collins' Diversions (PNF & PBD). Maximum total phosphorus concentrations were near or below baseline at all monitoring sites.

Orthophosphate concentrations were below or near baseline at all monitoring sites except in the Mainstem below Rustic (PBR) (**Figure 3.6)**. Minimum orthophosphate concentrations were measured below the reporting limit (5 µg/L) at all sites and the timing varied across monitoring locations. Median orthophosphate concentrations were measured near baseline at all monitoring sites. Maximum orthophosphate concentrations were near or below baseline at all monitoring sites except in the Mainstem below Rustic (PBR). The timing of maximum orthophosphate concentrations varied across monitoring locations, but the highest concentrations were generally observed during snowmelt runoff or following post-fire storm events in early fall.

*North Fork*

Total phosphorus concentrations were within the baseline range of values for all monitoring sites (**Figure 3.6)**. Concentrations ranged from below the reporting limit (10 µg/L) in the North Fork above Rabbit Creek and near Livermore (NRC and NFL) to a maximum 260 µg/L in the North Fork below Seaman Reservoir (NFG). Higher concentrations were measured in the North Fork tributaries (RCM and PCM) and marginally influenced concentrations downstream in the North Fork near Livermore (NFL). Minimum total phosphorus concentrations were near baseline at all monitoring sites except in the North Fork below Seaman (NFG) where concentrations were over 4 times greater than baseline. Minimum concentrations were observed in the late fall, except in the North Fork below Halligan and Seaman Reservoir (NBH and NFG) where higher concentrations were measured due to in-reservoir dynamics. In contrast, minimum total phosphorus concentrations at these sites were observed in April.

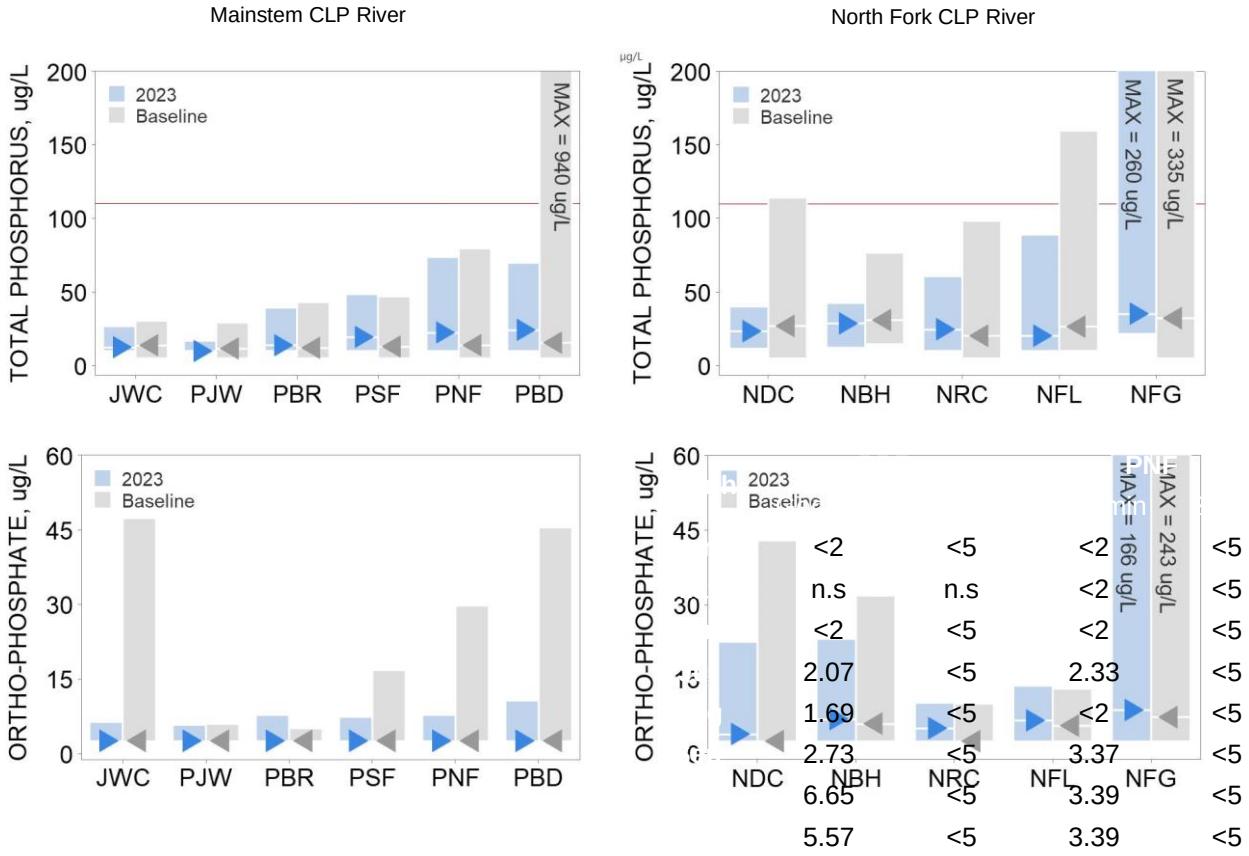


**Figure 3.6** – Total phosphorus (top) and ortho-phosphate (bottom) measured at key monitoring locations on the Mainstem CLP River (top) and North Fork CLP River (bottom) in 2023 compared to the baseline period of record. The red reference line indicates the interim TP water quality standard (TP = 110 ug/L) set by the Colorado Department of Public Health and Environment to protect aquatic life.

Median total phosphorus concentrations were near or slightly below baseline at all monitoring sites except in the North Fork above Rabbit Creek and below Seaman Reservoir (NRC and NFG) where concentrations measured slightly higher than baseline. Maximum total phosphorus concentrations were below baseline at all monitoring sites in the North Fork CLP River. Maximum total phosphorus concentrations were generally observed during snowmelt runoff in April and May except at monitoring sites directly downstream of the reservoirs (NBH and NFG). The interim water quality standard for total phosphorus of 110 µg/L was exceeded on the North Fork below Seaman Reservoir (NFG) in August and September, which was likely due to anoxic conditions in the reservoir.

Orthophosphate concentrations were within the baseline range of values at all monitoring sites except in the North Fork above Rabbit Creek and at Livermore (NRC and NFL) (**Figure 3.6)**. Concentrations ranged from below the reporting limit (5 µg/L) at all monitoring sites to a maximum of 166 µg/L in the North Fork below Seaman Reservoir (NFG). Orthophosphate followed similar seasonal trends to total phosphorus as discussed above. Minimum orthophosphate concentrations were near baseline for all monitoring sites. Median orthophosphate concentrations were near or slightly above baseline. Maximum concentrations were lower than baseline at all monitoring sites except in the North Fork above Rabbit Creek and at Livermore (NRC and NFL) both of which slightly exceeded baseline. The highest concentrations were measured in the North Fork tributaries (RCM and SCM), which influenced downstream orthophosphate concentrations in the North Fork near Livermore (NFL). Higher concentrations were also observed in the North Fork below Halligan and Seaman Reservoirs (NBH and NFG), which were generally observed in the late-summer and fall due to anoxic conditions in the reservoir.

## 3.5 TASTE & ODOR COMPOUNDS

Geosmin and 2-Methylisoborneol (2-MIB) are naturally occurring organic compounds that are produced by some species of cyanobacteria. These compounds can introduce an earthy odor to drinking water that can be detected by the most sensitive individuals at concentrations as low as 4 nanograms per liter (ng/L) or 4 parts per trillion (ppt). These compounds do not pose a public health risk but are of concern because they can negatively affect customer confidence in the quality of drinking water. Early detection of elevated concentrations of these compounds is important so that they can be removed during the water treatment process.

**Table 5** – Poudre River geosmin and 2-MIB concentrations (ng/L or ppt). Note: Reporting limits are 2 ng/L for geosmin and 5 ng/L for MIB. Concentrations below the reporting limits are estimates. n.s. = no sample collected

| Month | PBR | | PNF | |
|---|---|---|---|---|
| | Geosmin | 2-MIB | Geosmin | 2-MIB |
| April | <2 | <5 | <2 | <5 |
| May | n.s | n.s | <2 | <5 |
| Jun | <2 | <5 | <2 | <5 |
| Jul | 2.07 | <5 | 2.33 | <5 |
| Aug | 1.69 | <5 | <2 | <5 |
| Sep | 2.73 | <5 | 3.37 | <5 |
| Oct | 6.65 | <5 | 3.39 | <5 |
| Nov | 5.57 | <5 | 3.39 | <5 |

Geosmin and 2-MIB are monitored on the Mainstem below Rustic (PBR) and at the City of Fort Collins' Diversion (PNF) during routine upper CLP water quality monitoring events. A summary of geosmin and 2-MIB concentrations can be found in **Table 5**. Geosmin was measured above the reporting limit between July and November in the Mainstem below Rustic (PBR) and in July, September, October, and November at the City of Fort Collins' intake (PNF). This could be due to high elevation reservoir dynamics. 2-MIB was not detected at either site in 2023.

## 3.6 METALS

The presence of metals in source water supplies is most often due to mineral weathering and soil erosion. Metals enter the river via snowmelt runoff, wind, precipitation, and other natural processes. Additional sources of metals may include atmospheric deposition. Snowmelt runoff generally results in elevated metals concentrations, as do storm events. Metals were sampled throughout the monitoring season at select locations, but for the purposes of this report are only reported in the spring (May) and fall (October) at the City of Fort Collins' Diversion (PNF) and in the North Fork below Seaman Reservoir (NFG).

A summary of dissolved metals concentrations can be found in **Table 6**. As anticipated, detectable metals (aluminum, arsenic, copper, iron, manganese) were higher in the spring during snowmelt runoff, except for manganese in the North Fork below Seaman Reservoir (NFG), which was likely due to anoxic conditions in the reservoir and the release of manganese from reservoir sediments. Arsenic was detected slightly above the reporting limit in the North Fork below Seaman Reservoir (NFG) in the fall.

**Table 6** – Dissolved metals concentrations measured in spring (May 22/23) and fall (October 9/10) of 2023 on the Mainstem and North Fork Poudre River.

| Metal (ug/L) | Spring | | Fall | |
|---|---|---|---|---|
| | PNF | NFG | PNF | NFG |
| Al | 196 | 134 | 14.2 | <10 |
| As | <1 | <1 | <1 | 1.28 |
| Cd | <1 | <1 | <1 | <1 |
| Cr | <1 | <1 | <1 | <1 |
| Cu | 1.06 | 3.93 | 1.17 | 6.2 |
| Fe | 160 | 142 | 36.3 | 21 |
| Mn | 7.51 | 10.5 | 6.67 | 63.8 |
| Ni | <1 | <1 | <1 | <1 |
| Pb | <1 | <1 | <1 | <1 |
| Se | <5 | <5 | <5 | <5 |
| Zn | <10 | <10 | <10 | <10 |

## 3.7 MICROORGANISMS

Coliforms are types of bacteria that are found naturally in the environment in plant and soil material but can also be found in the digestive tracts of warm-blooded animals, including humans. Disease causing bacteria, viruses, and protozoa can be introduced to source water supplies from fecal contamination. Total coliforms were used as an indicator of the presence of these pathogenic microorganisms. In addition, *Escherichia coli* (*E. coli*) was measured and used as an indicator of animal fecal waste

pollution since the origin is more specific than total coliforms.

**Total Coliform**

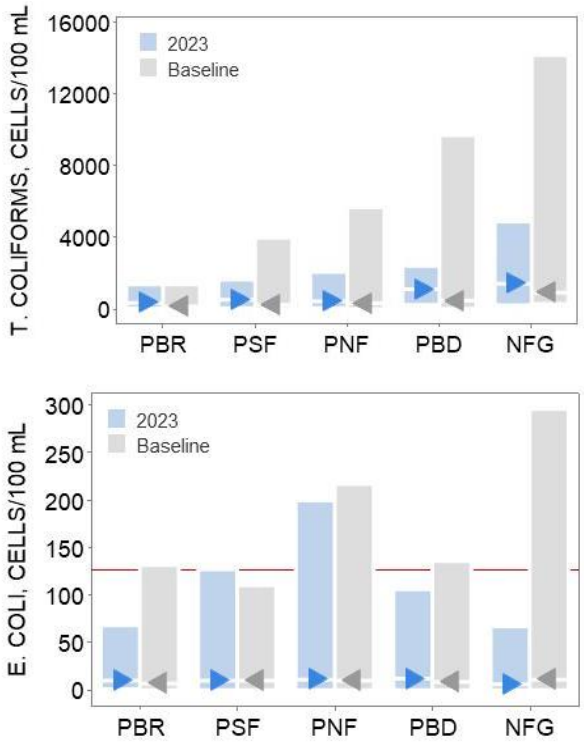


**Figure 3.7** – Total coliforms (top) and E. coli (bottom) concentrations measured at key monitoring locations on the Mainstem CLP River and North Fork CLP River – mainstem and NF sites in this figure are combined, as opposed to other figures – in 2023 compared to the baseline period of record. The red reference line indicates the E. coli water quality standard of 126 cfu/100 mL set by the Colorado Department of Public Health and Environment to protect recreational use.

Total coliform concentrations were within baseline at monitoring sites on the Mainstem over the 2023 water year (**Figure 3.7**). Concentrations ranged from a minimum 52 cells/100 mL in the Mainstem below Rustic (PBR) to a maximum 4,880 cells/100 mL on the North Fork below Seaman Reservoir (NFG). Minimum total coliform concentrations were near baseline at all monitoring sites except at the City of Greeley's Diversion (PBD) where concentrations were nine times greater than baseline. Minimum concentrations were observed in the early spring and late fall. Median concentrations were near baseline or slightly elevated at all monitoring sites. The largest difference occurred at the City of Greeley's Diversion (PBD) where baseline concentrations were exceeded by 632 cells/ 100mL. Maximum concentrations were below baseline at all monitoring sites except in the Mainstem below Rustic (PBR) where the maximum concentration was slightly higher than baseline. Maximum concentrations were generally observed during the late spring and early summer at all sites. In the North Fork below Seaman Reservoir (NFG) concentrations remained elevated through October.

***Escherichia coli***

*Escherichia coli* (*E. coli*) concentrations were within baseline at all monitoring sites except in the Mainstem below the South Fork (PSF), which were elevated. Concentrations were more variable along the Mainstem and ranged from a minimum 0 – 1 cells/100 mL at all monitoring sites to a maximum of 199 cells/100 mL at the City of Fort Collins' Diversion (PNF) (**Figure 3.7**). Minimum concentrations were near baseline at all Mainstem monitoring sites. Median *E. coli* concentrations were at or slightly above baseline at all Mainstem monitoring sites. Maximum concentrations, which were observed in mid-September following a storm event, were above the baseline at the Mainstem below the South Fork (PSF). Maximum concentrations at this site and at the City of Fort Collins' Diversion (PSF and PNF) exceeded the water quality standard.

There was less variability in the North Fork below Seaman Reservoir (NFG) where concentrations ranged from 0 cells/100 mL to 67cells/100 mL. Minimum concentrations were near baseline. Median and maximum *E. coli* concentrations were less than baseline. Concentrations were low throughout the monitoring season.

## 3.8 MACROINVERTEBRATES

Aquatic macroinvertebrates are animals that live in water, lack a backbone and are visible without the aid of a microscope. The Poudre River supports a diverse community of aquatic macroinvertebrates, including insects, shrimp, crayfish, worms, leeches, snails, clams and other groups. These animals live most of their lives on or within the streambed of the river, where they occupy a wide variety of ecological roles or "niches" in terms of their modes of feeding habits, habitat preferences, life cycles and other factors.

Key monitoring locations occur in three separate *EPA Level IV Ecoregions* (**Table 7**). The Mainstem above Joe Wright Creek (PJW) is located within the Crystalline Subalpine Forests Ecoregion; the Mainstem below Rustic (PBR), the Mainstem below the South Fork (PSF) and the Mainstem

near the City of Fort Collins' Diversion (PNF) are located within the Crystalline Mid-Elevation Forests; and the Mainstem near the City of Greeley's Diversion (PBD) is located within the Foothills Shrublands Ecoregion. Macroinvertebrate communities in the Crystalline Subalpine Forests Ecoregion are naturally less productive, are structured differently and are not directly comparable to communities in the two lower elevation ecoregions. Communities in monitoring locations in the Crystalline Mid-Elevation Forests and Foothills Shrublands are considered directly comparable for the purposes of this report.

Macroinvertebrate community metrics are often used to evaluate water quality and ecological health in streams and can be particularly useful when paired with chemical and physical water quality data to better understand cause and effect relationships between pollutants and the biota. Baseline biological condition was determined by calculating averages of routine macroinvertebrate community metrics using data from 2019 and 2020. Baseline (pre-fire) data were compared to 2023 data (post-fire) to understand macroinvertebrate community changes within and between key study locations following the Cameron Peak Fire. Differences in metric values of 20% or greater between baseline and 2023 data were deemed notable and are highlighted below (**Table 7**). It is important to note that analyses in subsequent years will be expanded to include short-and long-term trends, and to monitor impacts and recovery following the fire.

**Species Diversity**

Species diversity is a measure of the number of different macroinvertebrate species within a community. Communities with good water quality generally have higher species diversity than those with poor water quality. Species diversity was near baseline at all study locations in 2023 except at PSF and PNF, which departed from baseline by -21% and +38%, respectively. Communities within PSF were likely impacted to a greater degree by post-fire sedimentation than other study locations due to its proximity to burned hillslopes within the South Fork Poudre watershed.

**Shannon's H**

Shannon's H combines measures of species diversity and the relative abundance of each species within a macroinvertebrate community. Values > 3 generally indicate good community condition and water quality, whereas values <1 indicate poor community condition and degraded water quality. Shannon's H was within baseline across all monitoring locations in 2023, except at PBR (2.9) and PSF (2.6) which were 27% and 37% below baseline, respectively. The decline in Shannon's H at these monitoring locations generally indicated that macroinvertebrate community condition has declined because of continued post-fire pollution.

**EPT Diversity and % EPT**

EPT is an abbreviation for the sum of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) species. EPT are widely regarded as intolerant of water quality pollution, and therefore, higher measures of EPT diversity and percent of EPT in a community generally indicate that water quality is good. EPT diversity was higher than baseline at all sites except PBR and PSF, which were within baseline. Similarly, the percentage of EPT was above baseline at all sites except PJW and PNF, which were within baseline.

**Density**

Density is a measure of the number of individual organisms per square meter of the streambed. Changes in density can be associated with water quality pollution. Macroinvertebrate density was well above baseline at all sites except PJW, where density was 28% below baseline at 3,160. This decrease is likely due to post-fire pollution impacts. Macroinvertebrate density was the highest at PSF (10,715), indicating a 319% increase from baseline. These widespread changes in density are likely a community response to continued post-fire impacts.

**Collector-Gatherers**

Percent collector-gatherers refers to the percentage of macroinvertebrate species that feed on tiny organic particles deposited on or within the streambed, rather than through filtration. The percentage of collector-gatherers at all monitoring sites decreased substantially, except for at PJW which was within baseline. The largest departure from baseline occurred at PSF where there was a 78% decrease from baseline. The decrease in the percentage of collector gatherers across these study locations corresponds to an increase in the percentage of algae scrapers. These changes may be related to higher nutrient concentrations across all sites following the Cameron Peak Fire.

**Algae Scrapers**

Percent algae scrapers is the relative percentage of macroinvertebrates that scrape algae from the tops of rocks and logs. Algae scrapers can become more abundant in the presence of elevated nutrients as algal productivity increases and can decline due to excessive sedimentation. The percentage of algae scrapers greatly increased from baseline at all sites except PJW, where the percentage was 20% lower than baseline. The greatest departure from baseline was found at PSF where the percentage of algae scrapers was 438% greater than baseline. The concentration of nutrients at all sites has increased following the Cameron Peak Fire, which may explain the shift to more algal scrapers at these sites.

**Collectors-Filters**

Percent filter-feeders refers to the percentage of macroinvertebrate species in a community that feed by filtering tiny organic particles suspended in the streamflow. The abundance of these organisms often dramatically increases in locations exposed to elevated organic pollution. The percentage of collector-filterers on the Mainstem was generally consistent with baseline data. This is consistent with TOC concentrations measured at these monitoring sites, which have not changed following the Cameron Peak Fire.

**Leaf Shredders**

Percent shedders refers to the percentage of macroinvertebrate species that feed on leaves, pine needles, twigs and other large organic matter that is washed into the river. Decreases in the percentage of shredders in a community can indicate that riparian vegetation has been impacted and is providing less food for these organisms. In 2023, shredders generally made up a larger percentage of the community compared to baseline at PJW (3%) and PNF (4%). Shredders at PBR and PSF made up around 2% and 1% of the of the community, respectively; the reason for the decrease in shredders in these communities could be due to a decrease in leaf litter provided by the river corridors impacted by the Cameron Peak Fire.

**MMI Version 4**

The MMI Version 4 is the Colorado Department of Public Health and Environment's (CDPHE) multi-metric water quality index, which combines several ecological metrics into a single score that is compared to reference conditions. The Mainstem above Joe Wright Creek (PJW) is in CDPHE's biotype 2. The Mainstem below Rustic (PBR), the Mainstem below the South Fork (PSF), the Mainstem near the City of Fort Collins' Diversion (PNF) and the Mainstem near the City of Greeley's Diversion (PBD) are located in CDPHE's biotype 1. The MMI Version 4 is used by CDPHE to determine whether a stream community meets the State's surface water quality standards for the Aquatic Life Use. All study locations continued to attain CDPHE's MMI Version 4 aquatic life standards thresholds.

**Table 7** – Routine 2023 macroinvertebrate community metric results from key study locations along the Mainstem CLP. Data were compared to baseline data (average of 2019 and 2020 data) and notable departures as percentages of baseline are indicated in parentheses in red (decrease) and blue (increase).

| | PJW | PBR | PSF | PNF | PBD |
|---|---|---|---|---|---|
| **Level IV Ecoregion** | Crystalline Subalpine Forests | Crystalline Mid-Elevation Forests | Crystalline Mid-Elevation Forests | Crystalline Mid-Elevation Forests | Foothills Shrublands |
| **Species Diversity** | 38 | 41 | 32 (79%) | 44 (138%) | 32 |
| **Shannon's H** | 3.6 | 2.9 (73%) | 2.6 (63%) | 3.5 | 3.5 |
| **EPT Diversity** | 21 (124%) | 25 | 18 | 27 (146%) | 31 (138%) |
| **Percent EPT** | 79 | 91 (122%) | 94 (135%) | 86 | 93 (137%) |
| **Density (#/m$^2$)** | 3,060 (72%) | 8,945 (269%) | 10,715 (419%) | 3,852 (160%) | 10,110 (123%) |
| **Percent Collector-Gatherers** | 52% | 14% (34%) | 11% (22%) | 30% (52%) | 21% (78%) |
| **Percent Algae Scrapers** | 20% (80%) | 57% (238%) | 78% (538%) | 47% (214%) | 45% (138%) |
| **Percent Predators** | 21% (300%) | 9% | 2% | 7% | 6% |
| **Percent Collector-Filterers** | 5% | 17% | 8% | 12% | 27% |
| **Percent Leaf Shredders** | 3% | 2% | 1% | 4% | 1% |
| **CDPHE Biotype** | 2 | 1 | 1 | 1 | 1 |
| **MMI version 4** | 73.1 (Attainment) | 78.5 (Attainment) | 74.1 (Attainment) | 85.4 (Attainment) | 86.2 (Attainment) |

# 4.0 SOURCE WATER QUALITY TRENDS AND TREATMENT IMPLICATIONS

The temporal trends discussed in Section 4 focus primarily on monitoring sites located near the City of Fort Collins' Diversion upstream of the confluence with the North Fork CLP River (PNF) and the City of Greeley's Poudre River Diversion downstream of the confluence with the North Fork CLP River (PBD). It is assumed that water quality measured at PNF is representative of water quality upstream at the Munroe Tunnel Diversion. Monthly trends in water quality are strongly correlated with changes in hydrology and seasonal weather patterns.

*Presentation of Results*

Bar charts presented in Section 4 display monthly median values measured over the 2023 monitoring season for the months of April, May, and June when sampling is conducted twice per month, and monthly values from July through November. These data are compared to baseline median values calculated over the period of record from 2008 to 2012.

*Selected Variables*

The water quality parameters listed below are the focus of these trend analyses because they have a direct impact on water treatment processes.

- **Alkalinity**
- **pH**
- **Total Organic Carbon**
- **Turbidity**

## 4.1 ALKALINITY

Alkalinity was higher than the baseline median at the City of Fort Collins' Diversion (PNF) and lower than the baseline median at the City of Greeley's Diversion (PBD) (**Figure 3.2**). Seasonal trends in alkalinity were comparable to baseline at both monitoring locations with lower concentrations measured during snowmelt runoff and higher concentrations in the spring prior to snowmelt runoff and as streamflow receded through the summer and fall months. In general, monthly concentrations were greater than or near baseline at both monitoring locations throughout the entire monitoring season.

*City of Fort Collins' Diversion*

The median alkalinity concentration at the City of Fort Collins' Diversion was 19.2 mg/L, which was slightly higher than the baseline of 17.6 mg/L. Concentrations ranged from a minimum of 15.7 mg/L in the month of June to a maximum 31.4 mg/L measured in the month of November. Alkalinity was greater than baseline during April and measured 30.4 mg/L. Contrastingly, alkalinity was lower than baseline in May, measuring 16.1 mg/L. Alkalinity was lower during the summer months, but still measured well above baseline. Concentrations ranged from 15.7 mg/L in the month of June to 19.2 mg/L in the month of August. Alkalinity concentrations remained elevated over the fall months from September through November. Concentrations ranged from 23.4 mg/L in September to 31.4 mg/L in November (**Figure 4.1**).

*City of Greeley's Diversion*

The median alkalinity concentration at the City of Greeley's Diversion was 23.2 mg/L, which was less than baseline. Concentrations ranged from a minimum of 19.7 mg/L in the month of June to a maximum of 50.0 mg/L measured in the month of October. Alkalinity was less than baseline in the spring months (April and May) and concentrations were measured at 33.7 mg/L and 21.3 mg/L, respectively. Alkalinity was slightly higher than baseline over the summer months of June and July and lower than baseline in August. Concentrations over the summer season measured 19.7 mg/L in June, 21.4 mg/L in July, and 20.6 mg/L in August. Alkalinity concentrations remained above baseline through the fall months of September and October and slightly below baseline in November. Concentrations ranged from 26.0 mg/L in September to 50 mg/L in October. The largest departure from baseline was measured in the month of October when the concentration measured 1.7 times higher than baseline (**Figure 4.1**).

## 4.2 pH

pH was higher than the baseline median at both the City of Fort Collins' Diversion (PNF) and City of Greeley's Diversion (PBD) in 2023 (**Figure 3.1**). Seasonal trends in pH were comparable to baseline at both monitoring locations during the spring season. Notable differences were observed in pH during the summer and fall seasons at both monitoring locations. In general, pH slightly decreased in the spring and early summer. pH was elevated after snowmelt runoff and remained elevated through the summer and fall seasons.

*City of Fort Collins' Diversion*

The median pH value at the City of Fort Collins' Diversion was 7.68, which was 0.27 pH units higher than baseline. Concentrations ranged from a minimum 7.31 in the month of June to a maximum 8.11 measured in the month of April. pH measured slightly above baseline over the spring month of April and slightly below baseline in May. pH measured slightly below baseline in the summer month of June, slightly above baseline in July, and much higher than baseline in August. The largest departure from baseline was measured in the month of August at 7.78, which is 0.72 pH units higher than baseline. pH remained elevated through the fall season, with all months above baseline. The largest departure in pH over the fall season was observed in the month of September when the pH was 0.57 units greater than baseline. The higher pH values observed over the 2023 season, especially during the summer and fall seasons, likely resulted from high flows during monsoon events eroding soils which increased carbonates in the Mainstem Poudre River (**Figure 4.1**).

*City of Greeley's Diversion*

The median pH value at the City of Greeley's Diversion was 7.81 compared to the baseline median of 7.56. Concentrations ranged from a minimum of 7.39 in the month of June to a maximum of 8.41 measured in the month of September. A notable divergence from the baseline seasonal trend was observed over the summer and fall months from August through November. pH measured near baseline over the spring months of April and May. pH measured above baseline over the summer season. In the early summer month of June, pH remained near baseline, but measured 0.40 pH units higher than baseline in August. pH was even more elevated through the fall season. The largest departure in pH over the fall season was observed in the month of September when the pH was 1.05 units greater than baseline. The higher pH values observed over the 2023 season, especially during the summer and fall seasons, were likely due to a combination of increased carbonates introduced from eroded soils during the monsoon season, agricultural land-use in the North Fork, and algal blooms in Seaman Reservoir (**Figure 4.1**).

## 4.3 TOTAL ORGANIC CARBON

Total organic carbon (TOC) was near the baseline median at both the City of Fort Collins' Diversion (PNF) and City of Greeley's Diversion (PBD) in 2023 (**Figure 3.4**). Seasonal trends in total organic carbon were comparable to baseline at both monitoring locations with higher concentrations measured during snowmelt runoff and lower concentrations following runoff in the summer and fall months.

*City of Fort Collins' Diversion*

The median TOC concentration at the City of Fort Collins' Diversion was near baseline and measured 3.5 mg/L. Monthly concentrations ranged from a minimum of 2.4 mg/L in the month of October to a maximum of 7.1 mg/L measured in the month of May. TOC concentrations were above baseline in the spring month of April and below baseline in May and June. While concentrations in May and June were below baseline, they did exceed the 4 mg/L removal requirement (**Table 3**). Following baseline trends, TOC decreased in the summer months when concentrations measured near baseline. Concentrations during the fall months of September and November were above baseline while October was near baseline. The greatest departure from baseline occurred in September when TOC concentrations were 1.4 times greater than baseline (**Figure 4.1**).

*City of Greeley's Diversion*

The median total organic carbon concentration at the City of Greeley's Diversion was near baseline at 4.2 mg/L. Monthly concentrations ranged from a minimum 2.6 mg/L in the month of November to a maximum 7.0 mg/L measured in the month of May. Total organic carbon concentrations were above baseline in April when concentrations measured 1.2 times higher than baseline. Concentrations in May and June were below baseline but exceeded the 4 mg/L removal requirement (**Table 3**). TOC was slightly higher than baseline in the summer months of July and August and much higher than baseline in the fall months of September and October where concentrations

exceeded baseline by 1.3 and 1.4 times, respectively. Total organic carbon concentrations were generally higher at the City of Greeley's Diversion (PBD) compared to the City of Fort Collins' Diversion (PNF) due to contributions from the North Fork (**Figure 4.1**).

## 4.4 TURBIDITY

Turbidity was higher than the baseline median at both the City of Fort Collins' Diversion (PNF) and City of Greeley's Diversion (PBD) in 2023 (**Figure 3.1**). Seasonal trends in turbidity differed from baseline with elevated turbidity levels in the early spring, late summer and fall seasons, rather than just during runoff.

*City of Fort Collins' Diversion*

The median turbidity at the City of Fort Collins' Diversion was 6.52 NTU compared to the baseline median of 1.7 mg/L. Concentrations ranged from a minimum of less than 1 NTU in the month November to a maximum of 114 NTU measured in the month of June. Turbidity was much higher than baseline in the spring months of April and May. Turbidity in the month of April measured 3.95 NTU, which was 6.6 times higher than baseline. Elevated turbidity continued into May where concentrations were five times greater than baseline. Turbidity levels in the month of June showed the greatest departure from baseline at 107 NTU, which was 22 times greater than baseline. The higher values during this time were likely related to snowmelt runoff remobilizing sediments from the Cameron Peak Fire within the CLP River. Turbidity levels receded in the late summer months of July and August but were still slightly above baseline. Turbidity levels spiked again in the early fall month of September, when concentrations were 8.5 times greater than baseline. Turbidity levels in October and November returned to more normal conditions and measured near baseline. The elevated turbidity levels observed in the late summer and early fall were caused by post-fire storm events that were observed throughout the summer monsoon season (**Figure 4.1**).

*City of Greeley's Diversion*

The median turbidity at the City of Greeley's Diversion was slightly above baseline, measuring at 3.47 NTU compared to the baseline median of 1.8 NTU. Concentrations ranged from a minimum of below 1 NTU in the month of November to a maximum of 90 NTU measured in the month of June. Turbidity was much higher than baseline in the spring months of April and May where concentrations were 1.6 and 3 times greater than baseline, respectively. Similar to trends observed upstream at the City of Fort Collins' Diversion (PNF), elevated turbidity levels continued into the month of June. Turbidity during this time was 20 times higher than baseline. Like observations at the City of Fort Collins' Diversion (PNF), the higher values during this time were likely related to snowmelt runoff remobilizing sediments from the Cameron Peak Fire within the CLP River. Turbidity levels decreased in the late summer into the fall, but remained slightly elevated during the months of July, August, and September. Elevated turbidity during this time may have been influenced by contributions from the North Fork CLP River (**Figure 4.1**).

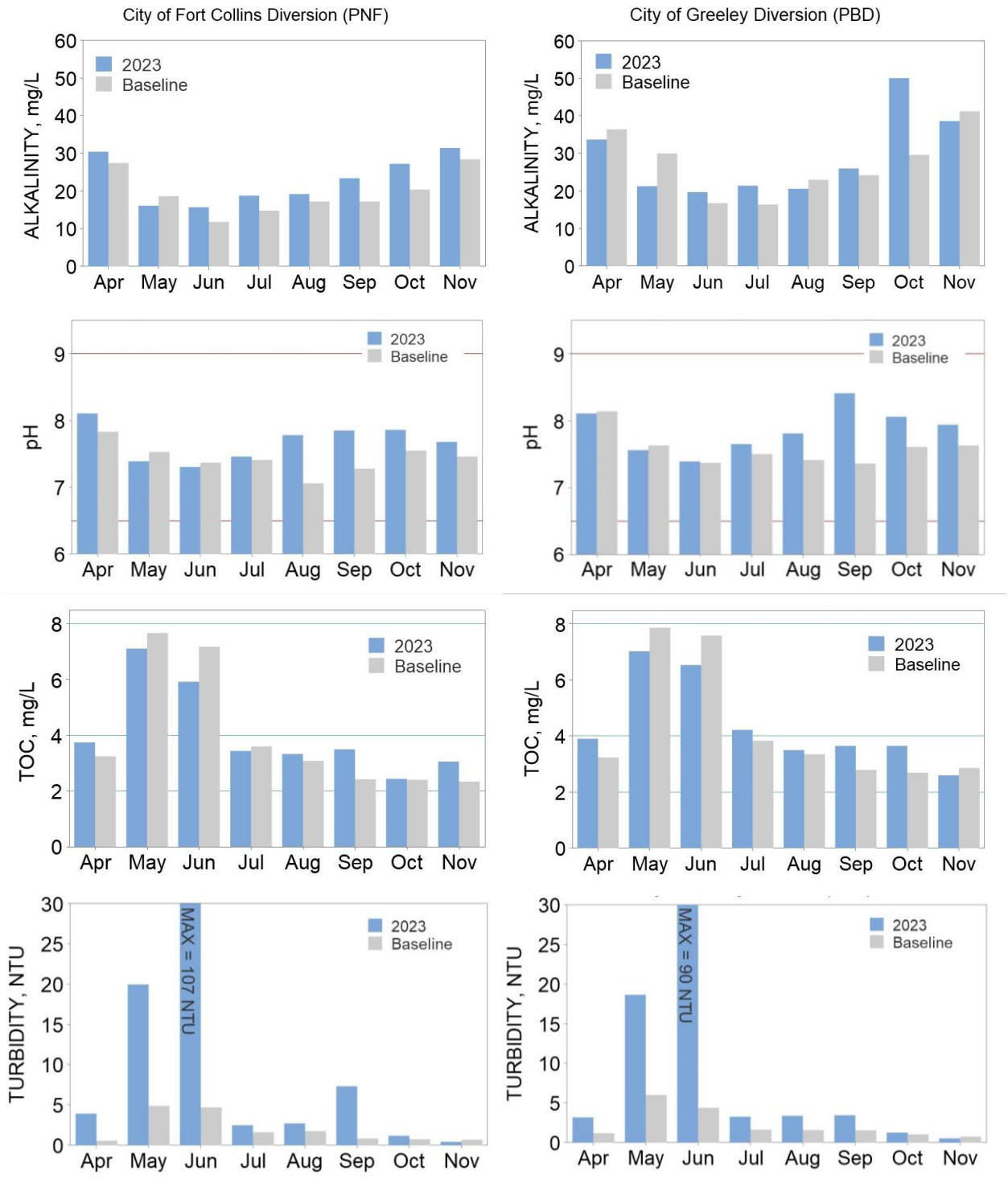


**Figure 4.1** – Monthly median alkalinity, pH, total organic carbon, and turbidity levels measured on the Mainstem CLP River at the City of Fort Collins Diversion (left) and City of Greeley Diversion (right) in 2023 compared to the baseline period of record. The red reference lines for pH indicate water quality standards set by the Colorado Department of Public Health and Environment to protect aquatic life and green reference lines for TOC indicate thresholds for TOC removal requirements. Note that the TOC removal requirements also consider raw water alkalinity concentrations.

# 5.0 SUMMARY

## 5.1 PROGRAM PERFORMANCE

Review of the 2023 Upper CLP Collaborative Water Quality Monitoring Program data indicates that the program adequately captures temporal trends in water quality and provides a spatial context for examining notable events. The results of the field quality assurance and control sampling indicate that data precision and accuracy were acceptable.

## 5.2 HYDROLOGY AND CLIMATE

Air temperature measured over the 2023 water year was warmer than baseline and ranked as the 13th warmest on record (32 years; 1990 to 2020) at the Joe Wright SNOTEL. Cooler conditions were observed over the winter, spring, and summer seasons followed by warmer temperatures in the fall, which ranked as the 8th warmest on record.

Total precipitation measured less than the baseline average. Peak snow water equivalent across the entire Cache la Poudre Watershed was above average and the rate of snowmelt occurred slightly slower than normal. Precipitation measured below baseline for all seasons, except winter. Dry conditions culminated in fall, which was the 2nd driest on record.

The total volume of water that flowed down the Mainstem CLP River, as measured at the Canyon Mouth stream gage, was 114% of baseline. Streamflow was above baseline over the winter, spring, and summer seasons and below baseline over the fall season. Peak streamflow measured 121% of the historical average peak (1881 – 2020) and occurred 10 days earlier than expected.

## 5.3 UPPER CACHE LA POUDRE RIVER WATER QUALITY

No significant water quality concerns were identified for the North Fork CLP watershed; however, notable water quality changes were observed in the Mainstem CLP watershed, specifically related to on-going impacts from the Cameron Peak Fire.

The typical challenges for water treatment were observed on the Mainstem and the North Fork during snowmelt runoff, exacerbated by remobilization of sediments from the Cameron Peak Fire within the CLP River. This resulted in elevated turbidity, specific conductivity, and nutrients. Like prior years, snowmelt driven impacts diminished in June.

The most notable impacts to water quality over the 2023 water year were associated with post-fire water quality impacts to the Mainstem CLP River from the Cameron Peak Fire burn scar during runoff and after high-intensity storm events in the summer monsoon season. Erosion from high intensity precipitation events that occurred over the Cameron Peak Wildfire burn scar resulted in periodic occurrences of degraded water quality in the CLP River including elevated turbidity. The largest impacts were observed in the Poudre below Rustic (PBR) downstream to the City of Greeley's Diversion (PBD). Seven of the post-fire storm events in 2023 exceeded turbidity thresholds for water treatment indicating poor water quality, which resulted in the shutdown of Poudre River water supply intakes and reliance on alternate water sources. However, the magnitude, duration, and frequency of these events has decreased in years following the Cameron Peak Wildfire.

"… notable water quality changes were observed in the Mainstem CLP watershed, specifically related to on-going impacts from the Cameron Peak Fire."

Elevated nitrate concentrations were observed at Joe Wright Creek (JWC) and in the Mainstem above Joe Wright Creek (PJW). High elevation reservoirs may act as a buffer between the severely burned hillslopes and the Mainstem CLP River, delaying the timing of the post-fire nutrient response. While nutrient concentrations may decrease in coming years in downstream sites on the CLP River, sites directly below high elevation reservoirs may see prolonged post-fire effects.

Physical parameters, including water temperature, pH, and turbidity were within the baseline range of values in the North Fork and Mainstem CLP River. Maximum turbidity

was greatly elevated in the Mainstem CLP River, driven by high-intensity precipitation events.

General parameters, including alkalinity, hardness, and specific conductivity concentrations were within the baseline range of values in the North Fork. Median hardness and specific conductivity values were slightly elevated within the Mainstem CLP. Elevated values were observed during periods of low streamflow, including early spring and late fall.

Total dissolved solids were within the baseline range of values in the North Fork CLP River and elevated in the Mainstem CLP River. Median total dissolved solids concentrations were higher than baseline at all monitoring sites along the Mainstem CLP River and measured 1.2 to 1.6 times higher than baseline. The largest differences were observed at the Mainstem Poudre below Rustic and below the South Fork (PBR and PSF).

Total organic carbon concentrations were near baseline along both the Mainstem CLP River and North Fork CLP River. Median concentrations were slightly higher than baseline at all North Fork CLP monitoring sites. Seasonal trends in total organic carbon were comparable to baseline, with the highest concentrations observed during snowmelt runoff.

Nutrients were within the baseline range of values in the North Fork CLP River, although anoxic conditions in both Halligan and Seaman Reservoir during the late summer and fall resulted in elevated nutrient concentrations in the North Fork CLP River. In-reservoir dynamics were driven by the above average temperatures and extremely dry conditions observed during this time. Elevated concentrations were measured at monitoring sites directly downstream of the reservoirs and appeared to have minimal impact to lower elevation monitoring sites. Nutrients were higher than baseline in the Mainstem CLP River. The greatest change was observed in nitrate, although total nitrogen concentrations were also above baseline at most sites. Maximum nitrate concentrations were 3 – 12 times higher than baseline and occurred during snowmelt runoff in May.

Geosmin was measured above the reporting limit from the late summer to late fall at both the Mainstem CLP below Rustic (PBR) and the City of Fort Collins' intake (PNF). These observations likely stem from high elevation reservoir dynamics. 2-MIB was not detected during 2023. Total Coliforms and *E. coli* concentrations were within the baseline range of values in the CLP River. Maximum concentrations were observed in the late spring and early summer, with concentrations in the North Fork CLP below Seaman Reservoir (NFG) remaining elevated through the fall. Maximum concentrations on the Mainstem CLP below the South Fork (PSF) and at the City of Fort Collins' Diversion (PNF) exceeded the water quality standard. These individual variances are not considered a long-term threat to water quality in the CLP River.

Macroinvertebrate communities continue to be impacted by post-fire pollution to varying degrees. The Mainstem CLP below the South Fork (PSF) showed the greatest impacts of all study locations, with a decline in species diversity and collector-gather populations, likely due to cumulative impacts of post-fire erosion, sedimentation, and increased nutrient loading. The Mainstem near the cities of Fort Collins' and Greeley's raw water intakes (PNF and PBD) experienced an increase in species diversity and density, but still showed shifts in feeding groups, which indicates stress. A significant increase in algae scrapers was observed at nearly all monitoring locations, likely due to an increase in nutrient concentrations and algae throughout the CLP. It is likely that impacts observed in these macroinvertebrate communities across all study locations is due to continued impacts from post-fire events, including excessive sedimentation in downstream sites and elevated nutrients prompting algae growth as well as fluxes in dissolved oxygen.

In summary, the Upper CLP watershed continues to supply a high-quality drinking water supply to the City of Fort Collins, City of Greeley and surrounding communities served by the Soldier Canyon Water Treatment Authority. The Cameron Peak Fire has resulted in notable changes to water quality compared to baseline conditions and post-fire storm events have posed challenges to drinking water treatment due to impaired water quality. However, the duration, magnitude, and frequency of these storm-induced poor water quality events has decreased in the years following the Cameron Peak Fire, indicating watershed recovery. Despite these challenges, early warning systems and alternate water sources have proven critical to avoiding or mitigating these impacts. Emerging trends will be important to monitor into the future to further help inform water treatment operations, track watershed health, and evaluate the continued impacts of the Cameron Peak Fire on this important water supply.

# 6.0 DATA QUALITY ASSURANCE AND CONTROL

The Upper CLP watershed collaborative monitoring program assures comparability and validity of data by complying with monitoring methods and implementing quality assurance and quality control (QAQC) measures. QAQC measures are good practice in environmental monitoring and can be used to determine potential error in data due to contamination of water samples, sampling error, equipment contamination, and/or laboratory error. The Upper CLP monitoring sites are representative of the goals and objectives outlined previously and demonstrate the true character of the watershed at the time of sampling. The remainder of this section summarizes QAQC data collected over the 2023 monitoring season.

## 6.1 FIELD QUALITY CONTROL

Field duplicates and field blanks were obtained at PNF and NFG during each monitoring event to determine precision of data and to identify potential for sample contamination. The field data quality sampling schedule is outlined in the 2023 annual sampling plan (Attachment 4). QAQC samples and accuracy of field equipment are reviewed by Watershed Program staff.

In 2023, nine percent (419 out of 4730) of the environmental samples collected were blank samples and nine percent (421 out of 4730) of the environmental samples collected were field duplicates. The results of the field quality assurance and control sampling indicate that precision and accuracy were acceptable.

### Field Duplicates

Precision is a measure of the deviation from the true value. For most constituents, duplicate determinations should agree within a relative percent difference of 10%. Duplicate samples with measured concentrations that differ by greater than 10% from field samples were flagged for further quality assurance and control evaluation. **Table 8** (a and b) outlines relative percent difference statistics for duplicate samples and illustrates that Upper CLP water quality data are of high precision. All duplicate samples were within 10% agreement at the 75$^{th}$ percentile during North Fork sampling, except total coliforms (22%) and copper (14%) (**Table 8a**). This result indicates that most of the duplicate samples were in agreement during North Fork sampling events. Similarly, all duplicate samples were within 10% agreement at the 75$^{th}$ percentile during Mainstem sampling, except total coliforms (17%) and Geosmin (32%) (**Table 8b**). The high variability in total coliform and *E. coli* samples was expected due to environmental variability in bacteriological sampling. All other duplicate samples collected on the Mainstem were less than a relative percent difference of 10% for at least 75% of the samples.

### Field Blanks

Blank samples should not contain analytes above the reporting limit. Field blanks were analyzed in the laboratory for a total of 33 different water quality parameters in 2023. Ninety-six percent of field blank samples reported below the constituent's respective reporting limits. The 4% of field blank samples that were detected above the reporting limits included alkalinity, copper, hardness, total dissolved solids, and total phosphorous (**Table 9**). The reporting limit was only exceeded once for each of these constituents except for copper and total dissolved solids, which exceed the reporting limit twice and eleven times, respectively.

Concentration exceedances were reported only slightly above the reporting limit for most samples and concentrations were minimal compared to concentrations of environmental samples. All exceedances were observed during North Fork sampling events, except total dissolved solids, which were observed on both North Fork and Mainstem sampling dates.

Potential causes of these contaminants are listed below:

- Atmosphere/particulates in the air slightly increasing total dissolved solids.
- Inadequate rinsing of sample bottles either in the field or laboratory may have left residuals increasing total dissolved solids.
- Copper or phosphorous contamination may be introduced by the field sampler and/or laboratory staff accidentally touching sample bottle or lid or introduced by the lab instrument, if not properly cleaned.

**Instrument Accuracy**

Accuracy is a measure of the degree of closeness a measurement is to the true measurement. Equipment calibrations were conducted prior to field monitoring exhibitions using certified standards to assure the accuracy of sensors on the multi-parameter water quality sonde. Quality assurance checks were conducted following field sampling missions to verify sensor accuracy.

## 6.2 LABORATORY QUALITY CONTROL

Upper CLP water quality samples analyzed by the Fort Collins Water Quality Laboratory are reviewed by the Quality Assurance Coordinator to ensure data are free of sample contamination, analytical, and/or data entry errors.

*Water quality laboratory staff analyze samples at the City of Fort Collins Water Quality Laboratory.*

The City of Fort Collins Water Quality Laboratory implements analytical QAQC measures by conducting laboratory blank, duplicate, replicate, and spiked samples. The City of Fort Collins WQL conducts most analyses for the Source Water Quality Monitoring Program and is a U.S. EPA Certified Drinking Water Laboratory with an established QA plan that is applied to all samples received by the laboratory (Elmund et al, 2013). The primary features of their QA protocol include:

- Precision: one duplicate sample is analyzed for every 10 samples; relative deviation should be less than 10%.
- Accuracy: one external QCS sample is analyzed with each set of samples analyzed. Methods may specify an acceptable recovery range. In general, Standard Methods limits are ± 5% and EPA methods are ± 10%.
- Recovery: one sample is spiked for every 10 samples; if there are different matrices, at least one sample per matrix is spiked. Limits for most methods are ± 15%. If one type of matrix spike fails and all other QC passes, those samples may be flagged.

A complete description of laboratory personnel, equipment, and analytical QA methods is outside of the scope of this report and is not addressed in detail here. As part of the City's Water Quality Services Division the WQL operates under the guidance of a general QA plan (Hill, 2019)

**Table 8a** – Data quality assurance statistics calculated for duplicated samples collected at NFG. The range in sample concentrations (minimum and maximum) was calculated for the combined environmental and duplicate samples collect over the monitoring season. The absolute mean difference was calculated by taking the difference between the environmental and duplicate sample concentration for individual monitoring events and then by calculating and average difference for the monitoring season. The relative percent difference was calculated by taking the difference between the environmental and duplicate sample concentrations divided by the average concentration between samples for each monitoring event. Percentiles (25th, 50th and 75th percentiles) were then calculated from these data to describe the distribution of relative percent differences for each constituent.

| a) NFG constituents | Range in QAQC sample concentration | | Reporting Limit | Absolute Mean Difference | Relative Percent Difference (%) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Percentile | | |
| | *min* | *max* | | | *25th* | *50th* | *75th* |
| Aluminum - S, ug/L | <10 | 284 | 10 | 6.55 | 0.00 | 1.43 | 4.54 |
| Aluminum - TR, ug/L | 95.1 | 512 | 10 | 10.58 | 0.67 | 1.42 | 1.89 |
| Ammonia as N, ug/L | <10 | <10 | 10 | 0.0096 | 0.00 | 0.00 | 0.00 |
| Arsenic - S, ug/L | <2 | <2 | 2 | 0.011 | 0.00 | 0.00 | 0.07 |
| Arsenic - TR, ug/L | <2 | 2.31 | 2 | 0.0075 | 0.00 | 0.00 | 0.11 |
| Calcium, mg/L | 12.9 | 40.2 | 0.5 | 0.8 | 0.46 | 1.13 | 1.63 |
| Chloride, mg/L | 6.02 | 16 | 1 | 0.0675 | 0.04 | 0.19 | 0.40 |
| Coliforms, Total, cfu | <1 | <1 | - | 0.0675 | 12.52 | 17.66 | 22.79 |
| Copper - S, ug/L | <3 | 6.2 | 3 | 0.0675 | 5.47 | 12.93 | 14.42 |
| Copper - TR, ug/L | <3 | <3 | 3 | 0.0675 | 0.00 | 0.00 | 0.00 |
| E. coli, cfu | <1 | <1 | - | 0.0675 | 0.00 | 0.00 | 0.00 |
| Hardness, mg/L | 131 | 133 | 5 | 0.0675 | 0.76 | 0.76 | 0.76 |
| Iron - S, ug/L | <10 | 664 | 10 | 0.0675 | 0.00 | 2.30 | 2.81 |
| Iron - TR, ug/L | 314 | 1320 | 10 | 0.0675 | 0.45 | 0.69 | 0.85 |
| Magnesium, mg/L | 2.75 | 10.1 | 0.2 | 0.0675 | 0.30 | 1.20 | 2.11 |
| Manganese - S, ug/L | 7.97 | 67.1 | 1 | 0.0675 | 0.66 | 1.22 | 2.25 |
| Manganese - TR, ug/L | 26.1 | 167 | 1 | 0.0675 | 0.34 | 0.53 | 1.44 |
| Nitrate, ug/L | <40 | <40 | 40 | 0.0003 | 0.00 | 0.00 | 0.00 |
| Nitrite, ug/L | <40 | <40 | 40 | 0 | 0.00 | 0.00 | 0.00 |
| Orthophosphate, ug/L | <5 | <5 | 5 | 0.0008 | 0.00 | 0.00 | 0.00 |
| Potassium, mg/L | 0.9 | 1.53 | 0.3 | 0.0008 | 0.64 | 1.35 | 3.00 |
| Selenium, | <1 | <1 | 1 | 0.0008 | 0.00 | 0.00 | 0.00 |
| Silver - S | <0.5 | 0.54 | 0.5 | 0.0008 | 0.00 | 0.00 | 0.00 |
| Silver - TR | <0.5 | <0.5 | 0.5 | 0.0008 | 0.00 | 0.00 | 0.00 |
| Sodium, mg/L | 4.77 | 12.2 | 0.4 | 0.0008 | 0.31 | 1.24 | 2.55 |
| Sulfate, mg/L | <5 | 9.66 | 5 | 0.0175 | 0.00 | 0.03 | 0.13 |
| Total Dissolved Solids, mg/L | 84 | 196 | 10 | 5.63 | 0.92 | 1.35 | 2.16 |
| Total Kjeldahl Nitrogen, ug/L | <100 | <100 | 100 | 0.0563 | 1.16 | 3.44 | 9.55 |
| Total Organic Carbon, mg/L | 4.65 | 10.3 | 0.5 | 0.138 | 0.41 | 0.92 | 1.29 |
| Total Phosphorus, ug/L | <10 | <10 | 10 | 0.0028 | 0.87 | 1.46 | 2.31 |

*cfu = colony forming units

**Table 8b** – Data quality assurance statistics calculated for duplicated samples collected at PNF. The range in sample concentrations (minimum and maximum) was calculated for the combined environmental and duplicate samples collect over the 2023monitoring season. The absolute mean difference was calculated by taking the difference between the environmental and duplicate sample concentration for individual monitoring events and then by calculating and average difference for the monitoring season. The relative percent difference was calculated by taking the difference between the environmental and duplicate sample concentrations divided by the average concentration between samples for each monitoring event. Percentiles (25th, 50th and 75th percentiles) were then calculated from these data to describe the distribution of relative percent differences for each constituent.

| b) PNF constituents | Range in QAQC sample concentration | | Reporting Limit | Absolute Mean Difference | Relative Percent Difference (%) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Percentile | | |
| | *min* | *max* | | | *25th* | *50th* | *75th* |
| **Ammonia as N, ug/L** | <10 | <10 | 10 | 0 | 0.00 | 0.00 | 0.00 |
| **Calcium, mg/L** | 4.43 | 8.88 | 0.5 | 0.093 | 0.28 | 0.48 | 0.90 |
| **Chloride, mg/L** | <1 | 2.86 | 1 | 0.004 | 0.00 | 0.00 | 0.00 |
| **Total Coliforms, cfu** | 53 | 731 | - | 79.25 | 7.37 | 12.21 | 17.13 |
| **E. coli, cfu** | 0 | 52 | - | 12.5 | 0.00 | 0.00 | 0.00 |
| **Geosmin** | 0 | 3.39 | 1 | 0.555 | 4.18 | 7.39 | 32.02 |
| **Magnesium, mg/L** | 1.1 | 2.41 | 0.2 | 0.03 | 0.49 | 0.92 | 1.29 |
| **Nitrate, ug/L** | <40 | <40 | 40 | 0.004 | 0.00 | 0.00 | 0.00 |
| **Nitrite, ug/L** | <40 | <40 | 40 | 0 | 0.00 | 0.00 | 0.00 |
| **Orthophosphate, ug/L** | <5 | <5 | 5 | 0 | 0.00 | 0.00 | 0.00 |
| **Potassium, mg/L** | 0.63 | 1.25 | 0.3 | 0.01 | 0.13 | 0.60 | 0.76 |
| **Sodium, mg/L** | 1.88 | 3.8 | 0.4 | 0.04 | 0.42 | 0.59 | 1.16 |
| **Sulfate, mg/L** | <5 | 5.98 | 5 | 0 | 0.00 | 0.00 | 0.00 |
| **Total Dissolved Solids, mg/L** | 41 | 144 | 10 | 11.1 | 2.22 | 3.23 | 6.90 |
| **Total Kjeldahl Nitrogen, ug/L** | <100 | <100 | 100 | 0.018 | 0.00 | 0.00 | 0.00 |
| **Total Organic Carbon, mg/L** | 2.4 | 7.26 | 0.5 | 0.049 | 0.17 | 0.56 | 0.95 |
| **Total Phosphorus, ug/L** | <10 | <10 | 10 | 0.004 | 0.13 | 2.42 | 5.45 |

**Table 9** – Blank samples detected above their respective reporting limit (RL), percent (%) exceedance and the percent of quality assurance and quality control samples collected over the 2023 monitoring season.

| WQ Parameter | Sample >RL | Total QAQC samples | % Exceedance | Total Samples | %QAQC |
|---|---|---|---|---|---|
| Alkalinity | 1 | 1 | 100% | 165 | 1% |
| Aluminum | 0 | 16 | 0% | 170 | 9% |
| Ammonia as N | 0 | 16 | 0% | 165 | 10% |
| Arsenic | 0 | 16 | 0% | 170 | 9% |
| Cadmium | 0 | 16 | 0% | 170 | 9% |
| Calcium | 0 | 12 | 0% | 168 | 7% |
| Chloride | 0 | 9 | 0% | 91 | 10% |
| Chromium | 0 | 16 | 0% | 170 | 9% |
| Coliforms, Total | 0 | 6 | 0% | 54 | 11% |
| Copper | 2 | 16 | 13% | 170 | 9% |
| E. coli | 0 | 6 | 0% | 54 | 11% |
| Hardness | 1 | 1 | 100% | 165 | 1% |
| Iron | 0 | 16 | 0% | 170 | 9% |
| Lead | 0 | 16 | 0% | 170 | 9% |
| Magnesium | 0 | 12 | 0% | 166 | 7% |
| Manganese | 0 | 16 | 0% | 170 | 9% |
| Mercury | 0 | 16 | 0% | 178 | 9% |
| Nickel | 0 | 16 | 0% | 170 | 9% |
| Nitrate | 0 | 16 | 0% | 165 | 10% |
| Nitrite | 0 | 16 | 0% | 165 | 10% |
| Orthophosphate | 0 | 16 | 0% | 165 | 10% |
| Potassium | 0 | 10 | 0% | 92 | 11% |
| Selenium | 0 | 16 | 0% | 170 | 9% |
| Silver | 0 | 16 | 0% | 170 | 9% |
| Sodium | 0 | 10 | 0% | 92 | 11% |
| Sulfate | 0 | 9 | 0% | 91 | 10% |
| Total Dissolved Solids | 11 | 17 | 65% | 165 | 10% |
| Total Kjeldahl Nitrogen | 0 | 16 | 0% | 165 | 10% |
| Total Organic Carbon | 0 | 16 | 0% | 165 | 10% |
| Total Phosphorus | 1 | 16 | 6% | 165 | 10% |
| Zinc | 0 | 16 | 0% | 170 | 9% |
| 2-Methylisoborneol (MIB) | 0 | 3 | 0% | 27 | 11% |
| Geosmin | 0 | 3 | 0% | 27 | 11% |

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# 7.0 REFERENCES


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Helsel, D.R. and R.M. Hirsch, 2002. Statistical Methods in Water Resources, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Hydrological Analysis and Interpretation, *United States Geological Survey*, 524 pages.

Hill, L., 2019. Quality Assurance Plan, *Internal Water Quality Services Division Document,* City of Fort Collins, June 1, 2019, 20 pages.

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# ATTACHMENT 1

## UPPER CLP COLLABORATIVE WATER QUALITY MONITORING PROGRAM SAMPLING SITES

| | Site ID | Station Name | Lat/Long |
|---|---|---|---|
| *Mainstem* | 100CHR | Joe Wright Creek below Chambers Lake | 40.60065, -105.8367 |
| | 101CHD | Joe Wright Creek below Chambers Lake Dam | 40.6023, -105.843 |
| | 090BMR | Barnes Meadow Reservoir Outflow | 40.60065, -105.8367 |
| | 091BMD | Barnes Meadow Reservoir Dam | 40.60044, -105.837 |
| | 080JWC | Joe Wright Creek | 40.61979, -105.819 |
| | 070PJW | Poudre above Joe Wright | 40.63411, -105.807 |
| | 060LRT | Laramie River Tunnel | 40.66803, -105.808 |
| | 050PBR | Poudre Below Rustic | 40.70002, -105.545 |
| | 040SFM | South Fork above Mainstem | 40.61824, -105.5254 |
| | 041SFC | South Fork at Confluence | 40.68506, -105.447 |
| | 030PSF | Poudre below South Fork | 40.69464, -105.448 |
| | 020PNF | Poudre Above North Fork | 40.70157, -105.241 |
| | 010PBD | Poudre at Bellvue Diversion | 40.66436, -105.217 |
| *North Fork* | 280NDC | North Fork above Dale Creek | 40.89759, -105.376 |
| | 270NBH | North Fork below Halligan Reservoir | 40.87763, -105.3386 |
| | 240SCM | Stonewall Creek Mouth | 40.80754, -105.2535 |
| | 260NRC | North Fork above Rabbit Creek | 40.8092, -105.2685 |
| | 250RCM | Rabbit Creek Mouth | 40.81023, -105.2857 |
| | 230PCM | Lone Pine Creek Mouth | 40.79478, -105.2873 |
| | 220NFL | North Fork at Livermore | 40.78773, -105.2525 |
| | 200NFG | North Fork below Seaman Reservoir | 40.70222, -105.234 |

# ATTACHMENT 2

## 2023 UPPER CLP MONITORING PARAMETER LIST

| | | |
|---|---|---|
| **Field Parameters** | | |
| Specific Conductance | Indicator of total dissolved solids. | All sites with water quality sonde. |
| Dissolved Oxygen | Profile indicates stratification, importance for aquatic life and chemical processes. | All sites with water quality sonde. |
| Temperature | Reflects seasonality; affects biological and chemical processes; water quality standard. | All sites with water quality sonde. |
| pH | Measure of acidity. | All sites with water quality sonde. |
| **General & Miscellaneous Parameters** | | |
| Alkalinity | Indicator of carbonate species concentrations; Acid neutralizing capacity of water; treatment implications. | |
| Discharge | Necessary for flow dependent analysis and load estimation. | Measured during sampling at NRC, RCM, SCM, PCM, PJW, SFM when conditions allow |
| Geosmin | Taste and odor compound | Measured monthly at PBR and PNF |
| Hardness | Treatment implications. Hard water causes scaling and soft water is considered corrosive. | |
| Total Dissolved Solids (TDS) | Indicator of overall water quality; includes both ionic and non-ionic species. | |
| Total Organic Carbon (TOC) | Important parameter for water treatment; precursor of disinfection byproducts. | |
| Turbidity | Indicator of suspended material; important for water treatment. | |
| **Nutrients** | | |
| Nitrogen, Ammonia | Primary source of nitrogen to algae, indicator of pollution by sewage, septic tanks, agriculture and atmospheric deposition; water quality standard. | |
| Nitrate | Primary source of nitrogen to algae; indicator of pollution by sewage, septic tanks, agriculture, and atmospheric deposition; water quality standard. | |
| Nitrite | Toxic inorganic nitrogen species; rarely encountered at significant concentrations; water quality standard. | |
| Total Kjeldahl Nitrogen | Sum of organic nitrogen and ammonia. | |
| Orthophosphate (Soluble Reactive Phosphorus) | Form of phosphorous (dissolved $PO_4^{-3}$) most available to algae; indicator of pollution by sewage, septic tanks, agriculture and atmospheric deposition. | |
| Total Phosphorus | Includes dissolved and adsorbed, organic and inorganic forms of phosphorus, indicator of pollution by sewage, septic tanks, agriculture and atmospheric deposition. | |

| Major Ions | | |
|---|---|---|
| Calcium | Major ion. | 6x/yr |
| Chloride | Major ion. | 6x/yr |
| Magnesium | Major ion. | 6x/yr |
| Potassium | Major ion, minor importance as a nutrient. | 6x/yr |
| Sodium | Major ion. | 6x/yr |
| Sulfate | Major ion. | 6x/yr |
| **Biological Constituents** | | |
| *E. Coli* | Indicator of human or animal waste contamination; water quality standard. | Only from Rustic downstream, and NFG |
| Total Coliform | Indicator of human or animal waste contamination. | Only from Rustic downstream, and NFG |
| Macroinvertebrates | Community species metrics can be used to indicate pollution and overall watershed health. | PJW, PBR, PSF, PNF, PBD |
| **Metals** | | |
| Aluminum, total & dissolved | Naturally occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels; Aesthetic effects to drinking water | Only PNF & NFG |
| Arsenic, total & dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels; water quality standard. | Only PNF & NFG |
| Cadmium, total & dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels; water quality standard. | Only PNF & NFG |
| Chromium, dissolved | Natural occurs in rocks and soil. Water quality standard. | Only PNF & NFG |
| Copper, dissolved | Natural occurs in rocks and soil. Water quality standard. | Only PNF & NFG |
| Iron, total & dissolved | Natural occurs in rocks and soil. Affects aesthetic quality of treated water. | Only PNF & NFG |
| Lead, total & dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels; water quality standard. | Only PNF & NFG |
| Manganese, total & dissolved | Natural occurs in rocks and soil. Aesthetic effects to drinking water; water quality standard | Only PNF & NFG |
| Nickel, dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels; water quality standard. | Only PNF & NFG |
| Silver, dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels. | Only PNF & NFG |
| Zinc, total & dissolved | Natural occurs in rocks and soil. Indicator of pollution from mining activity at elevated levels. | Only PNF & NFG |

# ATTACHMENT 3

## ANALYTICAL METHODS, REPORTING LIMITS, SAMPLE PRESERVATION, AND HOLDING TIMES

| | Parameter | Method | Reporting Limit | Preser-vation | Holding Time |
|---|---|---|---|---|---|
| Micro-biological | Total Coliform, *E.coli* - QT | SM 9223 B | 0 | cool, 4C | 6 hrs |
| | *Giardia & Cryptosporidium* (CH Diagnostics) | EPA 1623 | 0 | cool, 4C | 4 days |
| | Algae I.D. (Phyto Finders) | SM 10200E.3, SM 10200F.2c1 | | Lugol's Solution, cool, 4C | 12 mo |
| General & Misc. | Alkalinity, as $CaCO_3$ | SM 2320 B | 2 mg/L | cool, 4C | 14 days |
| | Chlorophyll a | SM10200H modified | 0.6 ug/L | cool, 4C | 48 hrs |
| | Hardness, as $CaCO_3$ | SM 2340 C | 2 mg/L | none | 28 days |
| | Specific Conductance | SM 2510 B | | cool, 4C | 28 days |
| | Total Dissolved Solids | SM 2540 C | 10 mg/L | cool, 4C | 7 days |
| | Turbidity (NTU) | SM2130B,EPA180.1 | 0.01 units | cool, 4C | 48 hrs |
| Nutrients | Ammonia - N | Lachat 10-107-06-2C | 0.01 mg/L | $H_2SO_4$ | 28 days |
| | Nitrate | EPA 300 (IC) | 0.04 mg/L | cool, 4C (eda) | 48 hrs |
| | Nitrite | EPA 300 (IC) | 0.04 mg/L | cool, 4C (eda) | 48 hrs |
| | Total Kjeldahl Nitrogen | EPA 351.2 | 0.1 mg/L | $H_2SO_4$ pH<2 | 28 days |
| | Phosphorus, Total | SM 4500-P B5,F | 0.01 mg/L | $H_2SO_4$ pH<2 | 28 days |
| | Phosphorus, Ortho | SM 4500-P B1,F | 0.005 mg/L | filter, cool 4C | 48 hrs |
| Major Ions | Calcium | EPA 200.8 | 0.05 mg/L | $HNO_3$ pH <2 | 6 mos |
| | Chloride | EPA 300 (IC) | 1.0 mg/L | none (eda) | 28 days |
| | Magnesium, flame | EPA 200.8 | 0.2 mg/L | $HNO_3$ pH <2 | 6 mos |
| | Potassium | EPA 200.8 | 0.2 mg/L | $HNO_3$ pH <2 | 6 mos |
| | Sodium, flame | EPA 200.8 | 0.4 mg/L | $HNO_3$ pH <2 | 6 mos |
| | Sulfate | EPA 300 (IC) | 5.0 mg/L | cool, 4C (eda) | 28 days |
| Metals | Cadmium | EPA 200.8 | 0.1 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Chromium | EPA 200.8 | 0.5 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Copper | EPA 200.8 | 3 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Iron, (total & dissolved) | EPA 200.8 | 10 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Lead | EPA 200.8 | 1 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Nickel | EPA 200.8 | 2 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Silver | EPA 200.8 | 0.5 ug/L | $HNO_3$ pH <2 | 6 mos |
| | Zinc | EPA 200.8 | 50 ug/L | $HNO_3$ pH <2 | 6 mos |
| TOC | TOC | SM 5310 C | 0.5 mg/L | $H_3PO_4$pH <2 | 28 days |
| Analysis conducted by City of Fort Collins Water Quality Lab (FCWQL), unless otherwise noted. | | | | | |
| Reporting Limit = lowest reportable number based on the lowest calibration standard routinely used. | | | | | |

# ATTACHMENT 4

## UPPER CLP COLLABORATIVE WATER QUALITY MONITORING PROGRAM 2023 SAMPLING PLAN

### 2023 Upper Cache la Poudre Water Quality Monitoring Program

#### Mainstem Cache la Poudre River

| | Apr 10 | Apr 24 | May 8 | May 22 | Jun 12 | Jun 26 | Jul 17 | Aug 14 | Sep 11 | Oct 9 | Nov 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CHD** | F,GM,N | F,GM,I,N | F,G,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,G,GM,I,N | F,G,GM,N | F,G,GM,I,N | F,G,GM,I,N |
| **BMD**[1] | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,I,N |
| **JWC** | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,I,N |
| **PJW** | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,G,GM,I,N | F,G,GM,Mc,N | F,G,GM,I,N | F,G,GM,I,N |
| **LRT** | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,N | F,GM,I,N | F,GM,I,N |
| **PBR** | E,F,G,GM,N | E,F,GM,I,N | E,F,G,GM,N | E,F,GM,I,N | E,F,G,GM,N | E,F,GM,I,N | E,F,G,GM,N | E,F,G,GM,I,N | E,F,G,GM, Mc,N | E,F,G,GM,IN | E,F,G, GM,I,N |
| **SFM** | D,F,GM,N | D,F,GM,I,N | D,F,GM,N | D,F,GM,I,N | D,F,GM,N | D,F,GM,I,N | D,F,GM,N | D,F,G,GM, I,N | D,F,G, GM,N | D,F,G,GM, I,N | D,F,G,GM, I,N |
| **PSF** | E,F,GM,N | E,F,GM,I,N | E,F,GM,N | E,F,GM, I,N | E,F,GM,N | E,F,GM, I,N | E,F,GM,N | E,F,GM, I,N | E,F,GM, Mc,N | E,F,GM, I,N | E,F,GM, I,N |
| **PNF**[2,3] | E,F,G,GM, M,N | E,F,GM,I, M,N | E,F,G,GM, M,N | E,F,GM,I, M,N | E,F,G,GM, M,N | E,F,GM,I, M,N | E,F,G,GM, M,N | E,F,G,GM,I, M,N | E,F,G,GM,Mc, M,N | E,F,G,GM,I, M,N | E,F,G,GM,I, M,N |
| **PBD** | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM,Mc, M,N | E,F,GM,I, M,N | E,F,GM,I, M,N |

#### North Fork Cache la Poudre River

| | Apr 11 | Apr 25 | May 9 | May 23 | Jun 13 | Jun 27 | Jul 18 | Aug 15 | Sep 12 | Oct 10 | Nov 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NDC** | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,I,M,N |
| **NBH** | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,I,M,N |
| **NRC** | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM,I, M,N |
| **RCM** | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | | | | | |
| **SCM** | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | | | | | |
| **PCM** | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | D,F,GM, M,N | D,F,GM,I, M,N | | | | | |
| **NFL** | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,M,N | F,GM,I,M,N | F,GM,I,M,N |
| **NFG**[2] | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM, M,N | E,F,GM,I, M,N | E,F,GM,I, M,N |

[1]Call River Commissioner to determine whether water is flowing.
[2] Field blanks and duplicates (denoted with red text in table) will be collected for the following parameters: *E. coli*; general and miscellaneous; major ions; metals; nutrients and TOC; and geosmin/MIB

D = discharge
E = *E. coli* and total coliform
F = field data (dissolved oxygen, pH, temperature and turbidity)
G = geosmin/MIB
GC = *Giardia/Cryptosporidium*
GM = general and miscellaneous (alkalinity, hardness as $CaCO_3$ and total dissolved solids)
I = major ions (sulfate, chloride, calcium, potassium, sodium, magnesium)
M = metals (aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc
N = nutrients (ammonia-N, nitrate-N, nitrite-N, Total Kjeldahl Nitrogen, Total Phosphorus and ortho phosphorus) and TOC