Loveland Water and Power

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Big Thompson River Watershed Source Water Quality Conditions

Fall 2023

December 11, 2023

Common Acronyms

CB-T	Colorado-Big Thompson Project
CPF	Cameron Peak Fire
CFS	Cubic Feet per Second
LWP	Loveland Water and Power
mg/L	Milligrams per liter (parts per million)
$CaCO_3$	Calcium carbonate
NTU	Nephelometric Turbidity Unit
North Fork	North Fork of the Big Thompson River
SU	Standard Units
SWMP	Source Water Monitoring Program
TOC	Total Organic Carbon
ug/L	Micrograms per liter (parts per billion)
uS/cm	Microsiemens per centimeter
WQL	Loveland Water and Power Water Quality Laboratory

Executive Summary

Fall 2023 water quality conditions were similar to those documented earlier in the year. Some water quality parameters continued to reflect the effects of the Cameron Peak Fire (CPF) which occurred in fall 2020, although the magnitude of these effects on parameters such as turbidity, pH, manganese, nitrate, and orthophosphate appears to be diminished somewhat compared to fall 2022, indicating watershed recovery. However, other parameters, such as iron and copper continue to be substantially affected by the CPF. Total iron concentrations continued to be elevated and total copper concentrations continued to be lower than historic levels. These impacts were particularly notable in the area surrounding the North Fork Big Thompson River (North Fork), which was the most severely burned area of the Big Thompson River Watershed. Sampling from additional sites in the North Fork Watershed in 2023 continue to demonstrate that many of the changes in water quality in the Big Thompson River originated in the Miller Fork as a result of the CPF. However, the magnitude of these contributions appears to be slightly smaller in fall 2023 than in summer 2023. Although the water quality changes resulting from the CPF were challenging from a water treatment perspective, in terms of avoiding water with elevated turbidity among other issues, they provide a template for expected changes that will occur in the event of the next wildfire. Although some water quality challenges persist, they appear to be diminishing, and LWP Drinking Water Treatment staff were able to continue providing high quality drinking water.

Loveland Water and Power Source Water Monitoring Program

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

One central component of the SWMP is the source water sampling and analysis that is accomplished by staff at the Loveland Water and Power Water Quality Laboratory (WQL). LWP has collected operational source water data for over 30 years and a more targeted set of parameters for nine years from the three water sources utilized for drinking water (Colorado-Big Thompson Project, Big Thompson River, and Green Ridge Glade Reservoir). The values for these targeted parameters are available in a short amount of time due to in-house laboratory capacity, and therefore can be used to inform more immediate water system operational decisions.

Water quality information is routinely collected from 15 sites. Of these sites, two are intake locations at the Loveland Water Treatment Plant (river intake and reservoir intake), two are tributary sites (Fall River and North Fork Big Thompson River), seven are associated with the Colorado-Big Thompson River project (CB-T), and four are mainstem river sites (Table 1, Figure 1). Three additional sites were added beginning in spring 2023. One of these locations is located upstream of the Estes Park Sanitation District outfall (by the Rocky Mountain National Park visitor center). Another site added in spring 2023 is located on the North Fork) upstream of the confluence with the Miller Fork. The Miller Fork has been a substantial contributor of water affected by the CPF to the mainstem of the Big Thompson River. The site located above the confluence of the Miller Fork with the North Fork will assist in providing context for Miller Fork contributions. The final site is in the Miller Fork itself, just above the confluence with the North Fork. Sample collection at the three additional sites began in April 2023. All these sites are located upstream of the Loveland drinking water intake and therefore water quality results from these locations have implications for Loveland water treatment and drinking water quality.

Table 1. Big Thompson Watershed sampling location descriptions.

Site Name	Type	Description
S-BTR-10	River	Big Thompson River below Mary's Lake Bridge
S-BTR-15	River	Rocky Mountain National Park Visitor Center
S-BTR-20	River	Downstream of Olympus Dam
S-BTR-30	River	Big Thompson Mainstem above Confluence with North Fork
S-BTR-40	River	Mainstem Big Thompson at Narrows Park
S-BTR-50	River	Mainstem Big Thompson at Viestenz-Smith Park
S-BTT-10	Tributary	Fall River Court Bridge
S-BTT-15	Tributary	North Fork Big Thompson above Miller Fork Confluence
S-BTT-17	Tributary	Miller Fork at Streamside Drive
S-BTT-20	Tributary	North Fork Big Thompson at Storm Mountain Road
S-CBT-10	CB-T	Near Gate at East Portal
S-CBT-20	CB-T	Shore of Mary's Lake
S-CBT-30	CB-T	Shore of Pinewood Reservoir
S-CBT-40	CB-T	Shore of Flatiron Reservoir
S-CBT-50	CB-T	Downstream of Flatiron Reservoir
S-CBT-60	CB-T	Hansen Canal near Outlet to Green Ridge Glade Reservoir
S-LNN-10	Lab Line	River Line in Laboratory
S-LNN-20	Lab Line	Reservoir Line in Laboratory

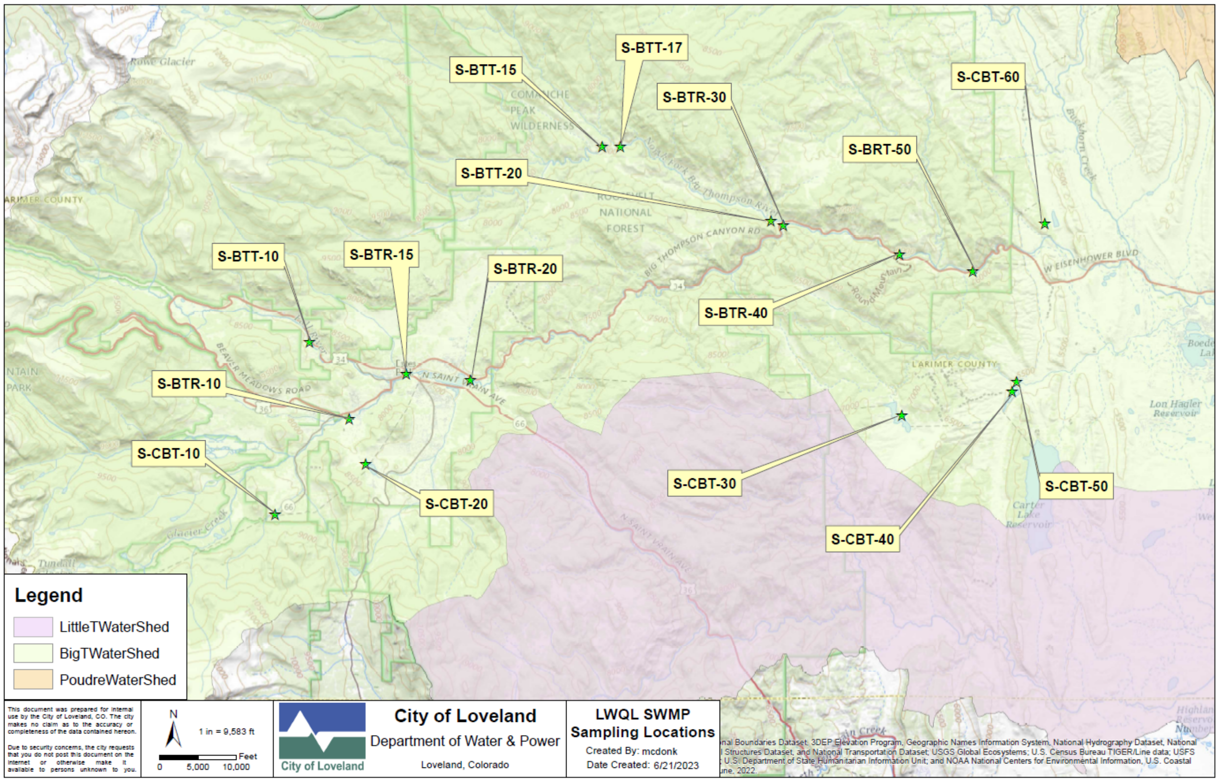

Figure 1. 2023 Source Water Monitoring Program water quality sampling sites.

Objective

The objective of these seasonal reports is to provide a description of notable events and a summary of important water quality parameters for those interested in the water quality of the Big Thompson River. These reports do not summarize all the water quality data collected by the WQL and are not meant to represent a quantitative statistical analysis of the data.

These comparisons provide the opportunity to understand recent conditions relative to the previous five-year time period and to established water quality standards. While water quality conditions have changed on time scales greater than five years, this relatively short time period provides context for recent conditions. Examination of longer-term trends and conditions can be found in LWP Big Thompson River Annual Reports. Figures associated with each water quality parameter are color coded to represent different components of the source water system. Sites presented with the same color are likely to be more similar than sites of different colors. In the figures, blue bars indicate sites located in the mainstem of the Big Thompson River, light blue bars indicate sites that are located in tributaries to the Big Thompson River, and aqua blue bars represent sites located in the Colorado-Big Thompson Project.

The results and findings presented in this report only represent source water and not the treated drinking water that is delivered to our customers. Drinking water information and the annual Consumer Confidence Report can be found on our website. (https://www.lovelandwaterandpower.org/city-government/departments/water-and-power/water-quality)

For this report, the term “fall” is defined as the months of August, September, and October. Water quality conditions during this time period are driven by baseflow conditions with periodic intense runoff events primarily in August. Average values were calculated from all samples collected during these months in 2023 and compared to the average value of all samples collected during these months from 2018 through 2022.

Summary Conditions

Fall 2023 water quality conditions were similar to those documented earlier in the year. Some water quality parameters continued to reflect the effects of the Cameron Peak Fire (CPF) which occurred in fall 2020, although the magnitude of the effect on parameters such as turbidity, pH, manganese, nitrate, and orthophosphate appears to be diminished somewhat compared to fall 2022 and indicate watershed recovery.

All of these parameters generally increase after a wildfire, but not always significantly (Rust et al. 2018). Specifically, between fall 2022 and fall 2023 average total manganese decreased from 0.149 to 0.035 ug/L, pH decreased from 7.45 to 7.36 SU, and orthophosphate decreased from 0.183 to 0.0004 mg/L. However, other parameters, such as iron and copper continue to be substantially affected by the CPF. Total iron concentrations continued to be elevated and total copper concentrations continued to be lower than they have been historically.

Generally, total copper concentrations tend to increase in a post-wildfire environment (Rust et al. 2018) but like most water quality effects of wildfire, these results are very location specific with results in some watersheds demonstrating a decrease after a wildfire and others demonstrating increases. In the case of the CPF in the Big Thompson watershed, total copper concentrations declined, and these lower concentrations continue to persist. This result is one of the few positive water quality effects of the CPF. These impacts were particularly notable in the area surrounding the North Fork. Sampling from additional sites in the North Fork Watershed in 2023 continue to demonstrate that many of the changes in water quality in the Big Thompson River originated in the Miller Fork as a result of the CPF. However, the magnitude of these contributions appears to be slightly smaller in fall 2023 than in summer 2023.

Although the water quality changes resulting from the CPF were challenging from a water treatment perspective, in terms of avoiding water with elevated turbidity among other issues, they provide a template for expected changes that will occur in the event of the next wildfire. Although some water quality challenges persist, they appear to be diminishing, and LWP Drinking Water Treatment staff were able to continue providing high quality drinking water.

Water Quality Parameters

Precipitation

The amount of precipitation is directly proportional to the amount of water present in the Big Thompson River. In addition, the amount of precipitation can provide an indication of the relative quality of the water as large rain events and runoff often result in increased turbidity and decreased water quality. Precipitation in fall 2023 was approximately average compared to the previous five-year time period (Figure 2).

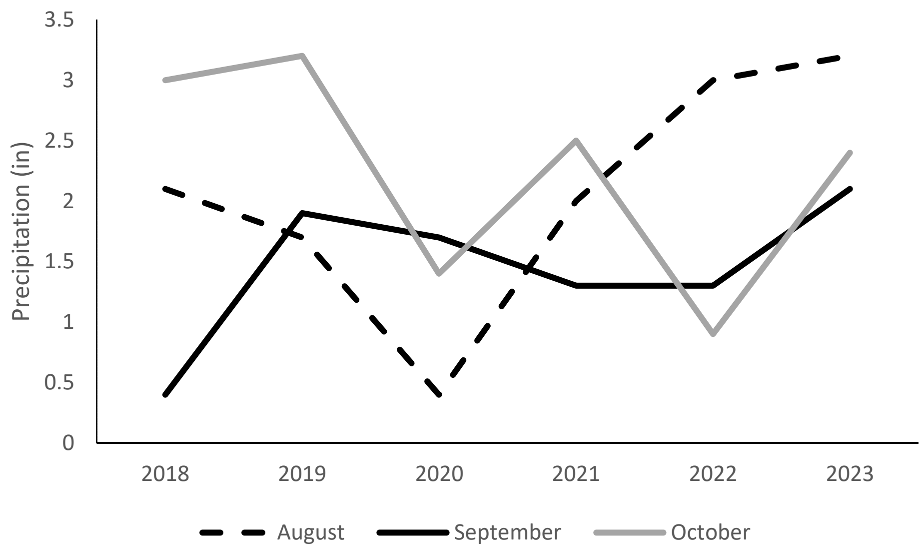

Figure 2. Monthly precipitation by year at the Bear Lake Natural Resources Conservation Service Snow Telemetry (SNOTEL) station.

Temperature

Aquatic organisms have preferred temperature ranges. These ranges can vary widely, and species with similar temperature tolerances are often associated with one another. Some organisms require relatively cold water to survive, particularly during spawning, egg/larval growth, and development. Consequently, elevated water temperatures can cause mortality as well as reduced reproduction and growth. Conversely, water temperatures can be too low for optimal growth and survival of some species, particularly those found in the lower reaches of the Big Thompson River.

In addition, temperature is of interest to water treatment operators because the temperature of the water influences the speed at which chemical reactions used to treat drinking water take place. Chemical reactions generally take longer to complete in colder water.

Similar to precipitation, fall 2023 temperatures were very close to average values in the past five years throughout the watershed (Figure 3).

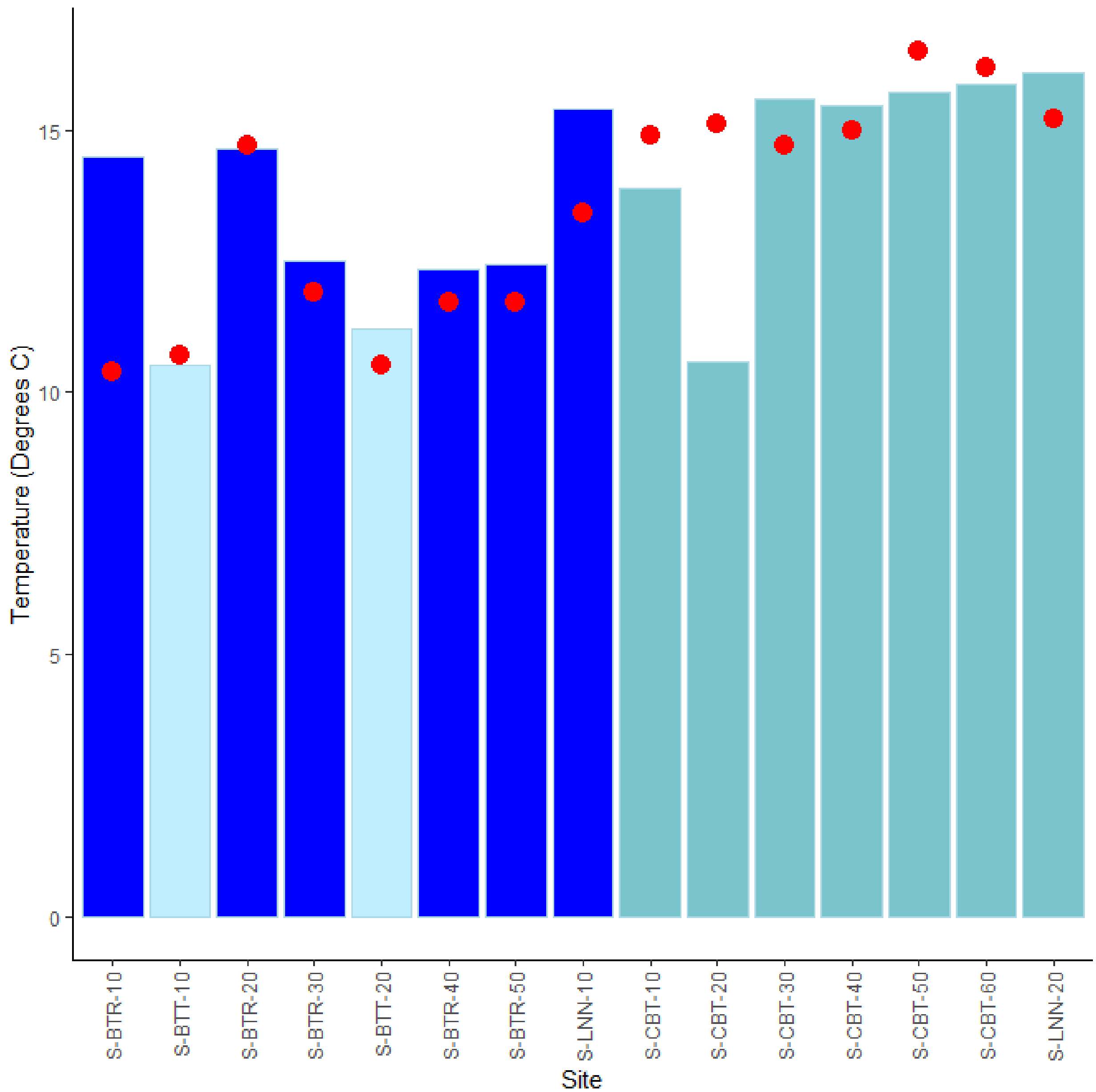

Figure 3. Average water temperature values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Turbidity

Turbidity is a general measurement of water clarity, measured as NTU (Nephelometric Turbidity Unit). Water with higher turbidity levels has a greater number of suspended particles in it and is less clear. Elevated turbidity has negative impacts on municipal water treatment plants and aquatic communities. LWP alters the location of water collection to avoid high levels of turbidity as it is an indicator of high sediment load. Turbidity levels are also positively associated with total organic carbon (TOC) levels which in turn require additional water treatment efforts.

Elevated turbidity can have negative direct and indirect effects on aquatic organisms and can be associated with high concentrations of some metals. Elevated turbidity and suspended sediment can also have negative effects on density and species richness of macroinvertebrates. Growth of trout species, such as rainbow trout (*Oncorhynchus mykiss*), is negatively associated with increased turbidity and increased turbidity can lead to increased mortality as well. Effects of elevated turbidity become more severe with longer exposure.

Turbidity levels in fall of 2023 continued to be relatively high in the North Fork and sites downstream with near average values elsewhere (Figure 4). However, the average turbidity value in the North Fork in fall 2023 was somewhat lower than the five-year average fall value, which is an indication of recovery from the CPF. The area in the North Fork watershed above the sampling site was included in the area that was most severely burned during the CPF in fall of 2020. Increased turbidity resulting from the aftereffects of wildfire can persist for several years (Rhoades et al. 2011) and the elevated turbidity level in the North Fork is likely due to these continued effects.

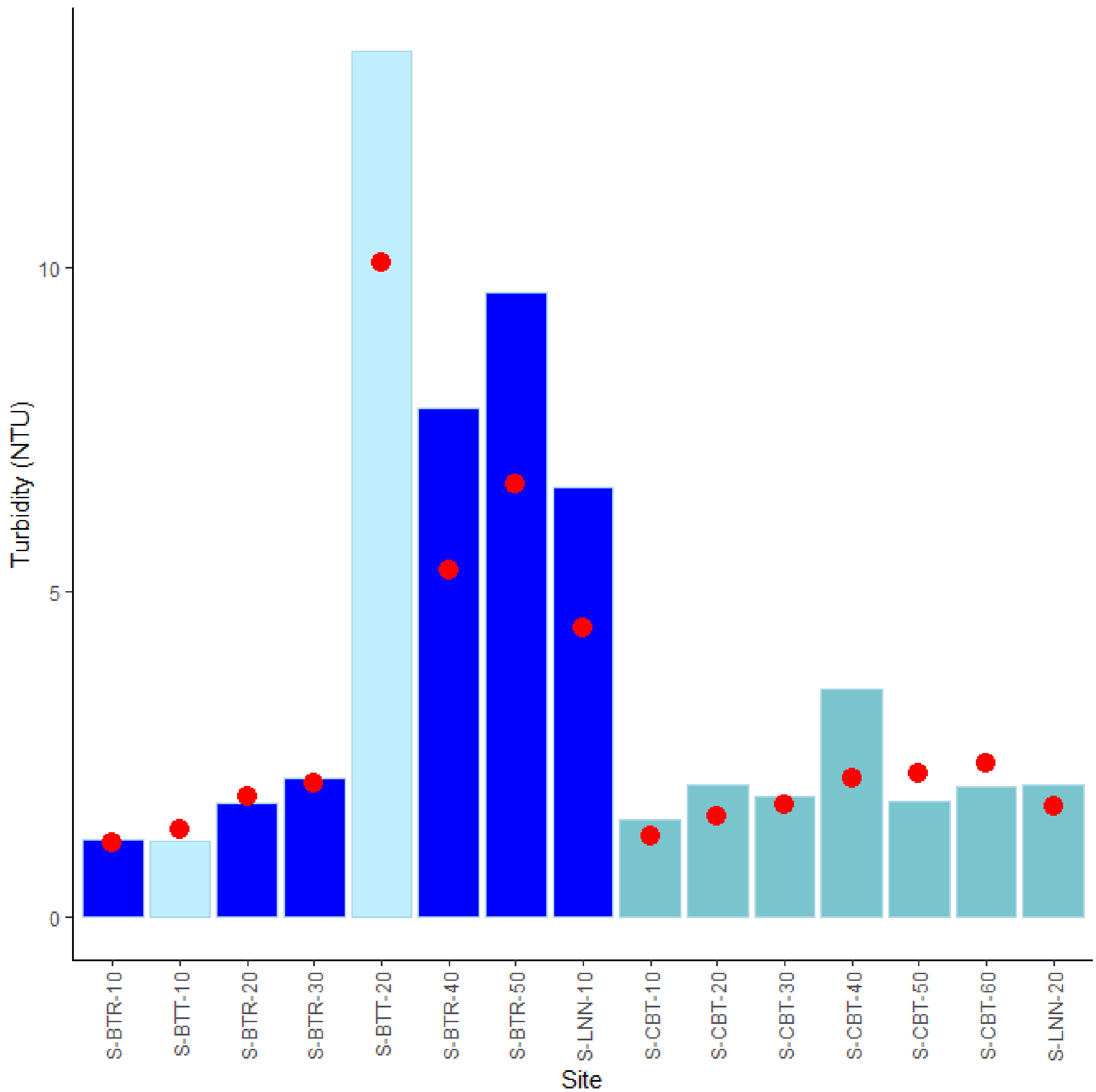

Figure 4. Average turbidity values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

pH

The pH value (SU, Standard Units) measures how acidic or basic water is. A pH value of 7 is considered neutral, with lower values considered acidic and higher values considered basic. Colorado Regulations 31 and 38 establish a pH of 6.5 as a minimum and 9 as a maximum to protect aquatic life. A maximum pH of 9 is also the Colorado Regulation 31 standard for drinking water supplies. The pH level also impacts the efficacy of alum coagulation in drinking water treatment with the optimal range being between 6 and 8. Outside this pH range, coagulation is less efficient in removing particles present in the water.

Mean pH values were somewhat lower than five-year average values at most sites in fall 2023 (Figure 5). These lower values are consistent with watershed recovery from wildfire as white ash from wildfires is generally basic (Rodela et al. 2022). Since all the sites continue to receive lower and lower amounts of ash from the CPF or the East Troublesome Fire as time goes on, it is reasonable to expect pH levels to continue to decline in coming years.

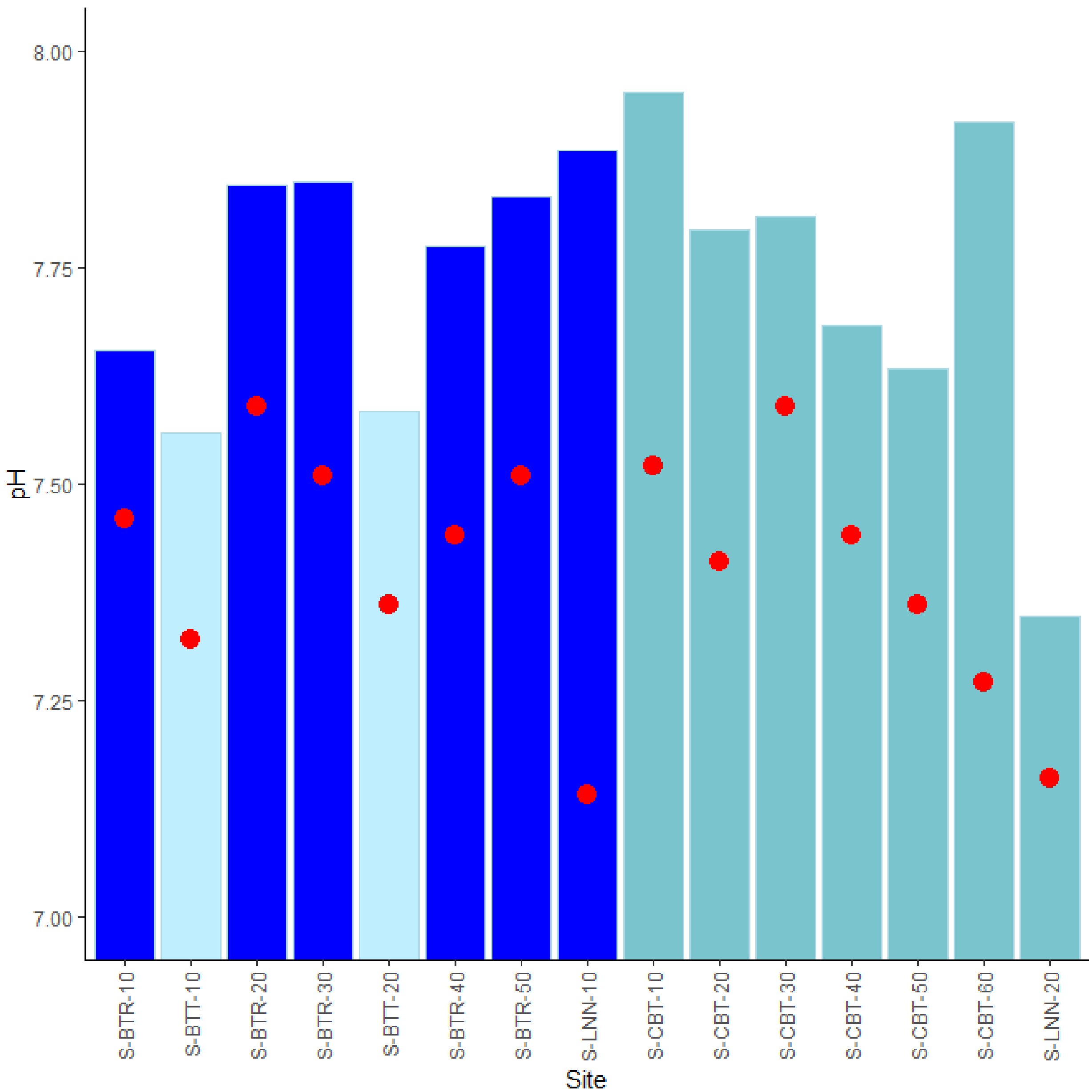

Figure 5. Average pH values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Dissolved Oxygen

Dissolved oxygen levels are important to aquatic life and drinking water facilities and are affected by a number of factors such as temperature, altitude, turbulence, and biological activity. Turbulent cold water at a low altitude can have higher levels of dissolved oxygen than still warm water at a higher altitude. Biological activity (particularly photosynthesis) can increase dissolved oxygen during the day as photosynthesis occurs and can decrease dissolved oxygen levels at night when respiration dominates. Often, biological activity has no net effect on dissolved oxygen levels, but it can increase the daily range of values with wider ranges being associated with greater biological activity.

Virtually all aquatic organisms require dissolved oxygen to survive with the necessary concentration differing by species. For example, many fish species in the upper portion of the Big Thompson River have evolved to live in cold water streams and require higher concentrations of dissolved oxygen (e.g., cutthroat trout *Oncorhynchus clarki*) than those that evolved to persist in the lower warm water portion of the river (e.g., plains killifish *Fundulus zebinus*). Aquatic organisms can experience mortality if the dissolved oxygen levels drop below their threshold level for even a short time. Although some life stages require higher levels of dissolved oxygen, a minimum threshold to support most aquatic life is approximately 6 mg/L (ppm, parts per million). In addition, dissolved oxygen levels regulate the degree to which some elements (like manganese) remain in solution. Relatively high dissolved oxygen levels allow these elements to precipitate out of the water column and make drinking water treatment easier.

Fall 2023 dissolved oxygen levels were generally very near historic averages across sites (Figure 6). Although dissolved oxygen concentrations were generally near historical values, the fall 2023 dissolved oxygen concentration in the Green Ridge Glade Laboratory Line (S-LNN-20) was notably above the five-year average value.

The high dissolved oxygen levels associated with site S-LNN-20 may be somewhat deceptive. The water sampled is reflective of the depth at which water is being taken from the reservoir to use as drinking water. These depths are associated with different depths of gates in the tower intake control structure. Each gate can be opened or closed to utilize water from different depths of the reservoir. Different depths contain water that has different water quality characteristics. The bottom of the reservoir (hypolimnion) becomes anoxic during the summer months and into the fall. Often, the primary gate utilized for source water is very near the thermocline. Therefore, depending on the depth of the thermocline in a given month, the dissolved oxygen concentration may seem particularly high or particularly low compared to the average concentration.

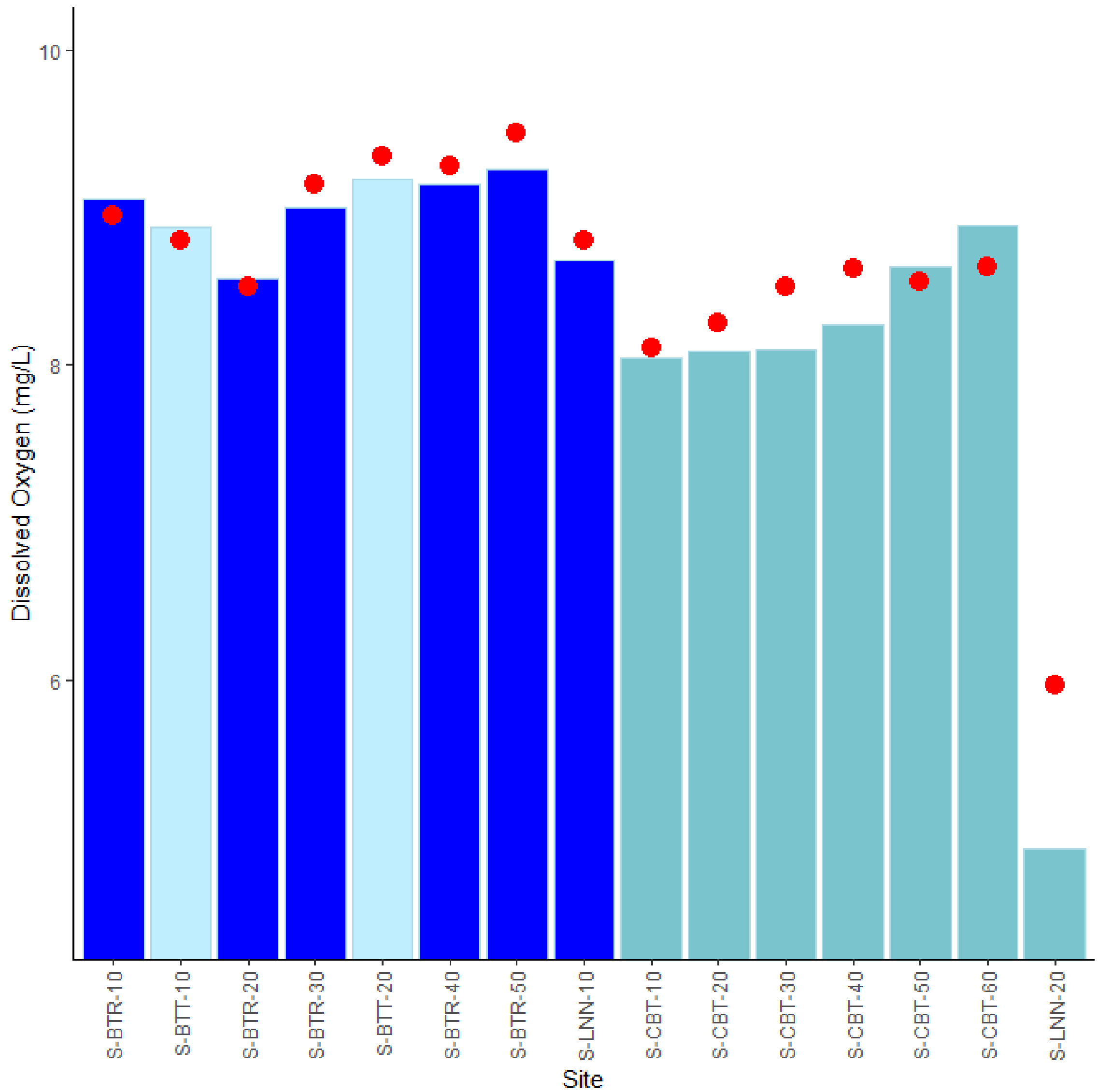

Figure 6. Average dissolved oxygen values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Alkalinity

Alkalinity is a measure of the ability of water to neutralize acid and resist declines in pH and is generally determined by the amount of calcium carbonate in water. Calcium carbonate provides buffering capacity to protect aquatic life from acidic conditions and decreases the ability of water to corrode distribution pipes. Conversely, water treatment plants (including Loveland Water and Power) often use flocculation techniques to purify water and these techniques are often optimized by altering the pH (Naceradska et al. 2019). High alkalinity makes this pH adjustment more difficult and requires higher doses while low alkalinity can cause incomplete chemical reactions and poor flocculation.

Differences between average values in fall 2023 and average fall values over the previous five years were small.

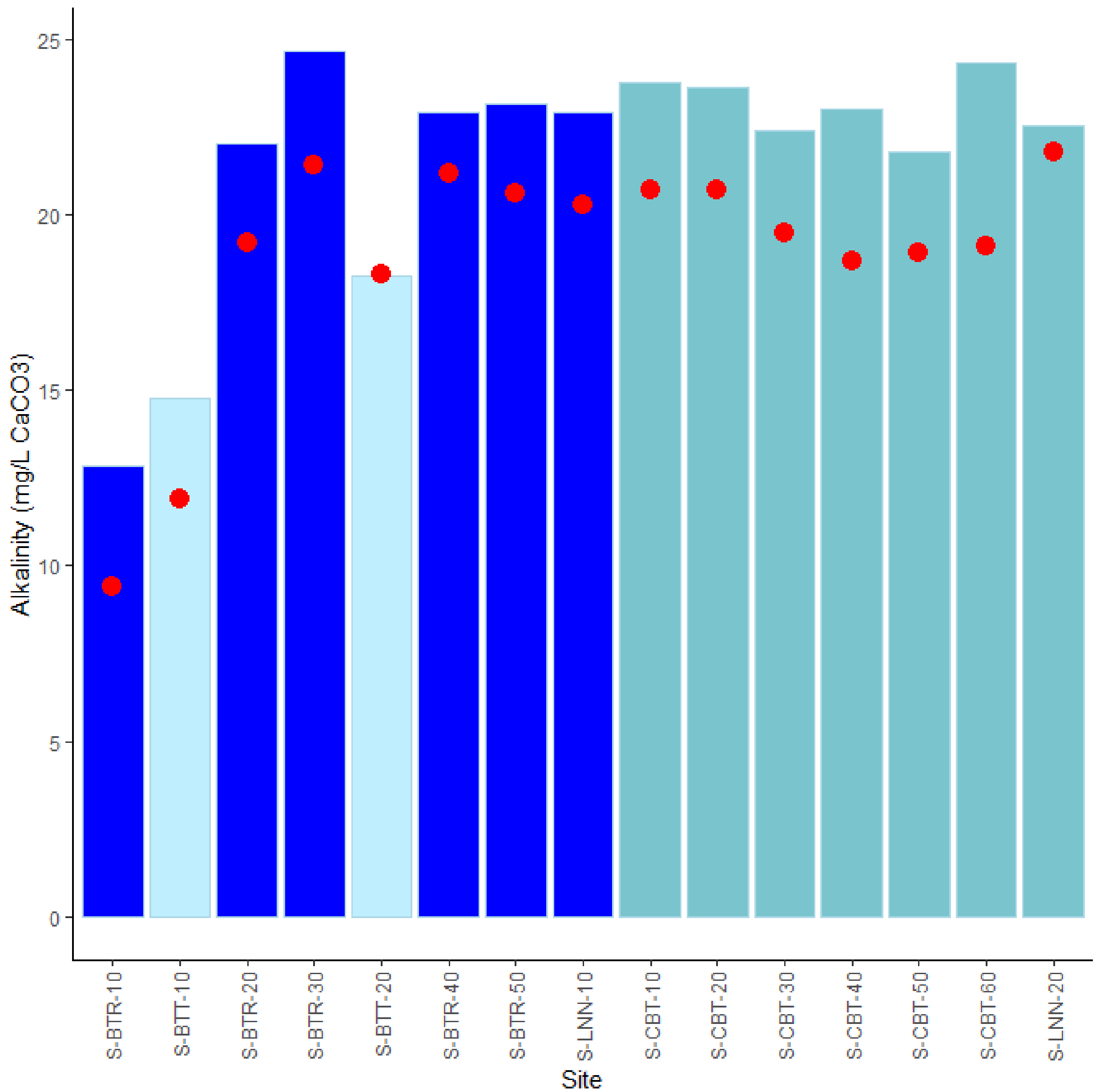

Figure 7. Average alkalinity values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Manganese

Manganese is an element that is considered beneficial to human health at low levels and is one of the least toxic elements. However, elevated levels can cause non-health related effects such as bad taste and staining of clothes and plumbing fixtures. Elevated manganese levels can also cause problems for water distribution systems. Specifically, manganese may cause buildup in water distribution pipes. The relative toxicity of manganese to aquatic life is based on the hardness of the water, but manganese levels of concern to aquatic life are much higher than those present in the Big Thompson River.

Concentrations of manganese measured in areas associated with the CPF, such as the North Fork (S-BTT-20), (Figure 7) continued to be high relative to other sites but the fall 2023 average values were lower than five-year average values. Increased manganese levels have been associated with the aftereffects of wildfire and the fact that they appear to be declining is consistent with ongoing recovery of the watershed from the CPF.

The EPA has a “secondary” standard of 0.05 mg/L (ppm) for manganese. This level does not make water unsafe to drink, but the water may be aesthetically unpleasing due to a reddish/black/brown color which can stain laundry, plumbing, sinks, and showers. Although manganese concentrations were somewhat elevated at some sites, none were above the secondary standard.

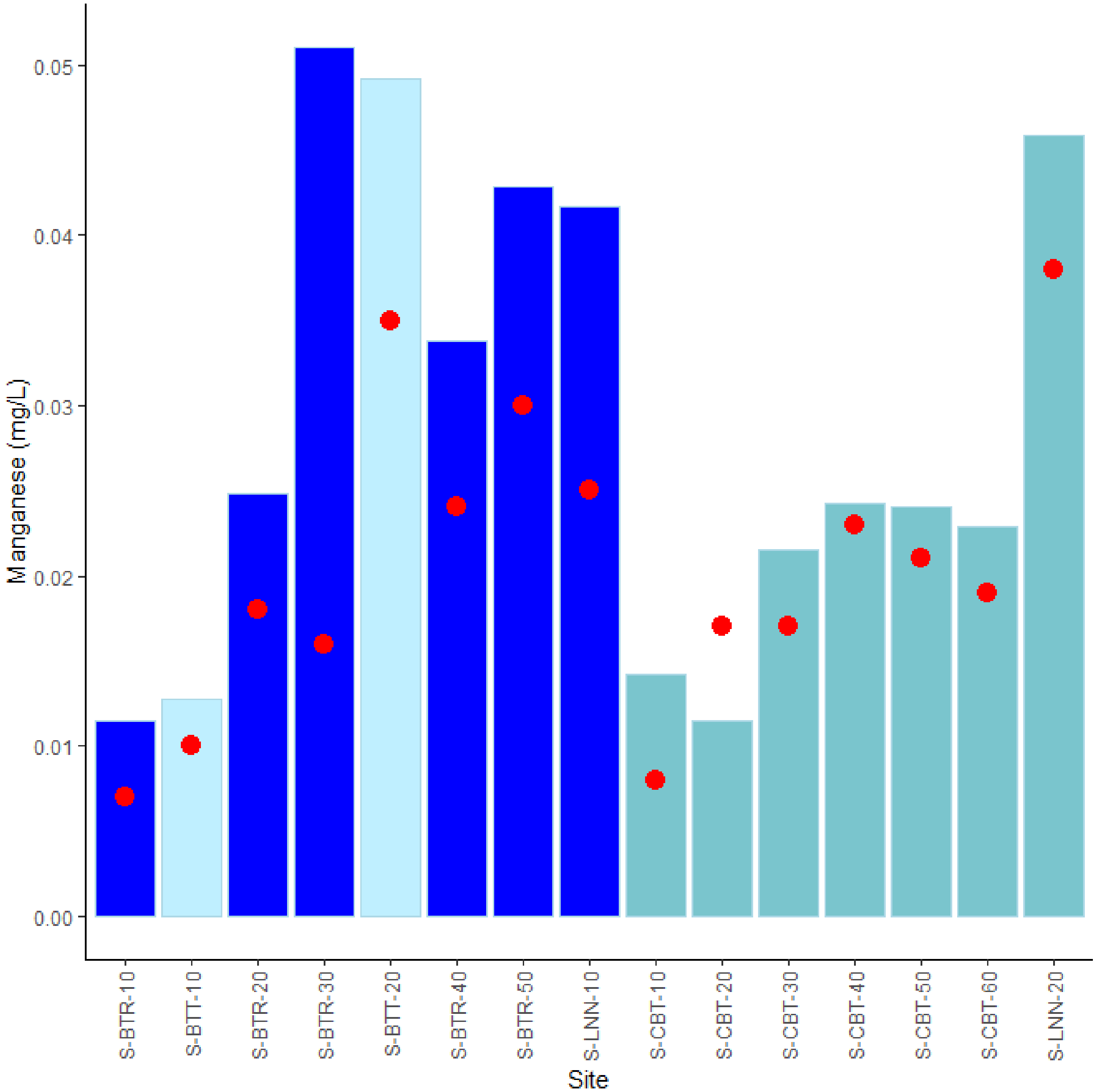

Figure 7. Average manganese values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Copper

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

Total copper levels in fall 2023 were below five-year average values (Figure 8) and total copper levels have generally been lower in the post-CPF time period. Although copper levels in the previous year (fall 2022) and season (summer 2023) appeared to be increasing toward pre-CPF copper concentrations, fall 2023 concentrations have declined from previous levels. While these lower levels indicate continued effects of the CPF, they are also positive from a water quality perspective and represent one of the few positive outcomes of the CPF. There was a dramatic decrease in total copper concentration in the first spring after the full fire effects were apparent (i.e. summer 2021) at locations impacted by the fire.

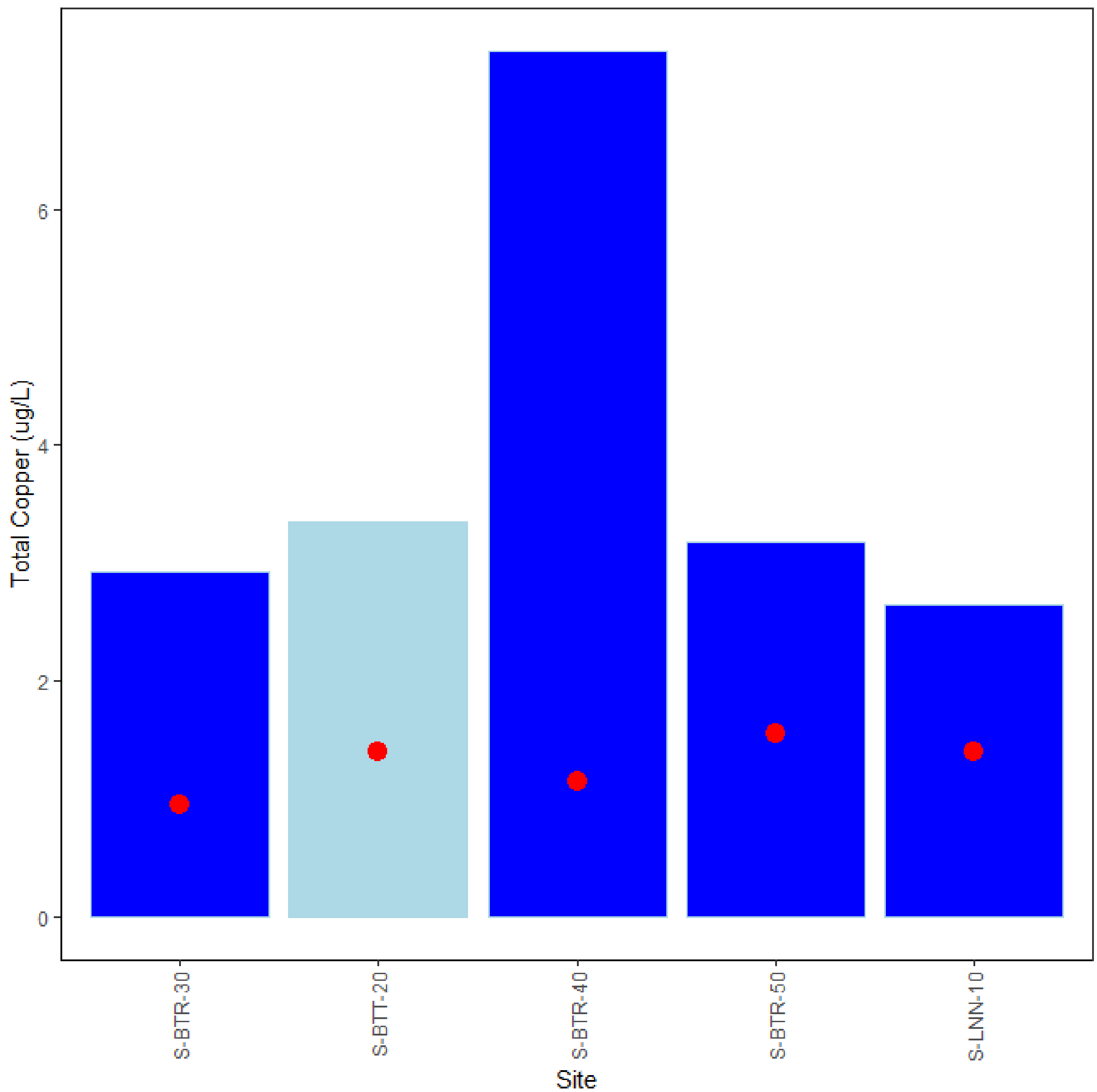

Figure 8. Average total copper values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Light blue bars indicate tributary sites and blue bars indicate mainstem sites.

Iron

Iron is common in surface water, although it is usually present at levels that are harmless to people and to aquatic life. However, water discoloration and staining issues can occur in water with dissolved iron levels greater than 3,000 ug/L (ppb), and the drinking water standard is a 30-day average value of 300 ug/L (ppb). Detrimental effects to aquatic life can occur when levels of dissolved iron are above 1000 ug/L (ppb). The levels of dissolved iron that can affect aquatic life are dependent in part on the hardness of the water. Less dissolved iron is necessary to negatively affect aquatic life in water with lower hardness values than in water with higher hardness values.

Average total iron concentrations in fall 2023 continued to be somewhat elevated at the S-BTT-20 (North Fork) site compared to the five-year historic average (Figure 9). The area in the North Fork watershed above the sampling site was included in the area that was most severely burned during the CPF in fall of 2020. Increased iron concentrations resulting from the aftereffects of wildfire have persisted for several years and will presumably begin to decline in coming years as the watershed continues to recover from the wildfire.

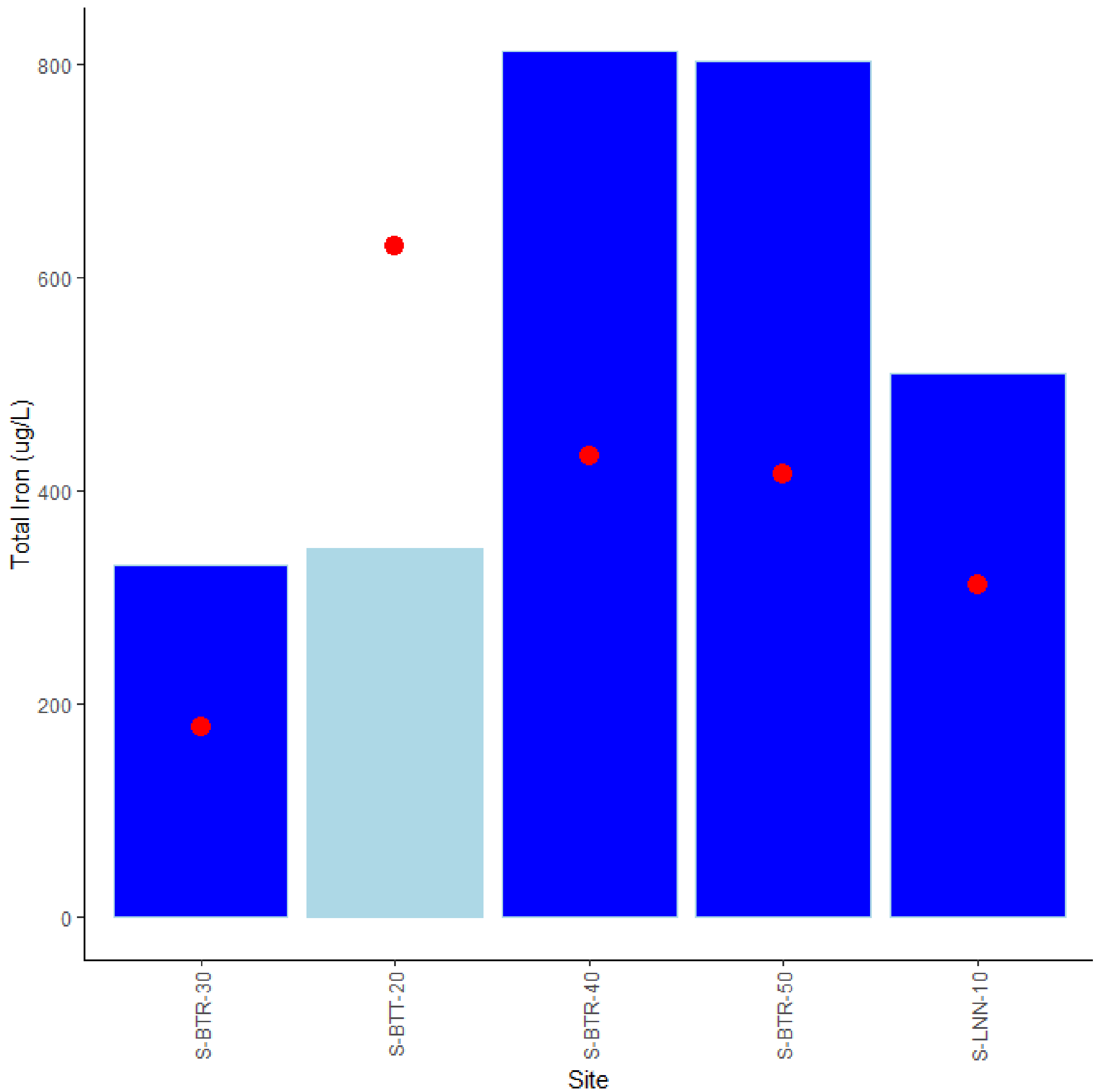

Figure 9. Average total iron values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Light blue bars indicate tributary sites and blue bars indicate mainstem sites.

Nitrate

Nitrate and nitrite are of interest due to the role they play in aquatic plant growth and their potential effects on human health. Nitrate, along with ammonia, is a form of nitrogen that is available for immediate uptake by algae and is therefore of interest due to its role in determining the productivity of a given waterbody. At higher concentrations (e.g. >10 mg/L (ppm)), nitrate can be of concern in drinking water because it can reduce the oxygen-carrying capacity of hemoglobin in humans and create a condition known as methemoglobinemia, particularly in those under two years of age. Nitrite is also available for uptake by algae but is rarely present at high concentrations.

Nitrate concentrations in fall 2023 were generally near five-year average values. Although fall 2023 values appeared near average, concentrations at sites affected by the CPF were substantially lower when compared to average values last year (e.g. S-BTT-20 fall 2022 nitrate concentration = 0.48 mg/L) and last season (e.g. S-BTT-20 summer 2023 nitrate concentration = 1.06 mg/L). Given that elevated nitrate can and has been an aftereffect of the CPF (Rust et al. 2018), near average values are another positive indication that the Big Thompson watershed is recovering from the CPF.

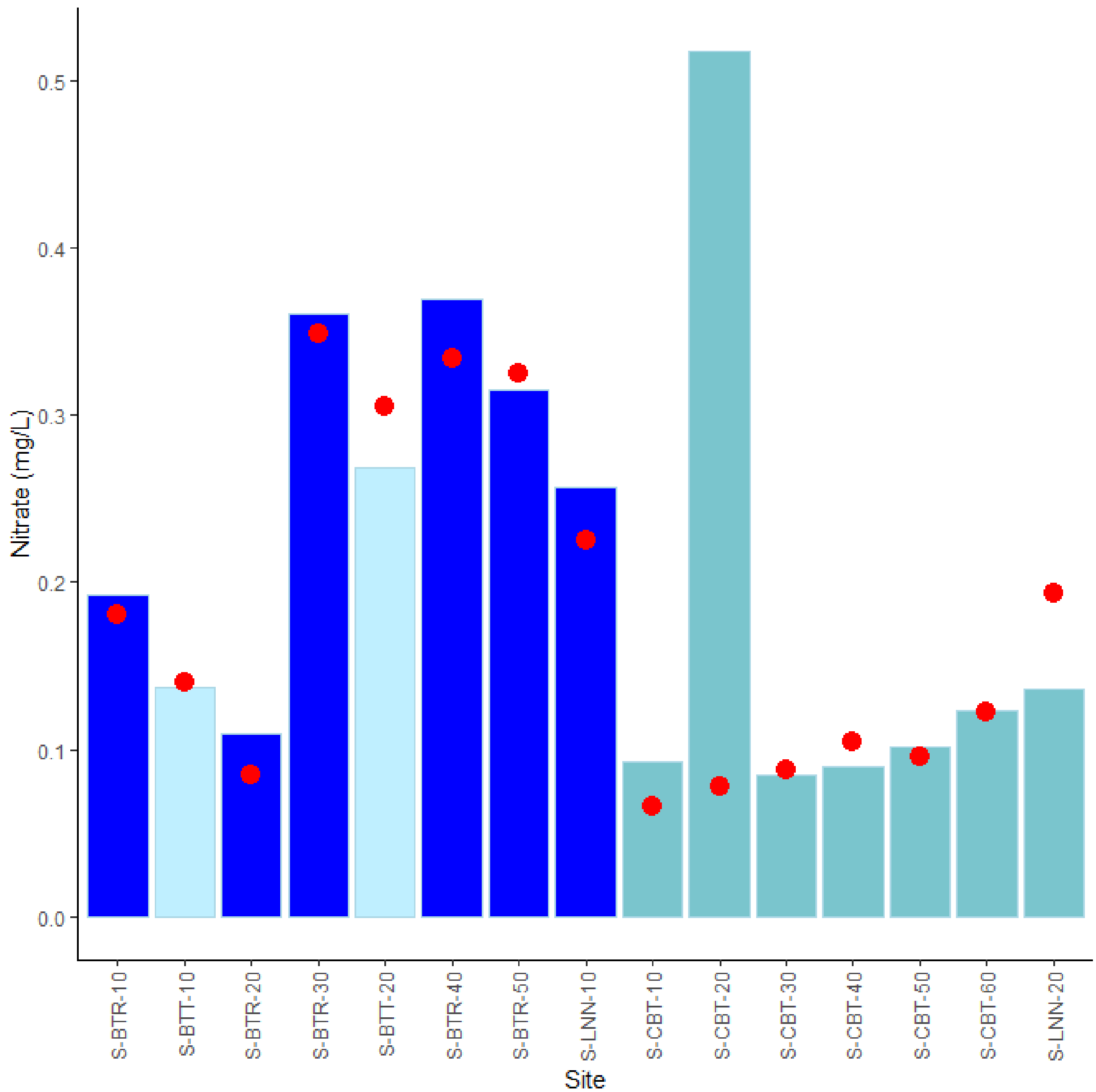

Figure 10. Average nitrate values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Orthophosphate

Orthophosphate is a dissolved form of phosphorus and is the only form that is immediately available for uptake by algae. Algal populations are often limited by orthophosphate concentrations and are of concern due to the ability of some algal species to produce toxins and to negatively affect drinking water taste and odor. Therefore, elevated orthophosphate levels can be of concern. Sources of orthophosphate include the decay of plant debris and other organic matter; the minerals that make up rocks, soils, and sediments in the watershed; wastewater treatment plant effluent; failing individual sewage disposal systems; runoff from fertilized agricultural lands and urban areas; and erosion of stream channels, dirt roads, construction sites, and other land surfaces.

Fall 2023 orthophosphate concentrations were generally low compared to the five-year average values for most sites (Figure 11). This result is a positive one from a water quality perspective and is consistent with wildfire recovery. Hopefully, these low and declining concentrations of orthophosphate will continue in coming years.

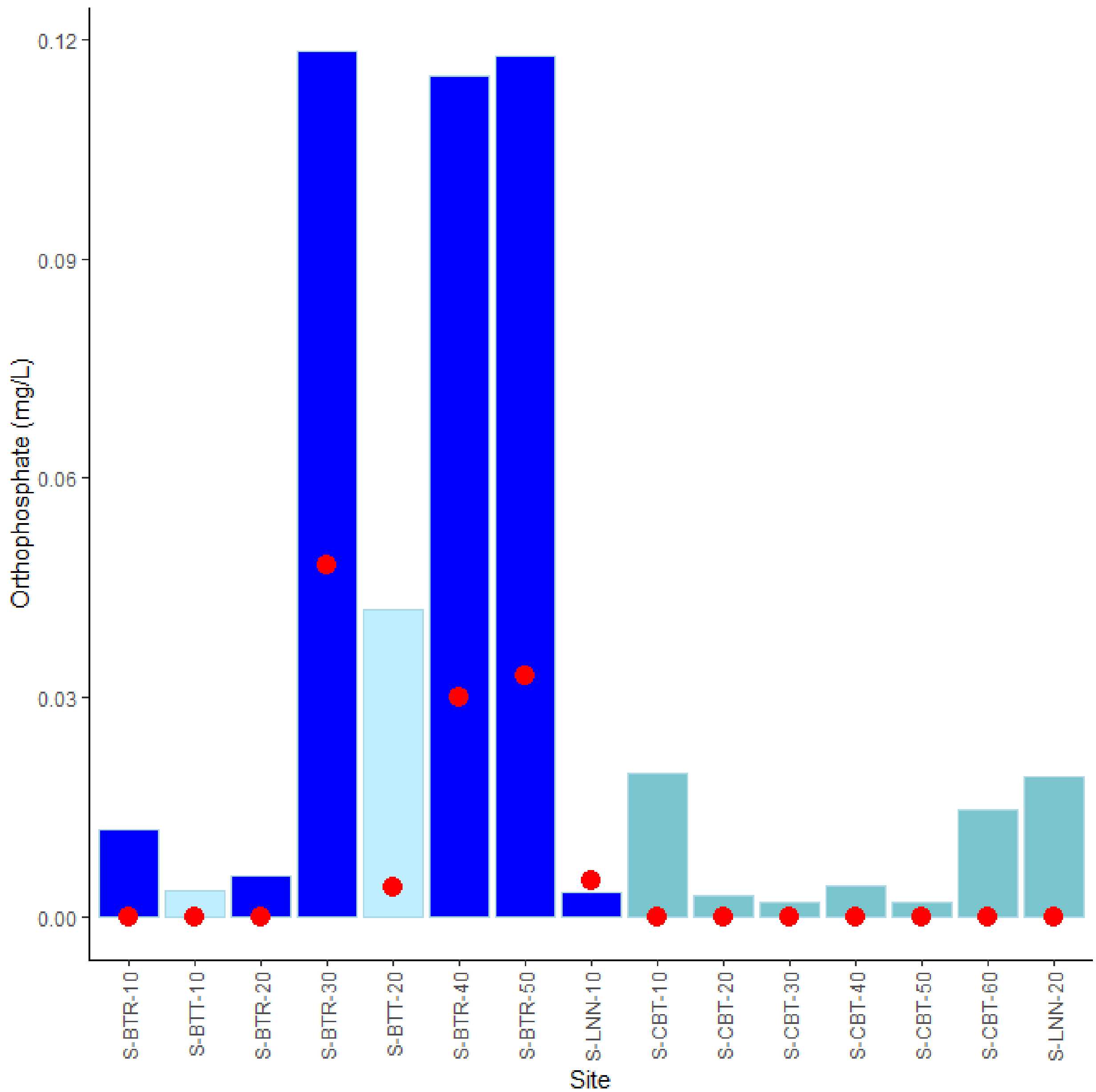

Figure 11. Average orthophosphate values for the months of August through October 2018-2022 and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Total Organic Carbon (TOC)

TOC is a measure of the amount of dissolved and particulate organic matter in a water sample. Organic carbon compounds are the result of the decomposition of organic matter such as algae, terrestrial plants, animal waste, detritus, and organic soils. The higher the carbon or organic content of a water body, the more oxygen is consumed as microorganisms break down the organic matter.

Although TOC is not a direct human health hazard, the dissolved portion of the TOC can react with chemicals (chlorine and others) used for drinking water disinfection to form disinfection by-products (Allen et al. 2022) that are regulated as potential carcinogens (e.g. chloroform $CHCl_3$). As such, TOC levels are of concern to drinking water treatment facilities.

Fall 2023 TOC values were very similar to five-year average values at virtually all sites (Figure 12). However, S-BTT-20 (North Fork) average TOC concentrations were somewhat above the five-year average value; a circumstance similar to summer 2023. The relatively high TOC value at site S-BTT-20 is likely related to the high turbidities in fall 2023. Although elevated TOC may be related to the elevated turbidity, the fact that TOC levels are elevated at this site, regardless of cause, can be a sign of forest recovery in a post-fire environment. In severely burned areas, organic carbon is often reduced compared to unburned areas immediately after a fire (Rhoades et al. 2019).

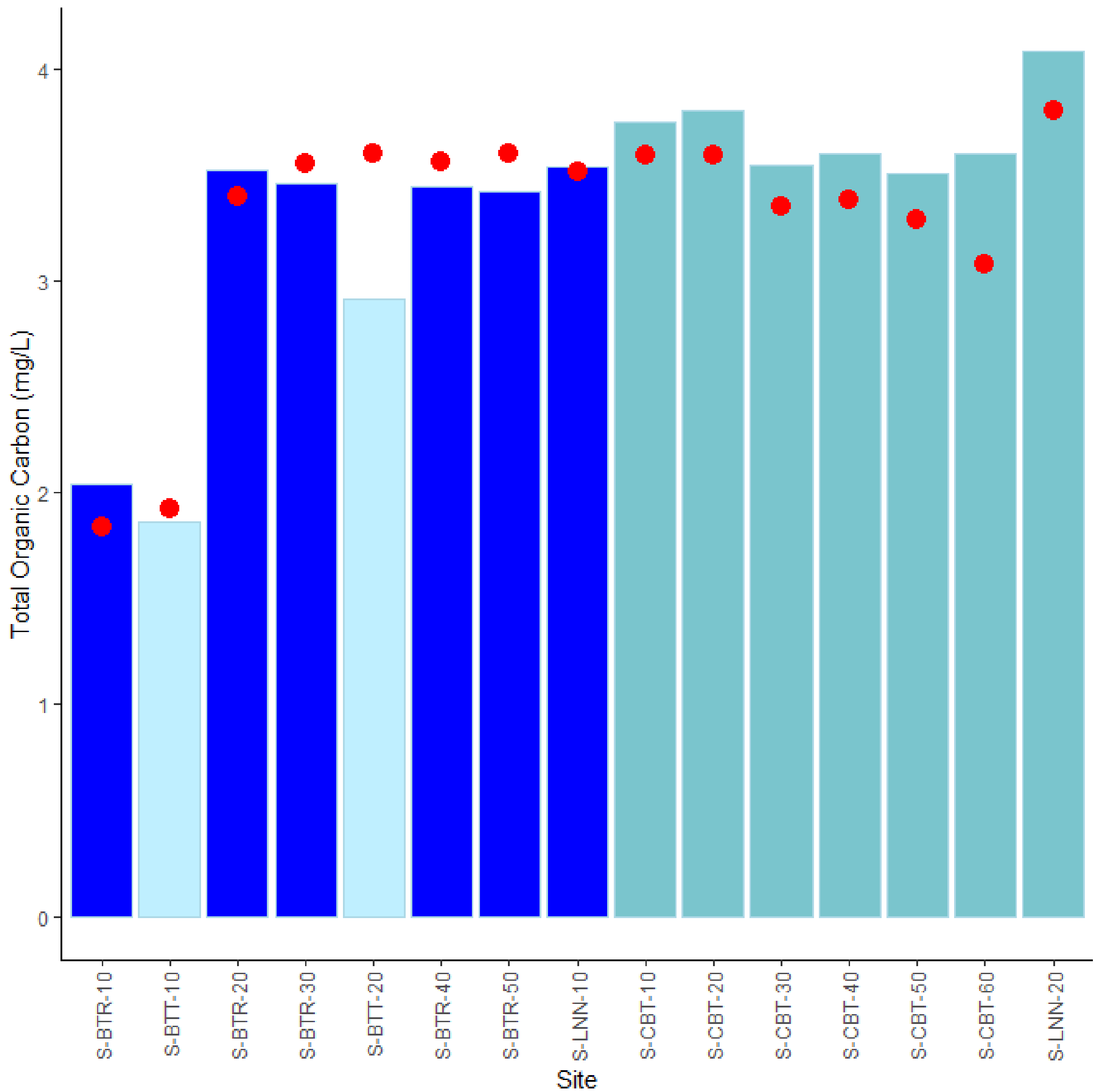

Figure 12. Average total organic carbon values for the months of August through October 2018-2022 (blue bar) and the 2023 average value (red dot) at sites included in the LWP SWMP. Blue bars indicate mainstem sites, light blue bars indicate tributary sites, and aqua blue bars represent Colorado-Big Thompson sites.

Water Quality Contributions of Miller Fork

In April 2023, we began collecting samples from two additional sites that were selected to further characterize the effects of the CPF and the water quality contributions of the Miller Fork in general. The Miller Fork is a contributor to the North Fork and its watershed experienced the most intense effects of the CPF within the context of the broader Big Thompson River Watershed. One site (S-BTT-17) is located in the Miller Fork itself, just above the confluence with the North Fork. The other site (S-BTT-15) is located in the North Fork above the confluence with Miller Fork. Examining data from these two sites in conjunction with an existing site in the North Fork below the confluence with Miller Fork (S-BTT-20), we can develop a better understanding of the water quality contributions of Miller Fork.

Although only two seasons of data are currently available, some marked contributions of the Miller Fork are apparent. The most notable results from fall 2023 included nutrients (nitrate and orthophosphate), turbidity, and total manganese (Figure 13) and these results were similar to those found in summer 2023. The concentrations of total manganese, orthophosphate, and nitrate from Miller Fork were much higher than concentrations in the North Fork above the confluence of the two streams. The contribution of these water quality constituents from the Miller Fork can be seen in the downstream location on the North Fork (Figure 13) as well as in the mainstem Big Thompson River. Water from the Miller Fork also contributed substantially to turbidity levels. Even three years after the CPF, water quality parameters continue to be substantially impacted and the importance of a relatively small tributary to overall water quality in the Big Thompson River is apparent.

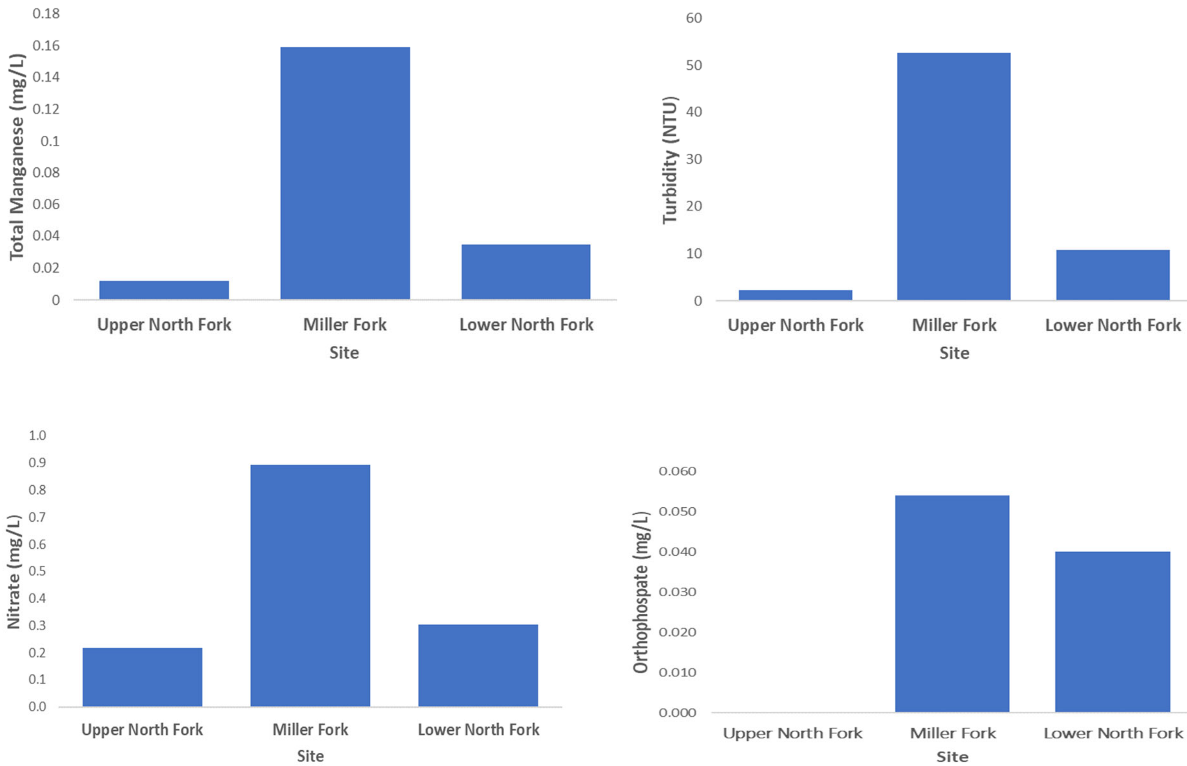

Figure 13. Values of water quality parameters in sampling stations above, in, and below the confluence of Miller Fork and North Fork in Fall (August-October) 2023.

Conclusions

LWP continued to provide high quality drinking water that met or exceeded all drinking water regulations despite ongoing impacts from the CPF in fall 2023. There are some indications that water quality effects of the CPF are beginning to dissipate, and the watershed is recovering from the fire although some fire effects are apparent and will likely continue for 2-5 more years. The potential long-term effects of some, such as increased nitrate levels, are unknown at this time. LWP has sought to mitigate these effects by partnering with organizations such as the U.S. Forest Service, Big Thompson Watershed Coalition, Coalition for the Poudre River Watershed, and Ayers Associates to construct point mitigation projects in fire affected areas. These point mitigation projects are designed to reduce erosion and sediment generation in areas affected by the CPF. LWP is now focusing efforts on mitigating the effects of the next wildfire in the Big Thompson Watershed by partnering with groups such as the Big Thompson Watershed Coalition and the Larimer Conservation District to conduct forest management projects, primarily through tree thinning (Figure 14). The purpose of these projects is to reduce the overall occurrence of wildfires and for those that do occur, to reduce the severity of their impact. Although water quality continued to be relatively good despite fire effects, we expect that these efforts, along with natural regenerative processes, will continue to result in improved water quality in the coming years.

Figure 14. An example of forest management in the Big Thompson River watershed. The forest on the left side of the road has been thinned to historic tree density. The forest on the right side of the road has not been treated.

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